The Role of Music Perception in Predicting Phonological Awareness in Five- and Six-Year-Old Children

Linda M. Lathroum

University of Miami, lindalath@gmail.com

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THE ROLE OF MUSIC PERCEPTION IN PREDICTING PHONOLOGICAL AWARENESS IN FIVE- AND SIX-YEAR-OLD CHILDREN

By

Linda M. Lathroum

A DISSERTATION

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the requirements for the degree of
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THE ROLE OF MUSIC PERCEPTION IN PREDICTING PHONOLOGICAL
AWARENESS IN FIVE- AND SIX-YEAR-OLD CHILDREN

Linda M. Lathroum

Approved:

Shannon K. de l’Etoile, Ph.D.
Program Director and Associate Professor, Music Therapy

Terri A. Scandura, Ph.D.
Dean of the Graduate School

Edward P. Asmus, Ph.D.
Associate Dean for Graduate Studies

Teresa Lesiuk, Ph.D.
Associate Professor, Music Therapy

Maria S. Carlo, Ph.D.
Associate Professor of Education

Carlos Abril, Ph.D.
Associate Professor, Music Education
The purpose of this study was to examine the role of music perception in predicting phonological awareness in five- and six-year-old children. This study was based on the hypothesis that music perception and phonological awareness appear to have parallel auditory perceptual mechanisms. Previous research investigating the relationship between these constructs—music perception and phonological awareness—has been promising, but inconclusive. Phonological awareness is an important component of early literacy which many children struggle to acquire. If the constructs are shown to be related, music-based interventions may then be developed to promote phonological awareness, thus enhancing early literacy.

Music perception, phonological awareness, and visual-spatial skills of 119 five- and six-year-old children were tested. The researcher administered the Children’s Music Aptitude Test (Stevens, 1987) in order to assess perception of pitch, rhythm, and melody. Subsequently, the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999) was administered in order to measure phonological awareness skills, including blending, elision, and sound matching. The Visual Spatial Relations subtest of
the Woodcock Johnson III (Woodcock, McGrew, & Mather, 2001) was later used to assess visual spatial skills.

Structural equation modeling (SEM) allowed the researcher to model relationships between the latent variables to investigate the contribution of music perception, visual-spatial skills, and age to phonological awareness. Results supported the hypothesis that music perception, visual spatial skills, and age predict phonological awareness.

Additionally, music perception made a statistically significant contribution to phonological awareness, when controlling for visual spatial skills and age. Specifically, music perception predicted a larger amount of standardized unit change in phonological awareness than did the other predictors in the theory. Thus, music perception appears to have a stronger relationship with phonological awareness than age or visual spatial skills.

Further, results showed that a model without music perception as a predictor of phonological awareness was not supported. These findings confirm that music perception plays a unique role in predicting phonological awareness, above and beyond the contribution made by visual spatial skills and age. This study’s results could be used in support of the development of music-based interventions for promoting phonological awareness in five- and six-year-old children.
Acknowledgements

Dr. Shannon K. de l’Etoile, my advisor, her dedication and commitment to this project, have truly allowed this dream to become a reality.

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The students who participated in my study, their parents, teachers, and school principals, without their support, this dissertation would not have been possible.
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Chapter One

Introduction

Statement of the Problem

Early literacy development is an area of focus among educators and researchers, since low levels of literacy are a problem among children and adults in the United States and throughout the world (United Nations Educational, Scientific, and Cultural Organization Institute for Statistics, 2008). One third of American fourth grade children read below the basic level (National Center for Education Statistics, 2011). This critical issue requires enormous resources from local, state, and federal entities. Emergent literacy includes a variety of skills that allow young children to eventually become successful in reading, writing, and other academic tasks. These skills include rhyming, picture naming, sound matching, familiarization with print concepts, and letter knowledge (Bailet, Repper, Piasta, & Murphy, 2009; Katims, 1991; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Roberts, 1992; Snow, 1991; Sulzby & Teale, 1991; van Kleeck, 1990). Children gradually develop these skills during their preschool years before formal instruction occurs.

One important component of emergent literacy is phonological awareness, or the understanding that spoken language can be subdivided into words, syllables, and phonemes (Lane & Pullen, 2004). Phonological awareness is foundational for later skills in decoding words and fluent reading (Ehri, 1989). Music interventions that are specially designed to address phonological awareness may be a way of promoting early literacy.
Music to Promote Early Literacy Development

Many researchers have examined the use of music to promote literacy (Copans-Astrand, 2000; Register, 2001; 2004; Register, Darrow, Standley, & Swedburg, 2007). To summarize these findings, Standley (2008) performed a meta-analysis of 30 studies related to the use of music to teach reading. Overall results showed an effect size of $d = .32$, which is considered to be a moderate, significant effect.

Studies that used music-based interventions specifically designed to promote specific reading skills showed a moderately strong, significant effect ($d = .42$). For example, one study used Orff methodology to teach skills, such as syllable segmentation (Copans-Astrand, 2000). Research has also focused on promoting reading comprehension by setting the text of a story to music (Clouser, 2001). In yet another study, Colwell (1988) used varied music interventions to promote emergent literacy skills, including letter recognition and phonics. Other researchers used movement, singing, and instrument playing to promote letter sound identification and word reading (Register, 2001; 2004). These studies using music to teach reading skills were very diverse in terms of their interventions, type of music stimuli used, and specific literacy target outcomes. Consequently, generalization becomes difficult, in terms of the specific techniques that were used and precisely how the findings could be attributed to the music interventions.

Another difference across studies was the population under investigation, varying from typically-developing children to children with special needs and learners of English as a second language. Furthermore, the age of the samples in the various studies included preschool through middle school. These methodological differences further contribute to the difficulty in generalizing results across studies.
As noted in Standley’s meta-analysis, a body of applied research in the area of using music to promote literacy exists. However, basic research is lacking that specifies exactly how musical experiences promote literacy development. This kind of research is necessary in order to provide a scientific foundation for clinical studies investigating these constructs. Findings from basic research are important because they will provide necessary evidence regarding the relationship between music perception and phonological awareness, and thus, explain why clinical studies using music to promote literacy may be effective. In essence, basic research provides a foundation for the development of specific, evidence-based music techniques to develop phonological awareness skills.

For this study, basic research begins with the understanding of the parallel auditory process that occurs in both music perception and speech perception, as it relates to phonological awareness and early literacy. Children’s music perception and phonological awareness appear to be related, as both processes are based on aural perception and manipulation of auditory stimuli (Anvari, Trainor, Woodside, & Levy, 2002; Bolduc & Montésinos-Gelet, 2005; Bozic, Habe, & Jerman, 2007; Ehri, 1989; Lane & Pullen, 2004; Patel, 2008). For example, both processes involve segmentation of either speech or music sounds into smaller units. Ultimately, speech and music perception both involve the integration of individual stimuli in order to form coherent, auditory Gestalts (Hodges, 1996).

Perception of pitch and rhythm requires the ability to attend to the current musical stimulus and make comparisons with sounds heard previously, as well as to make predictions about subsequent sounds. Thus, pitches and rhythms are perceived, processed,
and interpreted as relative to each other (Hodges, 1996). This ability results in the recognition of musical patterns in a sequence of separate sounds. Speech is also perceived and processed in a series of sounds, within a word, phrase, or sentence (Warren, 1970). Thus, speech sounds are also perceived in relation to one another.

These common perceptual capacities for music perception and phonological awareness point to parallel auditory processing mechanisms (Patel, 2008). Music and speech have common acoustic parameters, consisting of spectral and temporal qualities that are processed by overlapping neural mechanisms (Patel & Peretz, 1997). Specific neuroanatomical structures appear common to the perception of both musical sounds, and speech sounds that are involved in phonological awareness (Kuck, Grossbach, Bangert, & Altenmüller, 2003; Joanisse & Gati, 2003; Poldrack et al., 2001; Tervaniemi et al., 2006; Warrier et al., 2009). One of the reasons for this overlap is that regardless of whether an auditory stimulus is a speech or musical signal, the auditory system perceives rapidly-occurring temporal information or spectral information from either signal in similar ways. Over time, the young child’s skills in perception of speech and music become increasingly refined, showing dramatic improvement during the first five years of life (McPherson, 2006).

Research that is based on the perceptual overlap will be critical for understanding how music might function to influence speech skills, such as phonological awareness. Numerous researchers have explored this relationship using varying methodology (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Bozic et al., 2007). Although a positive relationship appears to exist between children’s music perception and phonological awareness, various methodological issues in previous studies, such as small
sample sizes and the use of measures with low reliabilities, have led to inconclusive answers and more research is warranted.

This current study used structural equation modeling techniques in order to investigate the specific contribution of music perception to phonological awareness while controlling for other contributing factors. This study will address some of the methodological issues from past research by increasing the sample size and using more reliable measures. The use of structural equation modeling will also allow the researcher to examine relationships among several variables simultaneously. Results from this current study intend to provide a foundation for exploring how musical experiences can benefit children in non-musical areas, including language and literacy development (Galliford, 2003; Register, 2001; 2004).

**Need for the Study**

This study will offer both theoretical and practical implications due to its focus on the relationship between music perception and phonological awareness. There is a need for studies that investigate this relationship by isolating the specific effects of music, while taking into account other contributing factors. The use of structural equation modeling (SEM) would allow the researcher to isolate music perception’s specific contribution to phonological awareness. This kind of basic research will provide a foundation for musical interventions to mediate change in specific skills in phonological awareness in young children, thus contributing to emergent literacy.

**Theoretical contributions.** Music processing and phonological awareness share common perceptual mechanisms (Patel, 2008; Thaut, 2005). This study’s findings may advance the understanding of the similarities between these constructs in several ways.
The current study’s results may lead to an increase in knowledge as to the role of music perception in phonological awareness, controlling for other contributing factors, such as developmental influences and non-verbal intelligence. Therefore, this study may show that music perception makes a unique contribution to phonological awareness that is separate from the effects of age, general intelligence, and non-auditory skills. Furthermore, this study’s results may provide a foundation for previous and future studies that recommend the use of musical interventions to promote emergent literacy (Standley, 2008).

**Practical contributions.** If the results support the role of music in predicting phonological awareness, they could benefit a variety of professionals, such as early childhood specialists, elementary teachers, reading specialists, and special educators who work to promote emergent literacy. This investigation’s findings would provide basic research evidence necessary for the development of music-based interventions to promote phonological awareness.

Specifically, music therapists could use this study’s findings to develop music-based interventions to benefit individuals with dyslexia. Some children with dyslexia appear to have difficulty with rapid, temporal processing, or the perception of sounds presented rapidly (Tallal, Miller, & Fitch, 1993). Although these children often do not show difficulty in certain musical skills, such as pitch discrimination, they tend to show deficits in timing skills in music, such as accurately perceiving, copying, and tapping rhythms (Overy, 2003). Difficulties with rhythmic timing perception may be a contributing factor to difficulty with the segmentation of speech into syllables in some children with dyslexia (Goswami, 2001; Overy, 2003). Interventions based on
discrimination of rhythmic patterns could be used in order to foster skills in syllable segmentation.

Another practical contribution of the current study is that it will provide a foundation for future research investigating the effect of music-based interventions to promote emergent literacy, including phonological awareness, in typical children and children at high risk for dyslexia and other reading disabilities. Thus, the overlapping neural mechanisms involved in music perception and phonological awareness would provide future studies with a foundation regarding the effects of specific music therapy interventions.

**Purpose of the Study**

The purpose of this study was to explore the role of music perception in predicting phonological awareness. This research used structural equation modeling (SEM) to examine the contribution of music perception to phonological awareness, controlling for age and visual-spatial skills. SEM techniques allowed the researcher to create latent variables to reduce the effect of measurement error of the observed variables and to account for other contributing factors. Previous research has used primarily bivariate correlations to examine the relationships between the constructs of interest. Such a statistical approach was insufficient because it only yielded information about two observed variables at once. This SEM approach builds upon and strengthens prior research by allowing the researcher to use modeling techniques to examine relationships among multiple variables, specifically the unique contribution of music perception to phonological awareness in five- and six-year-old children, controlling for age and visual-spatial skills.
Chapter Two

Literature Review

For the purpose of this study, research literature related to the role of music perception in predicting phonological awareness in five- and six-year-old children can be divided into four key areas. The first section highlights research related to phonological awareness; defining this construct, examining its developmental sequence, and exploring auditory temporal processing as it relates to phonological awareness. The second section follows a similar analysis for the second construct: music perception, including a discussion of Gestalt perceptual laws. This second section also summarizes parallel auditory processing as it applies to music perception and phonological awareness. Supporting this relationship, the third section presents neuroanatomical structures common to music perception and phonological awareness. The fourth section examines previous studies investigating the relationship between phonological awareness and music perception in five-and-six-year-old children. Thus, the literature review provides a foundation for the theory under investigation regarding the relationship between music perception and phonological awareness in five- and six-year-old children.

Phonological Awareness

Phonological awareness is defined as “children’s knowledge of the internal sound structure of spoken words” (Rayner et al., 2001, p. 37). This construct refers to children’s ability to subdivide spoken language into words, syllables, and phonemes (Lane & Pullen, 2004). Additionally, phonological awareness involves perceiving, manipulating, separating, and blending sounds in speech, and is key to fluent reading and the skilled decoding of words (Anthony & Francis, 2005; Ehri, 1989). Decoding is the process by
which early readers sound out written letters or graphemes in words (Goswami, 2001).

According to Lane and Pullen (2004), this essential skill allows children to establish links between speech and print. This process is difficult for children who lack the perceptual, processing, and cognitive skills required to identify and isolate individual sounds in words and pair sounds with letters. Consequently, performance on phonological awareness tasks is an excellent predictor of later reading success or disability (Morais, Mousty & Kolinsky, 1998).

To demonstrate phonological awareness, a child must be able to perceive, attend to, and discriminate units in a sound stream (Lane & Pullen, 2004). Children must then relate these linguistic components to their spoken vocabulary. Additionally, they must recognize linguistic sound categories in spite of variations in pitch, tempo, speaker, and context (Anvari et al., 2002).

The manipulation of sounds in phonological awareness involves multiple parts. Phonological awareness involves recognizing that a word is made up of particular sounds (Lane & Pullen, 2004). Another component of phonological awareness includes recognizing whether initial, middle, and ending sounds in different words are the same or different from each other. In order to identify and reproduce the beginning or ending sound in a word, a child must perceive the sound, and then compare it to a repertoire of previously learned and practiced sounds (Lane & Pullen, 2004).

As part of phonological awareness, the listener must segment speech into its component sounds (Anvari et al., 2002). Verbal segmentation as it relates to phonological awareness is the ability to isolate the sounds of a word into syllables, onset-rimes, and phonemes (Lamb & Gregory, 1993). An onset consists of any consonants in the
beginning of a syllable, and a rime consists of a vowel and any consonants that follow. For example, “cup” would be divided into ‘c’ (onset) and ‘up’ (rime) (Goswami, 1998). Additionally, a phoneme is the smallest unit of sound that can change the meaning of a word, (i.e., /c/, /u/, /p/) (Goswami, 2001).

Phonological awareness skills involve three related groups of abilities: phonological sensitivity, phonological naming, and phonological memory (Whitehurst & Lonigan, 2001; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993). Phonological sensitivity involves the detection and manipulation of sounds in oral language. Children may identify words that rhyme, blend syllables or phonemes to form words, or count the syllables or phonemes in a word. This skill is important for the later development of decoding, and entails the processing of dynamic, rapidly changing auditory information, such as distinguishing related phonemes from one another (i.e., /p/ and /b/) (Forgeard et al., 2008). Phonological sensitivity is the phonological awareness ability that is most relevant to this study.

Phonological naming involves retrieving phonological information from long-term memory, for example, looking at a page with different-colored squares and quickly identifying the colors verbally (Whitehurst & Lonigan, 2001). Another skill, phonological memory, involves short-term memory of auditory information, for instance, a child’s ability to recall a series of sounds or words. Phonological sensitivity, phonological naming, and phonological memory are essential for emergent decoding of written words.

Researchers assess phonological awareness using tasks in which children must reflect upon or manipulate the linguistic components in spoken language (Goswami,
2001). Some skills that are often assessed in order to evaluate children’s phonological awareness include sound segmentation, or elision; sound addition, also known as sound blending; and sound matching (Yopp, 1992). Additional tasks include correcting speech errors, discriminating words in terms of a different sound, and identifying words that have a common syllable. Furthermore, Gombert (1992) differentiates between phonological awareness tasks involving “epilinguistic” and “metalinguistic” processing. Epilinguistic processing entails a more global recognition of common phonemes or syllables, such as recognizing two rhyming words. Usually, this process does not require conscious awareness. In contrast, metalinguistic processing involves identifying and producing common phonemes or syllables, such as listening to a word and then producing a rhyming word. Metalinguistic processing requires conscious effort.

**Developmental Sequence For Phonological Awareness**

Some phonological awareness skills seem to be acquired informally as children learn to compare and discriminate words that sound similar. For example, rhyming is one of the first phonological skills that children master (Lane & Pullen, 2004). In fact, children can identify words that sound similar or different prior to being able to manipulate sounds in words. Children can also blend sounds to form words before they can segment the same word, that is to say, separate speech into discrete units or phonemes (Anthony & Francis, 2005). Thus, blending, phoneme deletion, and segmentation are increasingly complex skills that children gradually acquire.

As opposed to strict age parameters for the acquisition of phonological awareness, researchers focus on a developmental sequence from pre-school through early primary years, which progresses from perception of larger to smaller units of sounds, such as
words in compound words, to individual phonemes (Anthony & Francis, 2005; Blachman, 1991; Carroll, Snowling, Hulme, & Stevenson, 2003). As children become more skilled at phonological awareness, they are better able to discriminate between and manipulate “small” segments of sounds or phonemes. In this way, their phonemic awareness, or the ability to discriminate and manipulate individual phonemes in words, improves (Goswami, 2001).

During kindergarten, children demonstrate development in phonological awareness. For example, they do well in rhyme-related tasks (Calfee, Chapman & Venezky, 1972; Stanovich, Cunningham, & Cramer, 1984; Yopp, 1988). Some kindergarten children can also divide syllables into onsets and rimes (Treiman & Zukowski, 1991). At this age, deletion tasks can be difficult for children, but some kindergarteners can delete word onsets (Calfee et al., 1972; Dow, 1987). Children of this age still have difficulty detecting, isolating, and manipulating individual phonemes in words (Bowey & Francis, 1991). In summary, kindergarten-age children can do well on phonological awareness tasks that require manipulation of onsets and rimes; however, they show limited awareness and ability to manipulate individual phonemes in words.

According to the “lexical restructuring theory,” (Metsala, 1999) phonological representations become more and more fragmented, distinct, and specific in terms of phonetic characteristics during children’s development. As children’s vocabularies grow, they need to be able to discriminate among a vast number of words which may differ by one phoneme. Thus, vocabulary acquisition promotes phonological awareness because children need to compare and differentiate between similar-sounding words in their
language (Goswami, 2001). The ability to distinguish between these words partly depends on children’s skills in auditory temporal processing.

**Auditory Temporal Processing**

Auditory temporal processing involves the ability to perceive and integrate auditory information that enters the central nervous system in rapid succession, sequentially over time (Tallal et al., 1993; Tallal, Miller, Jenkins, & Merzenich, 1997). Brief, auditory stimuli can occur at a rapid pace, within milliseconds of each other. Thus, auditory temporal processing is sometimes referred to as rapid and brief auditory temporal processing. More specifically, auditory temporal processing requires the ability to process acoustic signals over time and includes the ordering, integration, and resolution of auditory signals (Tallal & Gaab, 2006). This process is involved in human perception of auditory information, whether linguistic or non-linguistic. Consequently, auditory temporal processing influences perception of all aspects of music, speech, and general listening tasks. Children in particular must be able to process auditory information at a rapid pace in order to develop appropriate listening skills necessary for language, and to process non-linguistic sounds (Boets, Wouters, van Wieringen & Ghesquière, 2007).

**Auditory Temporal Processing And Phonological Awareness**

Auditory temporal processing skills appear necessary for children’s development of phonological awareness. Along with the role of the role of auditory temporal processing, it is important to note the role of children’s development of phonological representations in phonological awareness (Rayner et al., 2001). Due to the purpose of this dissertation, the literature review focuses on the role of auditory temporal processing.
In regard to children’s perception of speech, auditory temporal processing involves the detection of rapid acoustical changes in linguistic information (Tallal & Gaab, 2006). Children must be able to detect differences in acoustic stimuli, occurring within tens of milliseconds, in order to discriminate between certain consonants in speech. For example, certain consonant syllables, including /ba/, /da/, /ga/, /ka/, /pa/, and /ta/, have brief frequency envelopes that last only tens of milliseconds. Thus, auditory temporal processing is essential for children’s accuracy of speech perception and their discrimination of similar-sounding consonants and other speech sounds.

To explain further, spoken language consists of two different types of acoustic events: dynamic auditory signals that contain time-varying, temporal cues or brief acoustic events; and steady-state cues, containing spectral components which remain relatively stable (Tallal et al., 1993; Tallal et al., 1997). For example, the syllable [pa] consists of a temporal cue with a rapid temporal component [p] and a spectral cue, consisting of a more stable vowel [a]. As previously mentioned, children’s auditory temporal processing skills are necessary for discrimination between rapidly changing acoustic signals, especially changes occurring within tens of milliseconds. Auditory temporal processing is integral to phonological awareness particularly in the detection, isolation, and manipulation of individual phonemes in words (Tallal et al., 1997). Furthermore, auditory temporal processing is especially important in perceiving temporal cues in speech, particularly discriminating between consonants.

To summarize this first section of the literature review, phonological awareness involves children’s ability to detect and manipulate individual sounds in words. Development of phonological awareness follows a sequence that begins with children’s
ability to recognize larger components of speech such as words, and proceeds to their ability to detect syllables, then individual phonemes. Auditory temporal processing plays an important role in phonological awareness because it is fundamental to children’s ability to perceive rapid acoustical changes in speech stimuli. In an effort to explore whether parallel perceptual processes exist between music perception and phonological awareness, the following section will focus on children’s music perception.

**Music Perception**

An examination of music perception requires a definition of the construct, an examination of Gestalt Laws of perception and how they relate to music perception, and an exploration of children’s development of music perception. Music perception can be defined as the act of perceiving and processing musical sounds that unfold over time (Hodges & Sebald, 2009; Krumhansl, 2000). These sounds can have various components, such as rhythm, pitch, and melody. During the process of music perception, these components are perceived as part of integrated, coherent melodies and harmonies. This ability results from the recognition of patterns in a sequence of separate tones. According to Meyer (1973), the ability to process rhythm, pitch, and melody involves perceiving coherent patterns of tones over time which is what allow humans to perceive music.

Rhythm refers to the temporal or durational qualities of music, including beat, tempo, and meter (Hodges & Sebald, 2009). A steady or isochronous beat offers a framework in which the listener organizes sounds. Tempo is related to how quickly or slowly beats occur (Hodges & Sebald, 2009). Humans can perceive beats starting at 30 beats per minute (BPM) and ranging up to 300 BPM, and can more easily detect a decreasing tempo as opposed to an increasing tempo. Meter is an important
organizational component in music because it organizes sounds into equal or unequal subdivisions over time (Radocy & Boyle, 2003).

Pitch is associated with a tone being perceived as high or low on a continuum (Radocy & Boyle, 2003; Stainsby & Cross, 2009). Frequency or vibrations per second primarily determine pitch; however, pitch is also influenced by other factors, including sound intensity. Melody consists of a succession of musical tones that includes both pitch and rhythm (Radocy & Boyle, 2003; Schmuckler, 2009). Melodic perception requires the integration of both pitch and durational qualities as they interact with each other.

Human beings appear to be “wired” to perceive musical elements, such as rhythm, pitch, and melody in meaningful ways (Flohr & Hodges, 2002). Studies investigating children’s music perception are of particular importance in terms of understanding early musical and brain development. By studying children and adults, researchers can investigate how perceptual processes change with age, musical exposure, or training.

Researchers investigating the development of children’s skills in regard to pitch, rhythm, and melody, examine not only perception, but also a variety of other skills, such as the ability to reproduce, improvise, and notate musical patterns (Deliege & Sloboda, 1995). Assessment of music perception in particular often involves engaging children in making comparisons about a series of tones (Colwell, 1965; Gordon, 1986; Knuth, 1967; Mills, 1988; Seashore, Lewis, & Saetveit, 1939; Simons, 1976; Stevens, 1987). For example, children listen to two series of musical sounds, whether rhythm patterns, pitch patterns, or melodies; and then make comparisons as to whether the two series are the same or different.
In addition to simply assessing perceptual processes, the previously mentioned tests have also been used to measure music aptitude, meaning to predict children’s future musical ability, or to examine children’s musical achievement. Little published research exists that specifically investigates five- and six-year old children’s music perception skills. More research is warranted in this area in order to further clarify the development of perceptual processes and to support a relation between music perception and phonological awareness.

**Gestalt Perception**

An understanding of the definition of music perception and how it is assessed, provide the foundation for an examination of Gestalt perceptual principles. In the early 1900s, German psychologists including Wolfgang Köhler, Kurt Koffka, and Max Wertheimer, established ground-breaking principles that have been influential in the field of perception and cognitive organization (Hodges & Sebald, 2009; Koffka, 1935). Gestalt perception explains how the brain combines stimulus elements that are perceived simultaneously and in succession to form a coherent, perceptual structure or a “whole” unit (Krumhansl, 1990; Neuhaus & Knösche, 2006). These principles also pertain to figure-ground relationships, or the ability to focus on certain features of the perceptual “whole,” while other elements fade into the background (Lipscomb, 1996). Perception of a “whole” stimulus depends on the ability to detect relationships among the distinct elements (Radocy & Boyle, 2003). Gestalt theorists indicate that elements of a stimulus should not be studied in isolation from their context, the “whole,” because doing so would lead to a loss of significance and meaning of the elements.
Gestalt Laws help to explain how perception of a whole musical pattern affects the listener’s ability to perceive, organize, comprehend, and recall musical information (Krumhansl, 1990; Radocy & Boyle, 2003). When perceiving and processing music, listeners do not typically hear individual, isolated sounds (Krumhansl, 1990). Rather, they use metric, rhythmic, melodic, and harmonic qualities to process and organize sound sequences into coherent, relevant patterns. Humans perceive individual auditory events as part of a larger pitch and rhythmic structure, as smaller units are grouped into larger and larger units in hierarchichal structures (Krumhansl, 2000; Radocy & Boyle, 2003). The perception of auditory patterns is important because it allows the listener to anticipate what will happen next musically (Hodges & Sebald, 2009). Another benefit of grouping elements according to Gestalt perceptual principles is that new information can be more easily comprehended and remembered.

In Gestalt perception, the relationships between musical elements are fundamental to the recognition of the “whole,” or the “Gestalt.” For example, humans recognize a melody, or a series of pitches, even when it is transposed to a different key (Hodges, 1996; Krumhansl, 1990). How this happens is one question that Gestalt Laws of perception seek to explain. The answer appears to rest in the fact that perceptually, a melody is more than just pitches. The intervals or relationships between the tones remain the same in a transposed melody. Thus, the intervals or relationships between the notes are more important than the exact notes themselves. In this way, a recognition of the Gestalt helps to give coherence and unity to the pitches that form a recognizable melody. Other factors may contribute to the recognition of the Gestalt, including rhythm or timbre, which may be maintained in spite of the transposition of the pitches.
A number of Gestalt Laws lead to grouping and organization in music perception (Hodges, 1996; Krumhansl, 1990; Radocy & Boyle, 2003). The law of proximity indicates that stimulus elements that are close together tend to be grouped with one another. In terms of music, tones presented close in time are usually grouped together. Additionally, proximity applies to pitch relationships and the distance between pitches. In Western tonal music, melodies are mostly comprised of intervals of a third or smaller (Hodges & Sebald, 2009).

Two other Gestalt laws include the law of similarity and the law of common direction (Hodges, 1996). The law of similarity refers to the organization of stimulus elements that have similar features. Humans tend to group similar-sounding musical elements into perceptual wholes. Musical tones may be alike in terms of timbre, pitch or frequency, and melodic contour, thus promoting the perception of separate tones as part of a larger whole (Radocy & Boyle, 2003). The law of common direction refers to the grouping of stimulus elements that have the same movement trajectory. In music, tones moving in a common direction, whether descending or ascending, are usually grouped together (Krumhansl, 1990).

The Gestalt Law of Prägnanz, also known as the law of simplicity, indicates that through perceptual and memory processes, humans seek to organize information in the simplest way possible (Krumhansl, 1990). This law can apply to pitch, rhythm, and melody, among other musical elements. For example, simple and repetitive patterns increase the likelihood of notes being grouped together.

Finally, the law of closure explains the perceptual tendency to complete an unfinished pattern. An application of the law of closure to music involves the tendency to
resolve cadences or leading tones (Hodges, 1996; Lipscomb, 1996; Radocy & Boyle, 2003). For example, when hearing an ascending scale, such as “do, re, mi, fa, so, la, ti” one would naturally expect to next hear “do,” the eighth scale degree. In conclusion, Gestalt laws allow the listener to organize sounds into coherent structures that are recognized as music. Furthermore, listeners tend to perceive the whole before identifying smaller units that constitute the whole.

**Gestalt Perception and Pitch**

Perception of pitch is influenced by Gestalt principles (i.e., how tones relate to one another). One aspect of music that influences these relationships is tonality. A sense of tonality is important for the perception of auditory Gestalts of pitch. Krumhansl (1990) refers to tonality as a Gestaltqualität, or property of the whole. This quality, tonality, has an effect on the perception of pitch, particularly because the role or function of a specific tone relative to other tones in a key affects human perception of pitches and their relationships (Cuddy, 1991; Krumhansl, 1990; Thomson, 1999). Thus, perception of pitch depends upon the tonal context in which tones are heard (Marmel, Tillman, & Dowling, 2008). This context is conducive to a sense of hierarchy among tones which affects human perception of the psychological distance or relatedness of certain tones (Krumhansl, 1990). Tonal stability depends on the tonal context in which humans encounter particular tones. Thus, listeners recognize certain tones more accurately and perceive them as better-fitting in a particular tonal context.

Typically, a musical “key” consists of seven notes that are arranged into a scale (Hodges, 1996). These notes are considered diatonic, meaning they are consonant with one another and help to form the harmonies that establish the key. In other words,
diatonic tones seem to “belong together.” Each diatonic note has a role or function in that key. Diatonic notes show different levels of tonal stability depending on the hierarchichal nature of the tones. For example, in any particular key, the first and fifth scale degree, the tonic and dominant, are the most stable tones. The leading tone or seventh note of the scale is considered highly unstable and perceptually leads to the tonic. At the same time, non-diatonic notes, or musical notes that are not one of the seven pitches in the diatonic scale, are dissonant and less stable than diatonic tones (Krumhansl, 1990).

In order to explain pitch perception within a tonal context, Krumhansl (1990) presents three principles that illustrate how tonality has an effect on the way tones are perceived as relative to each other, including contextual identity, contextual distance, and contextual asymmetry. Contextual identity, or self-similarity, refers to the perceived psychological distance between two instances of the same tone. Humans can perceive the repetition of a particular tone more accurately and identify that the tones are identical when tones are more stable in a context (i.e., consonant and diatonic) than when tones are less stable (i.e., dissonant and non-diatonic). Greater tonal stability of a particular note within a given context leads to improved recognition and memorization. For example, listeners can recognize and remember diatonic tones more easily than non-diatonic tones.

The second principle, contextual distance, involves the perceived psychological distance between two different tones. The tonal stability of the two tones affects the perception of contextual distance. More specifically, two tones will be heard as more closely related when they are perceived as more stable or consonant within the tonal hierarchy. On the contrary, tones that are less stable or show greater dissonance within the tonal hierarchy will appear to be less closely related to one another. Humans perceive
two diatonic tones to be more closely related than a diatonic and a non-diatonic tone (Krumhansl, 1990).

The final principle, contextual asymmetry, refers to the perceived distance, or difference, between two different tones depending on the order in which they are presented. The perceived psychological distance between the tones depends on the different roles that the tones may have within a key, as well as temporal order. Humans have a preference for an order of tones that ends on the more stable tone (Krumhansl, 1990). For example, in a given key, the seventh tone typically resolves to the tonic or first scale degree. Humans perceive the tones in a pattern where the seventh tone is followed by the first tone as more closely related than a pattern where the first scale degree is followed by the seventh scale degree. This difference is due to a preference for patterns ending on a more stable tone.

In summary, humans do not perceive musical pitches in isolation; instead, sounds are processed in a tonal context. That is, tones are interpreted in relation to each other, such that in a given context, they have particular functions and roles in respect to each other. As will be presented in the following section, Gestalt Laws of music perception are also evident in the perception of temporal aspects of music.

**Perception of Temporal Aspects in Music**

To further explore children’s music perception, the next section examines temporal processing as it relates to perception of pitch, rhythm, and melody. Drake and Bertrand (2003) postulate the existence of five temporal processing principles that are present across age groups and levels of musical experience. The first principle states that
humans show a tendency to group similar-sounding events or events that occur close in time, thus exemplifying the Gestalt Laws of Proximity and Similarity.

In relation to this first principle, researchers have studied sensitivity to musical phrase endings as an indicator of temporal segmentation to understand how people perceive the ending of one auditory Gestalt and the beginning of the next (Krumhansl, 2000; Krumhansl & Jusczyk, 1990). Bertrand (1999) studied segmentation in 4- to 12-year-old children with and without musical training. Results showed that children as young as four years old segmented tonal sequences according to musical elements, such as pitch change and pause duration. Participants also segmented an auditory sequence after a longer note, a pause, or a large pitch difference. Children showed a small improvement with age and musical training, but their progress may be due to possessing better skills related to the task, such as improved ability to sustain attention.

The second temporal processing principle presented by Drake and Bertrand (2003) involves a predisposition towards regular sequences, meaning sequences with a steady beat and tempo regularity. Humans do not encode precise durations of individual sounds. Instead, they compare the duration of a sound as it relates to other preceding sounds through relative processing. Thus, auditory stimuli are coded as being the same or different and longer or shorter than each other.

In a study investigating the effect of rhythmic regularity on temporal processing, Drake and Gerard (1989) tested five- and seven-year-old children using regular and irregular rhythmic reproduction tasks. Participants showed non-significantly better performance at reproducing regular rhythms than irregular ones. Drake, Jones, and Baruch (2000) have also examined the effect of temporal regularity by examining
listeners’ ability to discriminate small differences in tempo and to reproduce rhythms. Results indicated that four-year-old children could detect small tempo changes during rhythmic sequences with a steady beat, but showed difficulty during irregular sequences lacking a steady pulse.

The third principle states that humans actively seek regularity in temporal sequences (Drake & Bertrand, 2003). Listeners show a predisposition toward finding a regular beat or pulse in a given piece of music. Thus, the pulse serves as a framework to organize the musical events in time. Children prefer simple meters with beats that are isochronous, or have equal durations between beats. Four- to six-year-old children can tap in synchrony with the underlying beat of a piece of classical music which shows their ability to detect and synchronize a movement to a musical pulse (Drake et al., 2000).

A fourth principle in auditory temporal processing involves the rate at which temporal information is processed (Drake & Bertrand, 2003). Humans, from birth through adulthood, show maximum sensitivity to temporal changes when beats are 600 ms apart (Baruch & Drake, 1997). The zone of optimal processing for temporal information ranges from 300 to 800 ms interonset interval (IOI), that is, adults show greater sensitivity to tempo changes or temporal irregularities if beats are 300 to 800 ms apart (Drake & Bertrand, 2003). Children between four and ten years of age showed the same zone of optimal temporal processing, centered at 600 ms. When compared to four-year-old children, ten-year-old children demonstrated a wider range of sensitivity for beats occurring at a slower or faster rate than every 600 ms. By age ten, children showed the same zone of optimal processing as adults, ranging from 300 to 800 ms (Drake et al., 2000).
The fifth and last auditory temporal processing principle revolves around the human predisposition towards perceiving durations of sounds in simple ratios of two to one (Drake & Bertrand, 2003). Listeners tend to perceive sounds as being twice as long or twice as short as preceding sounds (Clarke, 1987; Parncutt, 1994). This principle leads to binary ratios being more predominant than ternary or more complex ratios. Five-year-old children show the ability to discriminate and reproduce short rhythms based on 2:1 ratios, but not 3:1 ratios (Drake, 1993a; 1993b). When asked to reproduce rhythms with complex ratios, five- and seven-year-old children tend to make errors due to a tendency to simplify rhythms into 2:1 ratios (Drake & Gerard, 1989).

In summary, children perceive musical sounds as relative to each other in terms of sound duration. Sounds are interpreted in a temporal context when they are organized around a steady beat and demonstrate tempo regularity. The following section will examine children’s development of music perception skills.

**Development of the Perception of Pitch, Rhythm, and Melody**

Extant research shows that children’s development of the perception of pitch, rhythm, and melody improves with age, and their enculturation for these musical elements happens slowly during the preschool years (Gembris, 2006; Hargreaves, 1986; Lamb & Gregory, 1993; Radocy & Boyle, 2003; Schellenberg & Trehub, 1996; Trehub, 2006; 2008). However, development of music perception in young children remains largely unexplored. Therefore, there is little research to present.

Existent research points to the fact that children are able to process global elements in pitch and rhythm (i.e., the “whole”) prior to perceiving local elements (i.e., smaller units that constitute the “whole”) (Deruelle, Schön, Rondan, & Mancini, 2005).
In terms of pitch perception, four-, five-, and six-year-old children are first aware of the overall direction of the melody or melodic contour and gradually become more aware of discrete pitches and pitch relationships (Lamont & Cross, 1994; Ramsey, 1983; Schellenberg & Trehub, 1996; Sergeant & Roche, 1973). Additionally, five- and six-year-old children can perceive direction in descending and ascending pitch patterns, but show difficulty in verbally labeling this direction (Trehub, 1993).

Assessment of the development of rhythm perception typically involves measuring children’s ability to keep the beat or their ability to repeat or perform specific rhythmic patterns (Gembris, 2006; Radocy & Boyle, 2003). Five- and six-year-old children’s ability to detect and maintain the underlying beat to music improves over time. By age seven, children slowly develop the ability to keep a steady beat because they are able to extract the pulse from the surface rhythm (Hodges & Sebald, 2009).

Five- and six-year-old children also acquire skills in melodic perception, for example, they show an awareness that melodies consist of a series of pitches of varying durations that are repeated in patterns (Sloboda, 1985). Children appear to undergo a critical period, at about age five or six, for the development of melodic discrimination which includes the perception of pitch and rhythm interacting with each other (Radocy & Boyle, 2003). Melodic discrimination allows five- and six-year-old children to recognize songs that they are exposed to, such as “Twinkle, Twinkle, Little Star,” “The Eensy Weensy Spider,” and “Old MacDonald Had a Farm” (Hodges & Sebald, 2009).

To summarize, the development of music perception in five- and six-year-old children requires exploration since little research has explored this topic. Children’s development of music perception proceeds from global to local perception. In other
words, children first demonstrate awareness of melodic contour. They increasingly develop more refined skills of detecting and discriminating specific pitch and rhythmic elements. The next section will present the perceptual parallel between phonological awareness and music perception.

**Conclusions Regarding the Perceptual Parallel between Phonological Awareness and Music Perception**

A comparative analysis of the perceptual processes in phonological awareness and music perception is fundamental to exploring the contribution of music perception to phonological awareness in five- and six-year-old children. As the preceding review of literature demonstrates, phonological awareness and music perception seem to involve parallel auditory perception processes.

Children perceive both speech and musical signals temporally or over time. In the case of phonological awareness, speech perception requires the use of auditory temporal processing, which allows children to process and discriminate speech sounds. More specifically, auditory temporal processing is key to children’s discrimination of similar-sounding consonants, an essential skill for phonological awareness. Similar to the perception of speech, musical sounds are also perceived temporally. During this temporal process, Gestalt laws explain the perception of rhythm, pitch, and melody. These laws are fundamental for perceiving coherent musical patterns from which individual musical elements are eventually recognized. Therefore, both speech and music consist of auditory elements that unfold over time. The meaning of each element is derived from perception of previous sound units, which then allows the listener to predict what is likely to come next.
The perceptual parallel between phonological awareness and music perception is further strengthened by a parallel developmental progression. These two constructs appear to share a parallel auditory developmental sequence that begins with perception of the “whole,” or global perception. Via age and experience, children gradually acquire the ability to perceive the smaller units that constitute the “whole,” or local perception. In the case of phonological awareness, children are initially able to perceive words and syllables. Gradually, they are able to differentiate and manipulate smaller speech units, such as rimes, onsets, and phonemes. In the case of music perception, younger children are initially able to detect the overall melodic contour of a musical phrase. With time, they are able to perceive smaller musical units, for example, the difference between two pitches. Consequently, similar perceptual skills may be used in the detection of speech and musical sounds. This perceptual overlap in development partially justifies an exploration of the role of music perception in phonological awareness.

The next area of the comparative analysis that will be examined is based on neuroanatomical structures that are involved in both phonological awareness and music perception. This review will be helpful in that the neuroanatomical functioning will provide further justification for a study of the contribution of music perception to phonological awareness, since parallel neurological functioning would further strengthen a relationship between the two constructs.

**Neuroanatomy of Phonological Awareness and Music Perception**

A parallel process between phonological awareness and music perception is apparent when studying the relevant neuroanatomical structures and their functions (Peretz & Zatorre, 2005; Zatorre, Belin, & Penhune, 2002). Perception of both music and
speech involves hemispheric differences in terms of processing specific aspects of sounds. Two parallel and complementary systems seem to exist, one in the left hemisphere that is specialized for rapid temporal processing, and the other in the right hemisphere that is specialized for fine spectral processing (Schönwiesner, Rübsamen, & von Cramon, 2005; Zatorre & Belin, 2001; Zatorre et al., 2002). To explain further, certain neural structures primarily in the right hemisphere are critical in the perception of pitch and in the perception of specific aspects of speech, such as prosody (Platel et al., 1997). Other structures primarily in the left hemisphere are integral in processing rhythm in music and particular aspects of speech, including rhyme judgments and phonemic discrimination (Zatorre & Schönwiesner, 2011). Thus, neuroanatomical functions, particularly hemispheric specialization, contribute to the perceptual parallel between phonological awareness and music perception.

More specific to the current study, researchers have studied neuronal activity during melodic and rhythmic processing in young children using functional magnetic resonance imaging (fMRI) (Overy et. al, 2004). Results showed activation of the left and right superior temporal gyrus (STG) during both melody and rhythm processing. Findings also demonstrated that like adults, six-year-old children exhibit a degree of hemispheric specialization for processing rhythm and melody. For the children, a region in the right STG, anterior and inferior to the primary auditory cortex, showed a statistically significantly higher activation during the processing of melody than rhythm. However, children did not show significantly greater activation of either hemisphere in the rhythm processing tasks. Thus, in this study, children demonstrated hemispheric dominance, but to a lesser degree than adults. The findings imply that hemispheric specialization may
develop with age and experience. Further research will show whether hemispheric differences for rhythm and melody emerge simply due to musical enculturation, or are dependent upon musical training.

Some other researchers have specifically investigated differential neural activation in the processing of temporal or spectral qualities of both speech and music (Joanisse & Gati, 2003; Schönwiesner, Rübsamen, & von Cramon; 2005). This research shows that regardless of whether sounds consist of speech or music, the brain processes auditory events similarly, based on temporal or spectral qualities of the signal. Therefore, these studies are critical to establishing a neuroanatomical parallel between phonological awareness and music perception.

Joanisse and Gati (2003) studied brain regions involved in the processing of rapid temporal auditory information in both speech and tonal sequences. Functional magnetic resonance imaging (fMRI) was used while participants discriminated between pairs of speech syllables or sinewave tones that varied spectrally or temporally. Results showed that overlapping neural systems seem to process the temporal characteristics of both speech and musical information, especially rapid temporal characteristics of both speech and tonal sequences (Joanisse & Gati, 2003). These neural systems include the posterior portion of the left and right superior temporal gyrus (STG) and superior temporal sulcus (STS), as well as the left inferior frontal gyrus (IFG) (Broca’s Area). A posterior region of the left superior temporal gyrus in particular appears to be sensitive to rapidly-changing auditory events, such as consonants in speech and “tone sweeps,” or tones that began or ended with a slight rise or fall in pitch.
During conditions involving spectral discrimination of speech and tones, such as perception of vowels or an unchanging steady tone, decreased activation was evident in these same neuroanatomical areas. By contrast, a parallel area in the right superior temporal gyrus showed greater activation for signals containing more steady-state events, such as vowels and tones with steady frequencies.

These findings support the theory of two parallel neural substrates involved in perceiving both speech and tones: one that is critically involved in processing rapidly-changing, temporal information, and another that processes spectral information. The temporal substrate is located in the bilateral STG and STS, and the left IFG. A parallel structure specialized for processing spectral information is located in the right STG, with decreased activation in the left STG and IFG, and bilateral STS (Joanisse & Gati, 2003).

Schönwiesner, Rübsamen, and von Cramon (2005) also investigated neural activation during spectral and temporal processing using fMRI. The authors used a noise-like sound stimulus that had characteristics of both speech and music, allowing for isolation and change of spectral and temporal components of the signal. The left and right Heschl’s gyrus (HG), or auditory cortex, showed activation during changes in spectral complexity of the signal, whereas the left superior temporal gyrus (STG) showed activation during changes in temporal complexity. The corresponding STG region in the right hemisphere showed a response only during increases in spectral complexity. Results point to the fact that hemispheric specialization is not due to whether a stimulus consists of speech or music, instead, it is a result of the processing of acoustic characteristics of the signal, particularly rapid-temporal and spectral components.
To summarize, parallel neuroanatomical structures appear common to the perception of both musical sounds, as well as speech sounds that are involved in phonological awareness. One of the reasons for this overlap is that regardless of whether an auditory stimulus is a speech or musical signal, these stimuli have common acoustical characteristics, including spectral and temporal qualities. Within each hemisphere, parallel neural networks process temporal or spectral aspects of speech and music, for example, both the left and right STG were involved in temporal processing, while an area in the right STG was involved in spectral processing. Bilateral structures, such as the STG and STS and the left IFG, show greater activation during temporal tasks, but decreased activation during spectral tasks.

In essence, the auditory system perceives rapid, temporal information or spectral information from either signal in parallel brain areas and pathways. These findings, in combination with the overlap in perceptual processing and perceptual development, provide a foundation for moving forward with the examination of the role of music perception in phonological awareness.

**The Relationship between Phonological Awareness and Music Perception**

The next part of investigating the relationship between music perception and phonological awareness involves the examination of previous studies that have also explored these same constructs. A number of researchers have considered the relationship between music perception and phonological awareness in children approximately four to six years old. In terms of musical components, researchers investigated relationships between phonological awareness and a variety of musical elements, including pitch, timbre discrimination, beat competency, rhythm perception, and rhythm production
(Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Bozic et al., 2007; David, Wade-Woolley, Kirby, & Smithrim, 2007; Forgeard et al., 2008; Lamb & Gregory, 1993; Moritz, 2007; Peynircioglu, Durgunoglu, & Oney-Kusefoglu, 2002; Rubinson, 2009).

The studies cited previously have also focused on diverse aspects of phonological awareness, such as rhyming, elision, and blending. Therefore, it is difficult to draw conclusions across studies about the relationships between specific components of phonological awareness and perception of pitch, rhythm, or melody.

**Phonological awareness and pitch and timbre perception.** Lamb and Gregory (1993) studied the relationships among pitch and timbre discrimination, phonological awareness, and reading. Participants were four-and-a-half- to five-and-a-half-year-old children (n=18) who were tested using an experimenter-designed pitch and timbre discrimination measure. In terms of phonological awareness, the researchers measured the children’s ability to match and differentiate first and last sounds in words. Researchers also used the Raven’s Coloured Progressive Matrices (1956) to assess general non-verbal ability.

Findings indicated that non-verbal ability and age did not correlate with the other variables, however, some relationships approached significance. Thus, researchers used partial correlations to remove the effects of age and non-verbal ability. Results showed a significantly positive correlation between sound matching and discrimination of first and last sounds in words and pitch awareness. Timbre discrimination showed no relationship with phonological skills. The authors did not examine the relationships between rhythm discrimination and phonological awareness.
This study’s results indicated that pitch perception appears to be related to the perception of small differences in phonemes. Both processes appear to require children to perceive differences in frequency. The researchers conclude by suggesting that music awareness predicts phonological awareness and reading, thus music education should be part of the elementary curriculum.

In a more recent study, Loui, Kroog, Zuk, Winner, and Schlaug (2011) also examined the relationship between phonological awareness and pitch perception and production in seven- through nine-year-old children (N=32). In order to test phonemic awareness, they used the Sound Categorization Test (Bradley & Bryant, 1985) and the Auditory Analysis Test (Rosner & Simon, 1971). During the Pitch Perception and Production Test (Loui, Guenther, Mathys, & Schlaug, 2008), participants were asked to hum a series of tone pairs and to identify whether the second tone in the pair was lower or higher than the first.

Pitch perception and pitch production were examined as individual variables. Additionally, researchers were interested in the level of consistency between a child’s pitch perception and pitch production skills. In previous research, adults with low levels of consistency between these two skill areas typically demonstrate tone-deafness. Based on the level of agreement between children’s perception and production abilities, the researchers calculated a score for each child, indicating consistency of pitch perception-production. Other variables were also assessed, including non-verbal intelligence via the Kaufman Brief Intelligence Test (Kaufman & Kaufman, 1990). Demographic data including children’s age, years of musical training, and socio-economic status (SES) were also collected.
Loui et al., (2011) found significantly positive correlations among consistency of pitch perception-production, phonemic awareness, non-verbal intelligence, and age. When taking into account only pitch perception or pitch production as individual variables, correlations with phonemic awareness were not significant. Partial correlations showed a significantly positive correlation between consistency of pitch perception-production and phonemic awareness, while controlling for non-verbal intelligence, age, SES, and music training. One limitation of this study is that results only showed significantly positive correlations between phonological awareness and the consistency of pitch perception and production, as opposed to children’s actual scores in pitch perception or production.

**Phonological awareness and rhythm perception and production.** David, Wade-Woolley, Kirby, and Smithrim (2007) performed a longitudinal study of the relationship between rhythm production (i.e., beat competency), phonological awareness, and reading development. In order to assess rhythm production ability at the beginning of the study, the researchers used the Rhythmic Competency Analysis Test (Weikart, 1989). The six-year-old participants (N=53) tapped the beat with their hands and walked to the beat (Weikart, 1989). During the initial testing phase, the researchers also tested the children’s phonological awareness using a variety of measures, including Sound Oddity (Bradley & Bryant, 1983), Blending Phonemes, Blending Onset and Rime, Phoneme Elision, and Sound Isolation (Wagner et al., 1993).

Results showed that children’s scores on the phonological awareness subtests correlated with one another. Therefore, the researchers combined the sub-test scores into a phonological awareness composite. Beat production showed a significantly positive
correlation with phonological awareness at age six. Results also showed that after controlling for phonological awareness, beat competency was a significant predictor of reading at age ten. David et al. (2007) conclude that the overlap between phonological awareness and music perception may possibly be due to skills in blending and segmenting sounds and in temporal sequencing.

In a second study examining the relationship between phonological awareness and rhythm perception and production skills in young children, Moritz (2007) tested kindergarten-age children (N=30) at the beginning and end of the school year. The researcher studied various components of phonological awareness, including segmentation of syllables, rhyming discrimination, and isolation of medial phonemes, using the Phonological Awareness Test (Robertson & Salter, 1997). In order to assess tempo production, rhythm pattern production, and rhythm pattern discrimination, Moritz used an adapted version of the Music Aptitude Test (Overy, Nicolson, Fawcett, & Clarke, 2003). The researchers also measured non-verbal intelligence using the Kaufman Brief Intelligence Test (K-BIT, Kaufman & Kaufman, 1990). An experimental group received daily Kodály music lessons for the entire school year, while the control group received weekly music lessons that were not based on Kodály.

Moritz used partial correlations to control for non-verbal intelligence based on K-BIT scores. Data showed a significantly positive relationship between rhythm production abilities and segmentation of syllables, as well as the phonological awareness composite, for all children at the beginning of the school year.

At the end of the school year, results showed differences between children who received weekly or daily music lessons in regard to the relationships between
phonological awareness and rhythmic skills. Children who received only weekly music lessons showed a statistically significant positive correlation between rhyming discrimination and rhythm discrimination; all other correlations were non-significant. By contrast, children who received daily Kodály lessons showed significantly positive correlations between rhythm pattern production and two phonological awareness skills: rhyming discrimination and isolation of medial phonemes. Based on results from children receiving daily Kodály lessons, the author suggests that activities involving production of rhythm patterns or songs with rhyming lyrics could be used to bolster phonological awareness skills (Moritz, 2007).

In summary, findings from both David et al. (2007) and Moritz (2007) suggest that rhythm perception and production are significantly related to certain aspects of phonological awareness. Specifically, rhythm production (i.e., beat competency) showed a consistently positive relationship to phonological awareness. However, results regarding the relationship between rhythm pattern perception and phonological awareness were inconclusive and warrant further investigation.

**Phonological awareness and both pitch and rhythm perception.** Other researchers have examined the relationship between phonological awareness and both pitch and rhythm perception. In one study, researchers investigated specific relationships between phonological awareness and music perception and production in four- to six-year-old American and Turkish children (Peynircioglu et al., 2002). The researchers were also interested in the interaction and differences between the constructs being studied and the language spoken, whether English or Turkish. They tested the children’s ability to perform phoneme and tone deletion tasks. For the phoneme deletion task, the researchers
used a series of words and pseudo-words in the children’s primary language. In the tone deletion task, short melodies were presented. In both cases, the children responded by speaking or singing the word or melody presented, minus the indicated sound. By using this particular music task, tone deletion, the authors used a task that more closely resembled the phonological awareness task than in studies that have been reviewed so far in this chapter.

The participants were tested using an experimenter-designed music aptitude test. The children listened to and reproduced melodic and rhythmic patterns. Based on the participants’ performance on this test, two judges rated each child as having, low, medium, or high music aptitude. Only the data from children in the low and high music aptitude groups were used. Children with high music aptitude obtained significantly higher scores on the phonological awareness measures than did children with low music aptitude. Phonological awareness differences between the Turkish and American participants also emerged. More specifically, deletion of the first and last tone correlated significantly with phonological awareness in the English-speaking children. However, only deletion of the last tone correlated significantly with phonological awareness in Turkish-speaking children. The researchers attribute these differences to linguistic characteristics of the participant’s primary language.

Peynircioglu et al. (2002) hypothesized that phonemic awareness and tonal processing might both involve similar skills in sound discrimination, temporal sequencing, attention, and working memory. Through exposure to speech and musical experiences, children practice and develop auditory skills, such as analyzing auditory
patterns, which may also contribute to the overlap among music perception, speech perception, and phonological awareness.

In another investigation, Bolduc and Montésinos-Gelet (2005) studied relationships between phonological awareness and music perception in kindergarten-age students. The researchers tested only 13, five-year-old children using the pitch and rhythm subtests of the Primary Measures of Music Audiation (PMMA; Gordon, 1986). They also tested Canadian children using a phonological awareness test in French, “L’épreuve de metaphonologie” (Armand & Montésinos-Gelet, 2001). Results showed a significant relationship between pitch awareness and the phonological awareness composite score; no relationship emerged between rhythm perception and phonological awareness skills.

Bolduc and Montésinos-Gelet (2005) conclude that their results provide evidence that rhythm and pitch perception are different perceptual processes. They support this claim by indicating that children who had low scores on pitch perception and phonological awareness usually had average or above average scores on rhythm perception. They also hypothesize that part of the overlap between phonological awareness and pitch processing might be skills related to segmentation of the auditory stream. The authors encourage experimental studies to verify the effect of musical training on phonological awareness. If results show a causality, then music education should be included as part of the school curriculum.

Finding contrasting results, Forgeard et al. (2008) also studied music and phonological processing in 44, six-year-old children. Thirty-two of the children had received instrumental music lessons, while twelve had not received lessons. The
researchers used the Primary Measures of Music Audiation (PMMA; Gordon, 1986) as well as a researcher-designed pitch and rhythm discrimination task to measure music perception, and also used the Auditory Analysis Test (Rosner & Simon, 1971) to evaluate phonological awareness. Results showed that children’s phonemic awareness was significantly and positively correlated with both pitch and rhythm discrimination. Data showed non-significantly stronger relationships in children who had received music lessons as opposed to the control group. Forgeard et al. suggest that musical interventions designed to develop pitch and rhythm perception should also develop linguistic skills, auditory processing, phonological awareness, and reading abilities in children with dyslexia (Forgeard et al., 2008).

More recently, Rubinson (2009) also investigated the correlation between music aptitude and phonological awareness in 62 kindergarten-age children. Participants’ skills in these two areas were tested using the Primary Measures of Music Audiation (PMMA; Gordon, 1986) and the Dynamic Indicators of Basic Early Literacy Skills (Good & Kaminski, 2007). Results showed significantly positive correlations between music aptitude, tested using the PMMA, and phonological awareness, specifically initial sound fluency, or the ability to identify the initial sound in a word, and phonemic segmentation fluency, or the ability to divide a word into phonemes. However, tonal aptitude and the composite music aptitude showed non-significantly higher correlations with phonological awareness than rhythmic aptitude. Regression analysis indicated that both music perception and SES were significant predictors of phonological awareness.

In a related study, Bozic, Habe, and Jerman (2007) also studied the relationship between pitch and rhythmic perception and phonological awareness in 67 Slovene five-
to six-year-old children. The researchers used the Primary Measures of Music Audiation and Intermediate Measures of Music Audiation (PMMA & IMMA; Gordon, 1986) and a Slovenian Test of Phonological Awareness. Results showed a significantly positive relationship between perception of pitch and rhythm, and phonological awareness. More specifically, the authors indicate that pitch perception was highly related to matching of first and last phoneme, while rhythm perception was highly related to phoneme blending.

Studying English speakers, Anvari, Trainor, Woodside, and Levy (2002) also tested the linguistic and musical skills of 100, four- and five-year-old children. The authors administered an experimenter-constructed music test assessing discrimination of pitch, rhythm, and harmony, and rhythmic production. They also used an experimenter-constructed phonemic awareness test measuring rhyme generation, oddity discrimination, and phoneme blending, and the Rosner Test of Auditory Analysis Skills (Rosner, 1979) to assess the ability to segment sounds in speech. Additionally, researchers tested math, digit span (auditory memory), and vocabulary, exploring the role of phonological awareness, auditory memory, vocabulary, and math skill in the relationship between music and reading. The researchers also took age into account by exploring differences between four- and five-year-old children.

For data analysis, Anvari et al., (2002) used ordered regression analysis to examine the link between music and reading. Thus, although Anvari and researchers explored relationships among music perception, phonological awareness, and other factors previously mentioned, they were ultimately interested in whether music perception could predict reading, while accounting for phonological awareness and other non-musical variables.
Differences emerged when comparing the four-year-old participants (N=50) and the five-year-old participants (N=50). Pitch and rhythm skills were significantly positively correlated with one another in four-year-old children, indicating that separate pitch and rhythm skills have not yet emerged at this age. However, five-year-old children showed distinct pitch and rhythm skills, (i.e., they were not correlated), indicating different representations of these two musical skills by this age. Results showed that the four-year-old children’s musical skills, pitch and rhythm together, were significantly positively related to phonological and reading measures. By contrast, pitch processing, but not rhythm, was significantly positively correlated with phonological awareness and reading in five-year-old children (Anvari et al., 2002).

The researchers present a number of interesting conclusions (Anvari et al., 2002). First, they reflect on the fact that they found results that varied by age in terms of relationships with rhythm perception and production. That is, rhythm perception and production showed a significantly positive relationship with phonological awareness in four-year-olds, but not in five-year-olds. The researchers hypothesize that young children’s rhythmic skills may develop before the acquisition of knowledge of melodic concepts.

According to the authors, the relationship between music perception and phonological awareness points to common auditory mechanisms. For example, both phonological awareness and music perception involve segmentation of an auditory signal into smaller units. Children also need to recognize these categories or individual auditory units in spite of changes in tempo, pitch, speaker or performer, and varying acoustic conditions. As an extension of their conclusions, the authors theorize about some of the
auditory processing abilities that might be part of the overlap between music perception, phonological awareness, and reading, namely, temporal sequencing, frequency resolution, and temporal resolution.

Based on inconclusive evidence from previous studies investigating the relationship between music perception and phonological awareness, the researcher (Lathroum, 2008) completed a pilot study for this dissertation. Lathroum studied the relationship between pitch processing and phonological awareness in 27, five- and six-year-old children. The researcher used the Primary Measures of Music Audiation (Gordon, 1986) and the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) to measure the constructs.

Results indicated a significantly positive correlation between pitch processing and elision, (i.e., the omission of a sound in a word), and between pitch processing and matching the last sound in paired words. Non-significant positive relationships were found between pitch processing and blending, and between pitch processing and sound matching total (i.e., first and last sound), as well as between pitch processing and the phonological awareness composite. Additionally, a non-significant negative relationship was found between pitch processing and matching of the first sound.

Results of this pilot study are inconsistent with previous research that reported significantly positive correlations among children’s pitch processing skills and certain aspects of phonological awareness (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Bozic et al., 2007; Lamb & Gregory, 1993; Peynircioglu et al., 2002). This study did not find a significant relationship between pitch processing and the phonological awareness composite score. However, previous research has only reported results related
to phonological awareness in a global sense, not particular components of phonological awareness. Lathroum, on the other hand, presented separate results for elision, blending, and sound matching subtests of phonological awareness. Data showed a significantly positive correlation between pitch processing and two components of phonological awareness, including elision and sound matching last. However, since previous research has not provided data regarding these individual components of phonological awareness, it is difficult to make a direct comparison of the results.

Lathroum (2008) concludes that pitch perception, elision, and sound matching appear to share common perceptual and processing demands reflecting a parallel auditory process as revealed in relationships between the constructs. This study supports further research regarding the relationship between pitch processing and phonological awareness due to significantly positive correlations that emerged between pitch processing, and elision and sound matching last.

This pilot study has some limitations that may hinder generalizability of the findings. The children tested attended private schools and most likely came from affluent families. Some research has shown that children with high socio-economic status perform better in phonological awareness and reading tests than children with low socio-economic status (Korat, 2005). Another limitation of this study was that exposure to music instruction may have led to enhanced pitch processing scores in some of the children. Results showed that participants who had received musical training outside of school achieved non-significantly higher scores on the PMMA than children who did not receive music training. These research limitations may have influenced the pitch processing
scores, thus affecting the observed relationships between pitch perception and phonological awareness.

Another limitation is that the pilot study did not test relationships between phonological awareness and perception of rhythm. Some of the phonological awareness tasks investigated in the pilot study, particularly blending, seem to have a strong rhythmic component. For example, in the blending task, the children listen to parts of a word, such as “can” and “dy.” These syllables or phonemes are presented using a recording at a steady tempo, thus children must retain the phonemes in short-term memory and blend the sounds to form a complete word. The accenting of syllables in speech also appears to add to the rhythmic component in the phonological awareness tasks. Although, previous research has shown inconsistent results regarding the relationship between rhythmic processing and phonological awareness (Bolduc & Montésinos-Gelet, 2005; Lamb & Gregory, 1993), these observations suggest these constructs merit further investigation.

**Conclusions regarding the relationship between phonological awareness and music perception.** Previous studies have pointed to a generally positive relationship between phonological awareness and music perception in young children. However, drawing conclusions from previous studies becomes difficult due to inconsistencies in methodology. Consequently, results regarding the relationship between phonological awareness and music perception remain unclear.

Two challenges to generalization of the findings include reliability of measures and measurement of different constructs. Some research to date has used measures with low reliability or experimenter-constructed tests for which reliability was not reported. Several previous studies used measures with questionable reliability, such as the Primary
Measures of Music Audiation (PMMA, Gordon, 1986). Researchers also differed in the way that they reported and analyzed the constructs measured. Although several studies assessed various phonological awareness skills, results were usually reported in terms of phonological awareness as a whole, not individual phonological awareness skills.

Yet another concern regards the type and number of participants. Most studies discussed here included small sample sizes of an average N=46, ranging from 13 to 100 participants. In terms of participant recruitment, most studies did not provide details in this area. However, several studies reported that recruitment took place in only one location, again affecting generalization of results.

Only one study investigating the relationship between phonological awareness and music perception also considered age as a variable of interest (Anvari et al., 2002). Development of phonological awareness is influenced by age and experience. Although age appears to influence music perception somewhat, other factors such as musical experience may also have an effect. Thus, age is an important variable and should be considered when exploring the relationship between phonological awareness and music perception.

Few studies reviewed here included general cognitive ability as part of their analysis (Anvari et al., 2002; Lamb & Gregory, 1993; Loui et al., 2011). Research investigating the role of music perception in phonological awareness would be strengthened by including a discriminant, non-verbal task, such as a visual-spatial task, that does not have a verbal component and thus, does not share an auditory parallel with the constructs under investigation. Providing this visual-spatial task would help control for the overlap between music perception and phonological awareness that might be due
to general cognitive ability or simply good test-taking skills. Results would demonstrate whether phonological awareness and music perception share an auditory parallel, beyond the variance shared with the discriminant non-auditory processing task.

Although the previous studies have investigated the relationship between music perception and phonological awareness in young children, researchers have used primarily bivariate analyses, not accounting for other variables that may play a role in the contribution of music perception to phonological awareness. A more appropriate approach would be to use structural equation modeling (SEM) techniques to create latent variables for music perception and phonological awareness. This approach would allow the researcher to use various observed indicators to create latent variables, thus reducing the effect of measurement error. SEM would also allow the simultaneous examination of other variables, such as age and a discriminant, non-verbal task. The inconsistencies noted in previous research justify further exploration of the unique contribution of musical processing to phonological awareness in five- and six-year-old children.

**Summary of the Literature Review**

The research literature supports an exploration of the role of music perception in predicting phonological awareness in five- and six-year-old children. Phonological awareness is the knowledge that spoken language can be divided into words, syllables, and phonemes (Lane & Pullen, 2004). This awareness also involves the perception and manipulation of phonemes in speech, and is a good predictor for later reading success. Furthermore, children utilize auditory temporal processing skills to discriminate between similar-sounding consonants and to later manipulate sounds as part of phonological awareness.
The second construct examined, music perception, involves children’s ability to detect pitches, rhythms, and melodies. These musical elements are first interpreted as patterns via coherent, auditory Gestalts. Smaller elements of pitch and rhythm are eventually identified according to the Gestalt laws of perception, as well as within a tonal or metric context.

Research findings support the idea of parallel auditory processing mechanisms in phonological awareness and music perception. Speech and music signals are interpreted over time based on skills in auditory temporal processing or use of Gestalt perceptual laws, respectively. Additionally, children develop music perception and phonological awareness skills in a parallel developmental sequence. Younger children show a more global perception, whereas older children show the ability to focus on more local elements (Deruelle et al., 2005; Lane & Pullen, 2004).

Speech and music stimuli also have common acoustical characteristics, including temporal and spectral qualities. The auditory system perceives these qualities from either a speech or music signal in similar ways. Underlying these auditory processes are parallel neuroanatomical structures for the perception of either temporal or spectral qualities in both musical and speech sounds. Therefore, parallel auditory processing and neuroanatomical functioning support research investigating the relationship between music perception and phonological awareness.

Overall, the studies presented here point to a general, positive relationship between phonological awareness and musical processing in four- to six-year-old children (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Bozic et al., 2007). Specifically, research has shown a significantly positive relationship between phonological awareness
and pitch processing. However, across studies, results regarding the relationship between phonological awareness and rhythm perception are inconclusive. Inconsistencies in variable definition and measurement in previous studies also limit generalization. Continuing research is needed in order to understand the unique contribution of music perception to phonological awareness. This understanding could inform music therapy applications in the treatment of children whose emergent literacy may be delayed or impaired.

**Purpose of the Study and Research Questions**

The purpose of the present study was to elaborate upon previous findings and to further the understanding of the role of music perception in predicting phonological awareness. This study used structural equation modeling (SEM) techniques in order to investigate the specific contribution of music perception to phonological awareness, while accounting for age and visual-spatial skills. Through the use of latent variables, the researcher was able to use multiple indicators of each construct, thereby reducing the effect of measurement error of single observed variables on the results of the model. Compared to previous research, the SEM approach was designed to yield more reliable estimates of the associations among the examined constructs than if only observed indicators were used.

In studying the contribution of music perception to phonological awareness, it was important to control for visual spatial skills and age. As previously mentioned, visual spatial skills were included as a function of general cognitive ability; a discriminant task that did not include an auditory component. Thus, through the use of SEM techniques, this study was able to isolate the overlap between music perception and phonological
awareness that might have been due to general cognitive ability or good test-taking skills. Second, controlling for age was necessary since research has shown that children’s music perception, phonological awareness, and visual-spatial abilities are greatly influenced by their development and their chronological age.

No previous research has been found that used this latent variable approach to examine the contribution of music perception to phonological awareness in five- and six-year-old children. Thus, the current study is positioned to further elucidate how music perception uniquely contributes to phonological awareness, as compared to the contribution of age and visual-spatial skills.

The following research questions were addressed:

1. Does the theory that music perception, (as defined by rhythm, pitch, and melodic discrimination), age, and visual-spatial skills predict phonological awareness, (as defined by elision, blending, and sound matching) fit the observed data of this study?

2. Does music perception make a unique contribution to the prediction of phonological awareness when controlling for visual-spatial skills and age?

3. Does a theory that includes visual spatial skills and age, but omits music perception, as a predictor of phonological awareness fit the data as well as a theory that allows music perception, visual spatial skills, and age to predict phonological awareness?

The null hypotheses for these research questions were the following:

1. The observed data of this study show poor fit to the theory that music perception, (as defined by rhythm, pitch, and melodic discrimination), age, and visual-spatial
skills predict phonological awareness, (as defined by elision, blending, and sound matching).

2. Music perception does not make a unique contribution to the prediction of phonological awareness when controlling for visual-spatial skills and age.

3. A theory that includes visual spatial skills and age, but omits music perception, as a predictor of phonological awareness fits the data as well as a theory that allows music perception, visual spatial skills, and age to predict phonological awareness.
Chapter Three

Methods

This chapter describes the participants, participant recruitment, and measures used in this investigation. Data collection, data analysis, and statistical models used in this study to investigate the research questions are also presented.

Participants

The participants were five- and six-year-old children who attended kindergarten at one of three public elementary schools in Miami-Dade County. Children were proficient in English, whether it was their first or second language. In order to complete the assessments, children needed to have at least conversational skills in English. An initial sample (N = 120) was recruited. Testing for one participant was discontinued because she did not understand the directions. Thus, data from 119 participants were included in the data analysis.

Participants ranged in age from five years and two months, to six years and four months (M = 5.75 years, SD = 0.31 year). The population under study involved typically-developing children. Therefore, children who had visual, auditory, cognitive, and/or speech and language impairments were not invited to participate in the study. See Table 1 for additional demographic information.

In terms of school music instruction, the children in one school attended music class provided by a music specialist, once a week. The kindergarten teachers at the other two schools integrated music into the curriculum; however, these students did not receive music instruction separately.
### Table 1

*Demographics of the Participant Sample*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>119</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>63</td>
<td>53%</td>
</tr>
<tr>
<td>Male</td>
<td>56</td>
<td>47%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>119</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Socio-economic status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$25,000 or below</td>
<td>32</td>
<td>27%</td>
</tr>
<tr>
<td>$25,000 to $50,000</td>
<td>23</td>
<td>19%</td>
</tr>
<tr>
<td>$50,000 to $75,000</td>
<td>18</td>
<td>15%</td>
</tr>
<tr>
<td>Over $75,000</td>
<td>39</td>
<td>33%</td>
</tr>
<tr>
<td>Did not report</td>
<td>7</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Language</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual language learners</td>
<td>82</td>
<td>69%</td>
</tr>
<tr>
<td>Monolingual</td>
<td>37</td>
<td>31%</td>
</tr>
<tr>
<td><strong>Music instruction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private lessons (instrumental)</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Group class outside of school</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>Sings in a choir</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>Family member is an active musician</td>
<td>16</td>
<td>13%</td>
</tr>
<tr>
<td>Did not report</td>
<td>95</td>
<td>80%</td>
</tr>
</tbody>
</table>
Age was the only demographic variable that was included in the final structural equation model because previous research shows that age contributes variance and can be predictors of phonological awareness (Carroll et al., 2003). Other demographic variables were not included because there was no reason to believe they would contribute to the model based on past research (Bowey & Francis, 1991).

**Participant recruitment.** The researcher submitted the research protocol to the human subjects research committees of the University of Miami and Miami Dade County Public Schools for approval. After obtaining approval, the researcher contacted various public elementary schools in Miami Dade County. Then, the researcher met the principals or assistant principals and kindergarten teachers in order to present the research project. The researcher then obtained letters of agreement for participation in the study from three public school principals. The researcher distributed letters of invitation and informed parental consent forms for participants’ parents (Appendix A and Appendix B). Additionally, the researcher distributed a demographic questionnaire that addressed questions related to the child’s age, first-language, socio-economic status, and musical background (Appendix C). The parents returned the signed consent form and demographic questionnaire. If parents wished to discuss the research or had any questions, they were invited to contact the researcher who explained details related to the study.

**Measures**

**Perception of rhythm, pitch, and melody.** An extensive review of existing measures of music perception for five- and six-year-old children was undertaken. Many tests were examined including, but not limited to: Janet Mills’ Group Tests of Musical
Abilities (1988), the Seashore Measures of Musical Talents (Seashore et al., 1939), Colwell’s Elementary Music Achievement Test (1965), Simons Measurements of Music Listening Skills (1976), and Knuth’s Achievement Tests in Music (1967). None of these tests were considered suitable for this study because they were designed for older children and they did not measure all of the specific variables that this study purports to measure. The Primary Measures of Music Audiation had been identified as a potential test for pitch and rhythm pattern perception (Gordon, 1986). However, this test was not used because of a low reliability and ceiling effects (Lathroum, 2008). The Children’s Music Aptitude Test (CMAT; Stevens, 1987) was determined to be appropriate for five- and six-year-old children and measured perception of pitch, rhythm, and melody. Therefore, it was used in this study.

To assess discrimination of specific musical elements, the rhythm, pitch, and melody subtests of the CMAT were administered to each child individually. Administration of the CMAT involved the presentation of recorded sequences of two to nine sounds each. Sounds included the woodblock for the rhythm subtest, and piano for the pitch and melody subtests. All sounds were previously recorded on a compact disc. Each child listened to a recording of two sound sequences in a row and determined whether the two patterns were the same or different in terms of pitch patterns, rhythm, and melody (pitch and rhythm combined).

Before beginning the music portion of the CMAT, the researcher showed each participant pairs of drawings that were either the same or different (i.e., two flowers that were the same, or two different candies). Participants responded verbally with one of three alternatives, “same,” “different,” or “I don’t know.” Three sets of two drawings
each were presented. The purpose of this part of the test was to ensure that each child understood the concepts of same and different. If they were successful at this task and gave an appropriate verbal response, one of the three alternatives mentioned above, the researcher proceeded to administer the music subtests. Participants did not need to have any musical knowledge in order to complete the CMAT.

The three subtests of the CMAT that the researcher administered included a total of 60 excerpts: 20 items for each of the subtests. Administering all three subtests took approximately 30 minutes.

The test-retest reliability for the pilot study of this test with first graders was \( r = .80 \) (Stevens, 1987). The test-retest reliability for the final version of the test with nine-through ten-year-old children was \( r = .91-.93 \). The split-half reliability for the final version of the test with five-year-olds was \( r = .85 \); and six-year-olds was \( r = .88 \). Table 2 includes a summary of reliabilities for the measures in this study. Thus, the reliability was appropriate for this age level. Additionally, the CMAT was designed for four-through nine-year-old children; therefore, it had a wide range in terms of item difficulty which decreased the possibility of ceiling effects with the sample of five- and six-year-old children.
Table 2

Measure Reliability

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure</th>
<th>Reliability</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception of rhythm, pitch, and melody</td>
<td>Children’s Music Aptitude Test (Stevens, 1987)</td>
<td>$r = .85^1$</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$r = .88^1$</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$r = .91-.93^2$</td>
<td>9-10</td>
</tr>
<tr>
<td>Phonological Awareness: Elision, Blending, and Sound Matching</td>
<td>Comprehensive Test of Phonological Processing (Wagner et al., 1999)</td>
<td>$\alpha = .87-.89^3$</td>
<td>5-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$r = .82^2$</td>
<td>5-6</td>
</tr>
<tr>
<td>Visual-Spatial Skills</td>
<td>Woodcock Johnson III-Test of Cognitive Abilities: Subtest 3-Spatial Relations (Woodcock et al., 2001)</td>
<td>$r = .90^4$</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$r = .83^4$</td>
<td>6</td>
</tr>
</tbody>
</table>

$^1$Split-half reliability, $^2$Test-retest reliability, $^3$Cronbach’s $\alpha$, and $^4$Reliability using the Rasch standard error of measurement person measures analysis procedures.

Phonological awareness. The researcher assessed phonological awareness skills using the Comprehensive Test of Phonological Processing (CTOPP; Wagner et al., 1999). The CTOPP is a widely-used measure for assessing phonological processing and phonological awareness in research related to children’s pre-reading skills. The CTOPP measures phonological awareness, phonological memory, and rapid naming in children of ages five and six years. However, the researcher only administered the phonological
awareness portion of the test, since this was the sub-test that was most relevant to this study.

Three tasks were used to assess the phonological awareness of five- and six-year-old children: elision, word blending, and sound matching. The elision sub-test included 20 items. In this part, the researcher said a particular target word. The participant repeated the target word aloud and then identified particular elements on demand. For example, the participant repeated the word “toothbrush.” The researcher then said, “Now say the word ‘toothbrush’ without saying ‘tooth’.” The task was for the child to indicate what word would be produced when the word “tooth” was dropped. The researcher ended this sub-test after the child missed three test items in a row.

The second sub-test, word blending, also included 20 items. In this part of the test, the participant listened to sounds on a compact disc recording. He or she then combined the sounds into words. For example, the researcher presented a recording of the sounds “can” and “dy.” The child responded by saying the word “candy.” The researcher ended this sub-test after the child missed three test items in a row.

The third sub-test, sound matching, consisted of 20 items. The task was to listen to a sound and identify other words that had the same initial or final sound. For example, the researcher pointed to a picture in the booklet and said, “This is a sock. Now look at these two pictures. This is the sun and this is a bear. The word ‘sock’ starts with the sound /s/. Which word starts with the sound /s/ like sock: sun or bear?” The child answered, “sun.” The researcher ended the sub-test when the child missed four out of seven consecutive test items. After the child completed the initial sound matching portion of the sub-test, the researcher proceeded to the final sound matching portion.
In the last portion of the test, final sound matching, the researcher said, “Look at the first picture. This is a can. Look at these two pictures: pot and sun. The word can ends with the /n/ sound. Which of these words ends with the /n/ sound like can? Pot or sun?” The child said, “Sun.” Once again, the researcher ended the sub-test when the child missed four out of seven test items. Administering the three sub-tests of the CTOPP took approximately 20-25 minutes, depending on the child’s performance on each sub-test which influenced how many items the child needed to answer, as determined by the previously mentioned cutoffs.

According to the test manual, median discriminating coefficients for the CTOPP average .49. Median item difficulty coefficients average .59, which is appropriate since item difficulty should approximate .50. In terms of reliability, coefficient alphas have a mean of .87 when age level and sub-test are collapsed. The researchers also calculated a mean coefficient alpha of .89 showing that the CTOPP is a reliable measure regardless of gender or minority group. Test-retest reliability yielded a mean correlation coefficient of .82.

Wagner, Torgesen, and Rashotte (1999) also addressed the validity of the CTOPP. Regarding content validity, the sub-tests in the CTOPP have been used over the past 25 years for diagnostic and research purposes. Criterion-related validity was evaluated with several studies including correlations between the CTOPP and other related tests, such as the Lindamood Auditory Conceptualization Tests (Lindamood & Lindamood, 1971) and the Test of Word Reading Efficiency (Torgesen, Wagner, & Rashotte, 1999). In order to assess construct validity, the researchers used confirmatory factor analysis, group differentiation, and age differentiation. These analyses showed that the various sub-tests
in the CTOPP measured the abilities of phonological awareness, phonological memory, and rapid naming. The psychometric properties of the CTOPP made it appropriate for the testing of phonological processing, and more specifically, phonological awareness.

**Visual-spatial skills.** The purpose of testing children’s visual-spatial skills was to provide a discriminant task, that is, it was used to account for children’s general intelligence, non-auditory skills, and test-taking skills. In order to identify an appropriate visual-spatial skills test, various experts were consulted, including: a school psychologist, a clinical psychologist, and two university professors in the field of educational psychology and assessment. Several tests were examined in order to find the best test of non-verbal spatial skills for this age group, including the Test of Non-Verbal Intelligence (TONI-3; Brown, Sherbenou, & Johnson, 1997) and the Wide Range Assessment of Visual-Motor Ability (WRAVMA; Adams & Sheslow, 1995). The TONI-3 was not used because it is only normed for children ages six and above. The WRAVMA was not used because the test items are designed in a way that children must access verbal codes in order to respond. Therefore, it did not fulfill the non-verbal requirement for the discriminant task. The researcher considered using Raven’s Progressive Coloured Matrices (1956) to measure non-verbal visual-spatial skills; however, that test was not used due to low reliability.

After reviewing a variety of tests, it was determined that the Woodcock Johnson III- Test of Cognitive Abilities: Subtest 3- Spatial Relations would be administered in order to assess non-verbal, visual-spatial skills (WJIII; Woodcock, McGrew, & Mather, 2001). This sub-test measured the ability to mentally visualize, rotate, and manipulate shapes. Specifically, children were first presented with a shape, such as a circle or square.
Then, they saw various parts of the original shape along with some alternate shapes. The children decided which of the various shapes would form the original shape when put together. This particular subtest was chosen as a discriminant task because children did not need to access verbal codes to determine and provide a proper response to the test items.

This subtest consisted of 33 items. The researcher said, “Look at these pieces of the puzzle. If we took this piece (point to piece A in child’s page) and this piece (point to piece B) and put them together, we would have this (point to complete shape).” In order to respond, the child pointed to the correct answer. Thus, a verbal response was not required. Depending on the item, the child could obtain a maximum score of 2 to 5 possible points, on that particular item. The items became increasingly difficult, and the researcher discontinued testing as determined by the cut-offs in the manual. For example, if the child scored 16 or fewer points out of a possible 27 points on items 1 through 13, then the researcher would stop testing. The researcher administered this test to each child individually which took 15 to 20 minutes. The reliability for the WJIII Spatial Relations test is .90 for five-year-old children and .83 for six-year-old children, as calculated using the Rasch standard error of measurement person measures analysis procedures (Woodcock et al., 2001).

Procedure

**Data collection.** The researcher first administered the Children’s Music Aptitude Test (CMAT) to each participant individually in a classroom at the children’s respective schools (Stevens, 1987). The test’s author determined that this age group should be tested
individually in order to improve test reliability. The researcher explained the procedures to the children as indicated in the test manual and provided examples.

The researcher placed the CD player near the participant so that the child could hear the examples. The researcher administered the three visual examples to determine whether the child understood the concept of same or different. Then, three practice examples using melody were administered. Subsequently, each child completed the rhythm subtest of the CMAT. This particular subtest was completed first because that was the order in which Stevens (1987) designed the test. After the child completed the 20 items in the rhythm subtest, the researcher gave the child a sticker sheet and two stickers to place on it as a tangible reinforcer and motivation to continue testing. The researcher then kept the sticker sheet until the end of the next subtest. Additionally, the child was allowed to take a three-minute break in which to stretch, do jumping jacks, or play the “Hokey Pokey.” This same reinforcement schedule was used on all three testing days for the three measures that were administered.

Following this break, testing resumed and the participant completed the 20 items in the pitch subtest. Upon completion, the participant received two more stickers for his/her sticker sheet and was once again allowed to take a short break, structured as previously specified. Last, the child completed the melodic subtest, which also consisted of 20 test items. When the participant completed this subtest, he or she received two more stickers and was allowed to keep the sticker sheet with six stickers. This reinforcement schedule helped to motivate the children to remain on-task throughout the test.

Within two weeks of administering the three sub-tests of the CMAT, the researcher administered the CTOPP (Wagner et al., 1999) to each child individually. The
researcher provided appropriate instructions and practice examples, as indicated by the testing manual. The researcher administered the following sub-tests: elision, word blending, and sound matching. The tests were always given in the same order as indicated by the CTOPP manual. After the child completed each sub-test, the investigator gave him or her two stickers to place on a sticker sheet. Then the child was allowed to take a short break to stretch, do jumping jacks, or play the “Hokey Pokey.” After the break, testing resumed, and the same procedure was followed at the end of each sub-test. Thus, participants received two more stickers upon completion of each sub-test and were given their sticker sheet upon completion of the CTOPP. This reinforcement schedule helped to motivate the children to remain on-task throughout the test.

Within two weeks of administering the CTOPP, the researcher administered the Woodcock Johnson III Spatial Skills Subtest (WJIII; Woodcock et al., 2001) to each child individually. The researcher provided instructions and practice examples as indicated by the testing manual and referenced in the earlier description of this measure. Following the same reinforcement schedule as in previous tests, participants received two stickers after completing half of the test items and were given the opportunity to take a short break. Upon completion of the entire test, the children received two more stickers and were allowed to have their sticker sheet. This schedule helped to motivate the children to remain on-task throughout the test.

In regard to scoring of the WJIII sub-test, the researcher recorded raw scores, as determined by the cut-offs mentioned in the procedures section of this document (Woodcock et al., 2001). Upon an initial descriptive analysis of the data, it was determined that results of the raw scores for this sub-test yielded a bimodal distribution
and the assumption of normality would be violated. This type of distribution was due to the fact that because of the cutoffs mentioned earlier, there were gaps in the scores. For example, the highest possible total raw score was 81, and no child scored between 41 and 49 points. As an alternative, the WJIII answer sheet form included a table that was used to convert the raw scores into age equivalents. The age equivalent scores yielded a normal distribution that was appropriate for assumptions of normality. Age equivalent scores, as opposed to raw scores, were thus included in the rest of the data analysis. To summarize the data collection, Table 3 presents an overview of the study calendar.

Table 3

*Study Calendar*

<table>
<thead>
<tr>
<th>Week</th>
<th>Measure</th>
<th>Variable</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Children’s Music Aptitude Test (CMAT)</td>
<td>Rhythm, pitch, and melody</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Week 3</td>
<td>Comprehensive Test of Phonological Processing (CTOPP)</td>
<td>Elision, blending, and sound matching</td>
<td>20 - 25 minutes</td>
</tr>
<tr>
<td>Week 5</td>
<td>Woodcock Johnson III-Test of Cognitive Abilities: Subtest 3-Spatial Relations (WJIII)</td>
<td>Visual-spatial skills</td>
<td>15 - 20 minutes</td>
</tr>
</tbody>
</table>
Data Analysis

SPSS 17.0 was used to obtain descriptive statistics and correlation/covariance matrices were obtained using Mplus6. This program was also used to test the proposed model and to estimate the coefficients and their respective standard errors, utilizing Maximum Likelihood (ML) estimation. No data were missing in the variables of interest. Figure 1 shows the proposed full structural equation model.

Measurement model and latent variables. In order to develop the latent variables in this study, a measurement model was used (Kline, 2005). The first part of the model represented music perception. The exogenous latent variable consisted of three observed indicators: rhythm, pitch, and melodic discrimination. The second part of the measurement model represented phonological awareness. The endogenous latent variable phonological awareness was defined using three observed indicators: elision, blending, and sound matching.

Structural models. After the measurement model and latent variables were developed, two types of structural models were examined: a full model and a comparison model. These models and their corresponding equations are presented in the following sections.
**Figure 1.** Full model to be investigated determining the unique contribution of music perception to phonological awareness, controlling for age and visual-spatial skills.

Full model. As shown in Figure 1, the full model examining the unique contribution of music perception to phonological awareness while controlling for age and visual spatial skills was defined as:

\[
\text{PhonologicalAwareness} = a_1 + b_1(Music) + b_2(\text{VisualSpatial}) + b_3(Age) + e_1, \quad (1)
\]

and

\[
\text{VisualSpatial} = a_2 + b_4(Age) + e_2, \quad (2)
\]

where \(a\) represents an intercept, \(b\) represents a slope coefficient, and \(e\) represents an error term.

This full model represented a regression of the phonological awareness latent variable on the music perception latent variable, the age indicator, and the visual spatial skills indicator. The second part of the full model represented a regression of visual spatial skills on age, showing the contribution of age to visual-spatial skills. This full
model investigated the distinct contribution of music perception to phonological awareness controlling for visual-spatial skills and age. In the case of age, both direct and indirect effects were examined in the model. Therefore, this model determined whether music perception made a unique contribution to phonological awareness above and beyond the contribution made by age and visual-spatial skills.

**Comparison model.** The next part of the analysis compared the structural model defined in equations 1 and 2 to a nested, comparison model that does not allow the music variable to have a direct effect on the phonological awareness variable. This comparison model is defined as:

\[
\text{Phonological Awareness} = a_1 + 0(Music) + b_2(VisualSpatial) + b_3(Age) + e_1, (3)
\]

and

\[
\text{VisualSpatial} = a_2 + b_4(Age) + e_2, \quad (4)
\]

where all components represent intercepts, slope coefficients, and error terms as in equations 1 and 2 above.

This comparison model represented a regression of the phonological awareness latent variable on the age indicator and the visual spatial skills indicator; however, the regression of phonological awareness on the music perception latent variable was held at zero. The second part of the comparison model represented a regression of visual spatial skills on age, showing the contribution of age to visual-spatial skills. The difference between the full model in equations 1 and 2 and the comparison model in equations 3 and 4 was examined in order to investigate the unique contribution of music perception to phonological awareness while controlling for age and visual-spatial skills.
Chapter Four

Results

This study was designed to examine the contribution of music perception to phonological awareness, when controlling for visual spatial skills and age. Standardized measures were used to test the variables of interest. This chapter focused on analyzing the data to answer the following research questions:

1. Does the theory that music perception (as defined by rhythm, pitch, and melodic discrimination), age, and visual-spatial skills predict phonological awareness, (as defined by elision, blending, and sound matching) fit the observed data of this study?

2. Does music perception make a unique contribution to the prediction of phonological awareness when controlling for visual-spatial skills and age?

3. Does a theory that includes visual spatial skills and age, but omits music perception, as a predictor of phonological awareness fit the data as well as a theory that allows music perception, visual spatial skills, and age to predict phonological awareness?

In order to run a structural equation model to answer the research questions, several steps were taken. First, the univariate analyses were conducted to clarify each variable. Next, covariance and correlation estimates were generated to describe the bivariate relationships between the observed variables. Then, a measurement model was examined using confirmatory factor analysis (CFA). This process was followed by an examination of the full model using (Mplus) to answer research questions 1 and 2. Finally, a nested model comparison was used to answer research question 3.
Univariate Analyses

Table 4 includes descriptive statistics for the eight observed variables in this study: rhythm, pitch, and melody; as well as elision, blending, and sound matching; plus visual-spatial skills, and age. Out of the three music perception measures, rhythm showed the highest mean score. When comparing the means of the three phonological awareness indicators, sound matching received the highest mean score.

Table 4

Descriptive Statistics of Observed Variables including Means, Standard Deviations, Minimum Scores, and Maximum Scores

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Possible Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhythm</td>
<td>12.71</td>
<td>3.97</td>
<td>4</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Pitch</td>
<td>11.22</td>
<td>3.45</td>
<td>3</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Melody</td>
<td>11.17</td>
<td>4.34</td>
<td>1</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Elision</td>
<td>4.34</td>
<td>3.01</td>
<td>0</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Blending</td>
<td>6.81</td>
<td>3.37</td>
<td>0</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Sound Matching</td>
<td>11.53</td>
<td>4.45</td>
<td>1</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Visual Spatial</td>
<td>7.11*</td>
<td>1.44*</td>
<td>4.5*</td>
<td>13*</td>
<td>21*</td>
</tr>
</tbody>
</table>

Note: *Represent age equivalent scores.

Bivariate Analyses

The univariate analyses were followed by the bivariate analyses. The covariance estimates and correlation estimates among all observed variables included in this study are presented in Table 5. All of the variables were positively correlated with one another. Bivariate correlations between the three observed indicators of music perception; rhythm, pitch, and melody, were statistically significant ($p < .001$) and ranged from $r = 0.61$ to $r = 0.73$. Bivariate correlations between the three observed indicators of phonological awareness, elision, blending, and sound matching, were statistically significant ($p < .001$).
and ranged between $r = 0.52$ and $r = 0.62$. According to Cohen (1988), these positive correlations are considered to be strong.

Bivariate correlations between each of the music indicators (rhythm, pitch, and melody) and each of the phonological awareness indicators (elision, blending, and sound matching) were statistically significant ($p < .05$) and ranged from $r = 0.20$ to $r = 0.39$. These can be considered moderate correlations (Cohen, 1988). Bivariate correlations between visual-spatial skills and all other indicators ranged from $r = 0.14$ to $r = 0.33$. These correlations were significant at the $\alpha = .01$ level, with two exceptions, the correlation between visual-spatial skills and pitch, and visual-spatial skills and melody, which were both non-significant. Bivariate correlations between age and all other indicators ranged from $r = 0.15$ to $r = 0.37$, with one exception, the correlation between age and melody which was $r = 0.03$. All bivariate correlations between age and the phonological awareness indicators were significant, $p < .01$. However, bivariate correlations between age and music perception indicators were non-significant. The correlations between visual-spatial skills and all other indicators, and between age and all other indicators can also be considered weak to moderate (Cohen, 1988).
Table 5 Covariance (Correlation) Structure of Observed Variables

<table>
<thead>
<tr>
<th>Measure</th>
<th>Rhythm</th>
<th>Pitch</th>
<th>Melody</th>
<th>Elision</th>
<th>Blending</th>
<th>Sound Matching</th>
<th>Visual-Spatial</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhythm</td>
<td>15.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>(1.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitch</td>
<td>8.78</td>
<td>11.82</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.65)**</td>
<td>(1.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melody</td>
<td>10.40</td>
<td>10.83</td>
<td>18.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.61)**</td>
<td>(0.73)**</td>
<td>(1.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elision</td>
<td>4.64</td>
<td>3.68</td>
<td>4.53</td>
<td>8.98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.39)**</td>
<td>(0.36)**</td>
<td>(0.35)**</td>
<td>(1.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blending</td>
<td>4.21</td>
<td>2.53</td>
<td>3.40</td>
<td>6.25</td>
<td>11.27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.32)**</td>
<td>(0.22)*</td>
<td>(0.24)**</td>
<td>(0.62)**</td>
<td>(1.00)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound Matching</td>
<td>5.37</td>
<td>3.30</td>
<td>3.89</td>
<td>8.12</td>
<td>7.73</td>
<td>19.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.31)**</td>
<td>(0.22)*</td>
<td>(0.20)*</td>
<td>(0.61)**</td>
<td>(0.52)**</td>
<td>(1.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual-Spatial</td>
<td>1.49</td>
<td>0.81</td>
<td>0.87</td>
<td>1.15</td>
<td>1.54</td>
<td>2.08</td>
<td>2.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.26)**</td>
<td>(0.17)</td>
<td>(0.14)</td>
<td>(0.27)**</td>
<td>(0.32)**</td>
<td>(0.33)**</td>
<td>(1.00)</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.18</td>
<td>0.16</td>
<td>0.04</td>
<td>0.021</td>
<td>0.029</td>
<td>0.37</td>
<td>0.16</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(0.15)</td>
<td>(0.03)</td>
<td>(0.23)**</td>
<td>(0.28)**</td>
<td>(0.27)**</td>
<td>(0.37)**</td>
<td>(1.00)</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01, ***p<.001 Note: All correlations above 0.20 are significant at the p<.05 level.
Measurement Model

Based on the covariance estimates observed among the variables, the next step of the statistical analysis was to examine the measurement model. The assumptions for normality and multicollinearity for the measurement model were met. As mentioned in the univariate analysis, skewness and kurtosis for all of the indicators were acceptable, ranging from -1 to +1. Elision was one exception (kurtosis=1.74). Although the kurtosis value for this indicator is higher than hoped for, structural equation modeling is robust to non-normality of this magnitude (Kline, 2005). As shown in Table 5 and discussed in the bivariate analysis, multicollinearity was not a concern because the largest correlation among indicators was .73 between pitch and melody. Therefore, the assumptions for the measurement model were met and the analysis proceeded.

The music perception latent variable was defined by using three observed indicators: rhythm, pitch, and melodic discrimination. The phonological awareness latent was defined using three observed indicators: elision, blending, and sound matching. A confirmatory factor analysis (CFA) for the two latent variables, music perception and phonological awareness, was used to confirm that the observed indicators loaded on their respective theorized latents as expected, while allowing the two latent variables to correlate with one another. Thus, CFA was used to develop new, latent variables from the shared variance of the observed variables that have measurement error (Kline, 2005).

Figure 2 shows a diagram of the confirmatory factory analysis. The CFA theory fit the observed data well as indicated by various model fit indices in Table 6. These fit indices meet criteria for acceptable model fit (Kline, 2005).
Figure 2. Results of confirmatory factor analysis showing the contribution of rhythm, pitch, and melody to the latent music perception, and the contribution of elision, blending, and sound matching to the latent phonological awareness. *** p<.001 Note: All figures reported are β values.
Table 6

*Fit Statistics of the Confirmatory Factor Analysis*

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$(df), $p$</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA (LB, UB)</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFA</td>
<td>6.63 (8), 0.578</td>
<td>1.00</td>
<td>1.01</td>
<td>0.00 (0.00, 0.00)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

In addition to an analysis of the model fit, the direct contributions of the indicators onto the latent variables were studied through an examination of the standardized coefficients. As shown in Figure 2, the standardized coefficients indicating the contribution of rhythm, pitch, and melody to music perception and for elision, blending, and sound matching to phonological awareness, ranged from 0.75 to 0.83 and 0.70 to 0.89, respectively. These coefficients are considered to be large effects as determined by the criteria for loadings established by Cohen (1988). Thus, the various indicators loaded well on the hypothesized latent variables in this study. These loadings mean that the indicators could be used to form a latent variable, and the indicators were working well together.

Another result of the CFA showed that the music perception latent variable was significantly, and positively correlated to the phonological awareness latent variable $r = .46$ ($p<.001$). The shared variance between these two latent variables is equal to .2116, indicating that music perception and phonological awareness share 21.16% of the observed variance with each other.
Full Model

Following the confirmatory factor analysis, the full model (Figure 3) was tested to examine the contribution of music perception, visual-spatial skills and age in predicting phonological awareness. As mentioned in the univariate analyses, bivariate analyses, and the assumptions for the measurement model, the assumptions for normality and multicollinearity for the full model were also met (Kline, 2005). Therefore, the analysis of the full model proceeded.

Results support research question 1 which asks whether the theory that music perception, visual-spatial skills, and age predict phonological awareness fit the observed data. The full model demonstrated good fit to the data as indicated by various fit indices shown in Table 7. All indices meet the criteria for acceptable model fit (Hu & Bentler, 1999; Kline, 2005). In terms of amount of variance explained in phonological awareness, 30.3% of the variance observed in phonological awareness was explained by the predictors in the full model: music perception, visual-spatial skills, and age. Therefore, the researcher rejected the null hypothesis: The observed data of this study do not fit the theory that music perception, (as defined by rhythm, pitch, and melodic discrimination), age, and visual-spatial skills predict phonological awareness, (as defined by elision, blending, and sound matching).
Figure 3. Results of the full model showing the contribution of music perception to phonological awareness controlling for visual-spatial skills and age. *p < .05, **p < .01, ***p < .001 Note: All figures reported are β values.
The results of the full model showed that music perception, visual spatial skills, and age, each significantly predicted phonological awareness when all three variables were included as predictors in the same model (See Figure 3 and Table 8). Research question 2 examined whether music perception made a unique contribution to the prediction of phonological awareness when controlling for visual-spatial skills and age. Results showed that music perception, while controlling for visual-spatial skills and age, made a significant contribution to phonological awareness ($b = 0.33$, $SE = 0.10$, $p < 0.001$, $\beta = 0.39$, $SE = 0.05$). Thus, a one standard deviation unit increase in music perception predicted a .39 standard deviation unit increase in phonological awareness. According to Cohen’s (1988) guidelines, this contribution is considered to be a moderate effect. The researcher rejected the null hypothesis: Music perception does not make a unique contribution to the prediction of phonological awareness when controlling for visual-spatial skills and age.

Visual spatial skills, while controlling for the other variables, also made a significant contribution to phonological awareness ($b = 0.42$, $SE = 0.17$, $p < 0.014$, $\beta = \ldots$ 

---

**Table 7**

*Fit Statistics of the Full Model*

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$(df), $p$</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA (LB, UB)</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Model</td>
<td>20.12 (17), 0.268</td>
<td>0.99</td>
<td>0.98</td>
<td>0.04 (0.00, 0.10)</td>
<td>0.06</td>
</tr>
</tbody>
</table>
0.24, SE = 0.10). Thus, a one-standard deviation unit increase in visual-spatial skills was associated with a .24 standard deviation unit increase in phonological awareness.

Table 8

*Results for the Full Model showing the Contribution of Music Perception, Visual-Spatial Skills and Age to Phonological Awareness*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Direct (b) (SE)</th>
<th>Direct (\beta) (SE)</th>
<th>Indirect (b) (SE)</th>
<th>Indirect (\beta) (SE)</th>
<th>Total (b) (SE)</th>
<th>Total (\beta) (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Music</td>
<td>0.33*** (0.09)</td>
<td>0.39*** (0.09)</td>
<td>---</td>
<td>---</td>
<td>0.33*** (0.09)</td>
<td>0.39*** (0.09)</td>
</tr>
<tr>
<td>Visual-Spatial Skills</td>
<td>0.42** (0.17)</td>
<td>0.24** (0.10)</td>
<td>---</td>
<td>---</td>
<td>0.42** (0.17)</td>
<td>0.24** (0.10)</td>
</tr>
<tr>
<td>Age</td>
<td>1.50* (0.77)</td>
<td>0.19* (0.10)</td>
<td>0.70* (0.33)</td>
<td>0.09* (0.04)</td>
<td>2.20** (0.74)</td>
<td>0.27** (0.09)</td>
</tr>
</tbody>
</table>

*\(p<.05, \ \\ ** p<.01, \ \\ *** p<.001*

Age had both direct and indirect effects on phonological awareness, when controlling for the other variables. The direct effect of age on phonological awareness was evident as: \(b = 1.50, SE = 0.77, p < 0.052, \beta = 0.19, SE = 0.10, p < 0.049\). Age also had an indirect effect on phonological awareness with visual-spatial skills as a mediator \(b = 0.70, SE = 0.33, p < 0.033, \beta = 0.09, SE = 0.04\). Therefore, the total effects of age made a significant contribution to phonological awareness \(b = 2.20, SE = 0.74, p < 0.003, \beta = 0.27, SE = 0.09\). Thus, a one standard deviation unit increase in age predicted a .27 standard deviation unit increase in phonological awareness. The standardized coefficients for the contribution of visual spatial skills and age to phonological awareness
can each be interpreted as moderate effects (Cohen, 1988). Results are shown in Table 8 and Figure 3.

As part of the analysis, the researcher compared the magnitude of the standardized coefficients ($\beta$), in this full model. Based on these coefficients, music perception predicted a larger SD-unit increase (.39) in phonological awareness than visual-spatial skills (.24) or age (.27).

**Comparison of Model Results**

To specifically test the contribution of allowing music perception to predict phonological awareness in the full model, a nested model comparison was used. A comparison model that holds the prediction of music on phonological awareness at zero is nested in the full model. A chi-square difference test was used to answer research question 3 to determine if a comparison model with a fixed parameter fit the data as well as the full model where music was allowed to freely estimate phonological awareness.

Results for the comparison model showed that when music was not allowed to predict phonological awareness, the data show questionable to poor fit to the theory according to four fit indices ($\chi^2(18) = 34.63, p < 0.01$, TLI = 0.92, RMSEA = 0.09, and SRMR = 0.13). Only one index showed adequate fit (CFI = 0.95). Research question 3 examined whether a model implying that music perception has no predictive power over phonological awareness fit the observed data as well as a model that allows music perception to predict phonological awareness. The chi square difference test showed that the comparison model in which music is not allowed to predict phonological awareness fits the data significantly worse than the full model discussed earlier in this study. For example, the chi square statistic decreased from $\chi^2 = 34.63$ (18), $p <.011$ in the
comparison model, to $\chi^2 = 20.118 \ (17), \ p < .268$ in the full model. The chi square
difference between both models is $\chi^2 = 14.509 \ (1), \ p < .001$. Results are shown in Table 9.

The researcher rejected the null hypothesis: A theory that includes visual spatial
skills and age, but omits music perception, as a predictor of phonological awareness fits
the data as well as a theory that allows music perception, visual spatial skills, and age to
predict phonological awareness. Thus, this difference test rules out the possibility that a
comparison model in which music is not allowed to predict phonological awareness could
fit the data just as well as the full model in Figure 3.

Table 9

| Fit Statistics of the Full Model and Comparison Model |
|---------------------------------|---|---|---|---|---|---|
| Model                           | $\chi^2$(df), $p$ | CFI | TLI | RMSEA (LB, UB) | SRMR | $\chi^2$ diff. (df), $p$ |
| Full Model                      | 20.12 (17), 0.268 | 0.99 | 0.98 | 0.04 (0.00, 0.10) | 0.06 | ----------- |
| Nested Model                    | 34.63 (18), 0.01  | 0.95 | 0.92 | 0.09 (0.04, 0.13) | 0.13 | 14.51(1), <.001 |

Another difference between the full and comparison models is the amount of
variance in phonological awareness that each model explains. The comparison model
where music is not allowed to predict phonological awareness explains 18.9% of the
variance in phonological awareness. That is to say, when only age and visual spatial skills
are allowed to predict phonological awareness, these two variables account for 18.9% of
the variance in phonological awareness. By contrast, the full model in which music is allowed to predict phonological awareness explains 30.3% of the variance in phonological awareness. In other words, when music, visual spatial skills, and age are allowed to predict phonological awareness, these three variables account for 30.3% of the variance in phonological awareness. Thus, allowing music perception to predict phonological awareness accounts for an additional 11.4% of variance explained in phonological awareness, beyond that which is explained by visual spatial skills and age alone.

**General Findings**

In summary, for these five- and six-year-old children, music perception, visual spatial skills, and age predicted phonological awareness. Music perception predicted a larger amount of standardized unit change in phonological awareness than did the other predictors in the theory. Additionally, a model without music perception as a predictor of phonological awareness was not supported.
Chapter 5
Discussion

Low levels of literacy are a problem among children and adults in the United States, prompting researchers to test interventions and strategies that may be effective in promoting literacy (Standley, 2008). Within early childhood, phonological awareness is a fundamental aspect of literacy. One set of possible strategies to promote phonological awareness may include music-based interventions. Before proceeding with the development of these interventions, basic research is necessary to clarify the relationship between music perception and phonological awareness.

The purpose of this study was to examine the role of music perception in phonological awareness in five- and six-year-old children, while controlling for age and visual spatial skills. Results from this study contribute to the understanding of the relationships among these variables, supporting previous studies and adding new findings. This study builds upon a pilot study (Lathroum, 2008) which found a statistically significant positive relationship between pitch perception and two specific phonological awareness skills: elision and sound matching.

In this study, music perception was assessed using three subtests from the Children’s Music Aptitude Test: rhythm, pitch, and melody (CMAT; Stevens, 1987). In addition, elision, blending, and sound matching skills in phonological awareness were tested using the Comprehensive Test of Phonological Processing (CTOPP; Wagner et al., 1999). Last, the researcher administered the Visual Spatial Skills subtest of the Woodcock Johnson III (WJIII; Woodcock et al., 2001). These data were analyzed using
structural equation modeling (SEM) techniques to investigate the role of music processing in phonological awareness, while controlling for age and visual spatial skills.

This chapter will provide an interpretation of the results based on the statistical analyses. The first section will present a discussion of the univariate and bivariate analyses, while the second section will discuss findings of the measurement model which used confirmatory factor analysis. The discussion will proceed to an examination of the full and comparison models to address the research questions. This section will interpret results from the current study and relate findings to previous literature. The two final sections will examine limitations and propose recommendations for future research, followed by theoretical and clinical implications.

**Discussion of the Univariate and Bivariate Analyses**

Findings from the univariate and bivariate analyses are necessary for understanding the constructs under investigation before proceeding to the confirmatory analysis and research questions. Results from the univariate analyses revealed differences in mean scores, that is, participants tended to obtain higher mean scores on certain tasks within music perception and phonological awareness, suggesting differences in terms of task difficulty. In the pitch, rhythm, and melodic processing tasks, children discriminated between pairs of sound sequences. The rhythm subtest showed the highest mean score, followed by pitch, then melody, thus indicating that rhythmic patterns were easiest for participants to process and melodic patterns were most difficult. Results confirm previous research indicating that children’s rhythmic perception skills develop prior to skills in pitch and melody (Hargreaves, 1986).
Findings also supported previous research regarding a sequence of complexity for phonological awareness skills (Lane & Pullen, 2004). Phonological awareness tasks have been shown to be progressively difficult in this order: matching sounds, elision, and blending (Carroll et al., 2003). During the sound matching task, children identified words that began or ended with the same sound. This task appeared to be the least complex of the phonological awareness tasks, as evidenced by the highest mean scores in this subtest.

The next task, elision, elicited the second highest mean scores. In this task, the children isolated one syllable or one phoneme and subtracted it from the rest of the word to create a new word (Lane & Pullen, 2004). The third phonological awareness task was sound blending, a task in which children listened to a series of sounds in order and joined them to form a whole word. Sound blending appeared to be the most difficult task, as evidenced by the lowest mean scores out of the three phonological awareness tasks. These findings support the phonological awareness progression in previous research (Carroll et al., 2003). Overall, results from the descriptive statistics support the idea of a developmental progression in children’s music perception and phonological awareness.

The descriptive statistics provided a foundation for the correlational analyses. All of the variables in this study showed positive correlations with each other. The three music perception indicators; rhythm, pitch, and melody, had statistically significant correlations with each other. The three phonological awareness variables; elision, blending, and sound matching, also had statistically significant correlations with each other. Additionally, results showed statistically significant correlations between the three music perception indicators and the three phonological awareness indicators. Consequently, this study’s results support previous correlational research (Bozic et al.,
indicating that perception of both pitch and rhythm were related to phonological awareness.

Additional confirmation for these findings can be found by comparing them to correlations obtained in the pilot study (Lathroum, 2008). Such comparisons help to determine whether the correlations were generalizable beyond this sample. Ensuring that the correlations in the sample for this study were not simply sample-specific correlations, and were instead, representative of population correlations, will allow results to generalize to five- and six-year-old children.

The current study is supported by the pilot study which found similar significantly positive correlations. Specifically, both studies revealed a significantly positive correlation between pitch perception and elision. In addition, both investigations found a significantly positive correlation between pitch perception and sound matching. In the case of the full study, pitch perception had a statistically significant correlation with the sound matching composite. Similarly, in the case of the pilot study, pitch perception and sound matching last showed a significant correlation with each other. The current study found a significantly positive correlation between pitch perception and blending; however, the pilot study did not. Overall, the comparisons between the current study and the pilot study are limited for measurement reasons. The pilot study used a different test to measure pitch and did not measure rhythm or melody; therefore, comparisons can not be drawn in respect to the two latter variables.

In summary, correlations from this study align with results from the pilot study and from previous research. Therefore, the correlations in the current study are not simply an anomaly of this particular sample. Results across both studies and previous
studies suggest that the sample of the current study is representative of the general population of five- and six-year-old children. Similarities in findings among the current study, the pilot study, and previous research, suggest that generalization of results to the general population is likely. In addition to generalizability of findings, the correlations support proceeding with the analysis to examine the measurement model.

**Discussion of the Measurement Model**

Upon completion of the correlational analysis, a confirmatory factor analysis (CFA) was used to examine the measurement model. This particular step in the SEM analysis was necessary because it allowed the researcher to verify how well the indicators loaded onto the latent variables of music perception and phonological awareness (Kline, 2005). In other words, CFA was used to create latent variables from observable indicators and to determine how well the indicators were loading, or sharing variance, to form these latent constructs, which were not measurable in and of themselves.

For example, music perception is an abstract construct that is difficult to measure with just one indicator, (i.e., pitch perception does not completely define music perception). The use of multiple indicators; such as perception of pitch, melody, and rhythm, to create a latent variable was more appropriate than using a single indicator. Similarly, assessing phonological awareness as a construct is difficult, so a latent variable was formed from elision, blending, and sound matching. In summary, the purpose of the CFA was twofold: first, to create latent variables representing constructs that could not be directly measured, and second, to determine how well the indicators, or measured variables, loaded to form those latent variables.
The CFA showed good fit as indicated by various model fit indices. In other words, the theory of how the indicators formed the latent variables was confirmed, and the CFA fit the data well. Specifically, the data showed that perception of pitch, rhythm, and melody loaded well to create a music perception latent variable. That is, each element contributed heavily to creating the music perception variable. Pitch showed a higher standardized loading (.87), than melody (.83) or rhythm (.75). Therefore, the children’s scores for pitch had a greater impact on determining the latent variable music perception. Although pitch showed a stronger contribution than melody or rhythm, these three loadings are quite similar, indicating a strong contribution from each of these indicators.

The CFA also allowed the researcher to create a latent variable of phonological awareness from the shared variance between elision, blending, and sound matching. All three indicators contributed heavily to the latent variable: elision (.89), blending (.71), and sound matching (.70). Elision showed a stronger contribution to phonological awareness than the other variables. However, the similar magnitude of the loadings indicates that all three indicators contributed heavily to the phonological awareness latent.

As mentioned, the indicators in this study loaded well onto their respective latent variables, meaning that they shared variance to create the music perception and phonological awareness variables. The use of latent variables offered two benefits (Kline, 2005). First, latent variables allowed the researcher to account for measurement error by using the shared variance among the indicators. Second, creating latent variables allowed the researcher to better assess the constructs by using multiple indicators, as opposed to
just one. For example, music perception could be better defined by using data regarding the processing of pitch, rhythm, and melody, as opposed to simply pitch processing.

By contrast, previous research has used only observed variables and not latent variables to study music perception and phonological awareness. By using individual, observed indicators as opposed to latent variables, prior studies did not have a way to account for measurement error which may have attenuated (i.e., reduced in magnitude) the regression coefficients (Kline, 2005). Therefore, the relationship between music perception and phonological awareness was potentially underestimated to a degree that directly relates to the amount of measurement error.

Results from the CFA also showed that the music perception latent variable was significantly and positively correlated to the phonological awareness latent variable, \( r = .46 \) (\( p < .001 \)). Findings for \( r^2 \) indicated that music perception and phonological awareness shared 21.16% of the observed variance with each other. Therefore, the \( r^2 \) value suggests that music perception accounts for 21% of the variance in phonological awareness, and vice versa.

To summarize, CFA was an important component of the analysis because it allowed the researcher to create latent variables. This step was essential for building the full model which examined the relationship between the latent constructs of music perception and phonological awareness. In addition, results from the CFA provided meaningful insight into the creation of the phonological awareness and music perception latent variables. The following section will examine the relationship between these constructs in more detail by studying results based on the research questions.
Discussion of the Research Questions Based on the Full and Comparison Models

The ensuing SEM analysis allowed the researcher to investigate three research questions. The researcher examined the full model in order to answer research questions 1 and 2. A chi-square difference test was then used to examine an alternative model and answer research question 3.

**Research question 1.** Research question 1 examined whether the theory that music perception, age, and visual spatial skills predict phonological awareness fit the observed data of this study. The model showed good fit to the data as indicated by various fit indices, and the variables were related as theorized. Therefore, fit results support this theory by confirming relationships among the variables.

In addition to the fit results, research question 1 is further supported by the amount of variance accounted for in regard to phonological awareness. Specifically, music perception, age, and visual-spatial skills accounted for 30.3% of the variance in the latent variable, phonological awareness. This amount of variance is somewhat lower than that reported in previous research that did not account for music perception, focusing instead on other variables. For example, McBride-Chang (1995) showed that cognitive ability, speech perception, and verbal memory accounted for 60% of the variance in phonological awareness. Similarly, McDowell, Lonigan, and Goldstein (2007) showed that age, SES, vocabulary, and speech perception accounted for 69% of the variance in phonological awareness.

This study measured different variables than these earlier findings, possibly contributing to the lower variance accounted for in phonological awareness. In contrast to previous investigations, the present study did not intend to examine all predictors of
phonological awareness. Instead, the researcher was more interested in the specific contribution of music perception, visual spatial skills, and age to phonological awareness. Therefore, speech perception, verbal memory, SES, and vocabulary, which have been shown to be predictors of phonological awareness, were not measured or included as predictors in the present study. As previously mentioned, the goodness of fit of the model and the variance that the model accounts for show that music perception, age, and visual spatial skills are related to phonological awareness in a meaningful way.

Because the relationship between music perception and phonological awareness is complex and multifaceted, researchers have accounted for several factors involved in this relationship. The present study makes a contribution to the research literature by also accounting for age and visual spatial skills, as related to music perception and phonological awareness. While previous research has explored a number of variables in the relationship between music perception and phonological awareness, none of those investigations used the same variables and methodology as this present study, thus limiting comparisons. Therefore, to the extent possible, this study’s findings will be compared and contrasted to previous studies.

This study confirms previous research that also found a relationship between music perception and phonological awareness while including age and various cognitive abilities (Anvari et al., 2002; Loui et al., 2011; Rubinson, 2009). Differences emerge in that these studies examined the constructs by investigating other variables that were either not measured or defined constructs differently than in this study.

Variables measured in other research, but not assessed in this study, include SES (Rubinson, 2009), and observed consistency between pitch production and perception
(Loui et al., 2011). Additionally, certain studies did not include rhythm perception as a variable (Loui et al., 2011). As another example, one study (Anvari et al., 2002) examined age as a grouping variable, whereas this study included age as a continuous variable. Anvari et al. also accounted for sound segmentation in speech, digit span (auditory memory), vocabulary, and math. Additionally, although these researchers measured phonological awareness, in the analysis they ultimately sought to predict early reading ability, as opposed to predicting phonological awareness.

To summarize the discussion for research question 1, results show that music perception in combination with other non-musical factors, such as age and visual-spatial skills, play a role in phonological awareness. Results confirm previous research investigating the relationships among these constructs (Anvari et al., 2002; Loui et al., 2011; Rubinson, 2009). These findings make an important contribution to the research literature investigating the relationship between music perception and phonological awareness. Results demonstrate that along with music perception, age and visual spatial skills are also significant predictors of phonological awareness. When comparing this study to previous literature, differences in methodology and definitions of the variables emerge. Additionally, previous studies did not use the latent variable approach in SEM. Therefore, comparisons with prior research are limited.

**Research question 2.** Research question 2 investigated whether music perception made a unique contribution to phonological awareness, while accounting for age and visual spatial skills. Results indicated that the music perception variable played a statistically significant role in predicting phonological awareness, above and beyond the influence of visual spatial skills, and age. Furthermore, this relationship had a positive
direction, meaning that children with better music perception skills tended to have better phonological awareness skills. Specifically, standardized regression coefficients showed that a one standard deviation unit increase in music perception, while controlling for age and visual spatial skills, predicted a .39 standard deviation unit increase in phonological awareness. In turn, a one standard deviation unit increase in visual spatial skills, while accounting for music perception and age, was associated with a .24 standard deviation unit increase in phonological awareness.

The variable of age had direct, indirect, and total effects on phonological awareness. That is, in addition to age’s direct effect on phonological awareness, it also had an indirect effect with visual-spatial skills as a mediator. The total effects, meaning the combined influence of the direct and indirect effects, showed that a one standard deviation unit increase in age, while controlling for music perception and visual spatial skills, predicted a .27 standard deviation unit increase in phonological awareness.

Based on the previous standardized regression coefficients, the contributions of music perception, visual spatial skills, and age can each be interpreted as having a moderate effect on phonological awareness. That is, each of the three variables had a meaningful role in predicting phonological awareness. However, music perception was associated with a larger standard deviation unit increase (.39) in phonological awareness, as compared to age (.27) or visual spatial skills (.24), showing that music has a greater role in phonological awareness than the other two variables.

Findings for research question 2 support previous research that found significant relationships between pitch perception and phonological awareness using partial correlations to remove the effects of non-verbal ability (Lamb & Gregory, 1993). Results
also confirm previous research (Moritz, 2007) that showed a relationship between rhythm and phonological awareness beyond non-verbal ability, also using semi-partial correlations.

In conclusion, results for research question 2 showed that music perception makes a unique contribution to phonological awareness, beyond age and visual spatial skills. Results also revealed that music had a larger contribution to phonological awareness than the other two predictors. Thus, music perception appears to have a stronger relationship with phonological awareness than age or visual spatial skills.

**Research question 3.** To further explore the contribution of music perception to phonological awareness and answer research question 3, differences between the full model and a comparison model were examined. The full model tested the theory that allowed music perception, visual spatial skills, and age to predict phonological awareness. By contrast, the comparison model tested the theory that included visual spatial skills and age, but omitted music perception as a predictor of phonological awareness. The researcher examined whether the comparison model fit the data as well as the full model.

Although the full model fit the data well as explained in the discussion of research questions 1 and 2, the possibility existed that other alternative models could also fit the data (Kline, 2005). Therefore, this study needed to examine an alternative theory that did not account for the construct of music perception. The comparison model, which omitted music perception as a predictor of phonological awareness, showed poor fit to the data. Poor fit meant that the data did not support the comparison model, which omitted music
perception as a predictor and only allowed visual spatial skills and age to predict phonological awareness.

Next, the researcher compared the two models, including the full model allowing all variables to predict phonological awareness, and the comparison model which omitted music perception as a predictor. Results showed that the comparison model fit the data significantly worse than the full model. In addition, the full model accounted for more variance in phonological awareness than the comparison model. That is, the full model (i.e., that included music perception as a predictor) explained 11.4% additional variance than was accounted for by visual spatial skills and age alone in the comparison model. These findings further confirm the important role that music perception plays in phonological awareness.

No previous study has examined the constructs of interest in this particular way, that is, verifying whether a theory that does not include music perception fit the data as well as a theory that does include music perception in predicting phonological awareness. The findings substantiate and further support results found in other studies indicating that music perception has a meaningful relationship with phonological awareness (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Bozic et al., 2007; David et al., 2007; Forgeard et al., 2008; Lamb & Gregory, 1993; Moritz, 2007; Peynircioglu et al., 2002; Rubinson, 2009). Results for research question 3 contribute to the understanding of the relationship between the constructs of interest in a way that previous studies have not addressed. Specifically, because of the analysis used in this study, these results offer a new understanding of these relationships by providing evidence that music perception
plays a unique role in predicting phonological awareness, that is above and beyond the role of visual spatial-skills or age.

In conclusion, the discussion of the three research questions showed that data were consistent with previous studies which revealed a positive relationship between music perception and phonological awareness. In regard to research question 1, results showed that music perception, visual spatial skills, and age contribute significantly to phonological awareness. Findings for research question 2 indicated that music perception makes a unique contribution to phonological awareness, separate from age and visual spatial skills. In relation to research question 3, results did not support a model in which music perception was not allowed to predict phonological awareness, providing further evidence that music perception has a unique role in predicting phonological awareness, above and beyond visual spatial skills and age. Taken together, these results show that although age and visual spatial skills play important roles in phonological awareness, music perception, in and of itself, also plays a significant role, thereby justifying its contribution to phonological awareness.

**Limitations and Recommendations for Further Study**

The findings of this study suggest that music perception contributes to phonological awareness beyond age and visual spatial skills. However, more research is necessary to further understand the relationships among these constructs. Limitations of this study will be discussed, including issues regarding children’s linguistic backgrounds. The results of this study provide various ideas for future studies with modifications to enhance external validity of the findings.
One limitation of this study was that 69% of the participants were dual language learners of both English and Spanish, and some of these children may have been more fluent in Spanish than in English. Research has shown that children’s proficiency in the English language, or lack thereof, may affect their phonological awareness skills in English, leading to lower scores in this area (Lopez, 2000). Therefore, dual language learners in this sample, particularly those who were more fluent in Spanish, may have obtained lower scores in phonological awareness as tested in English, than if they had been tested in Spanish. This particular sample of dual language learners may be characteristic of Miami Dade County and may not necessarily be representative of five- and six-year-old children across the United States. Therefore, the language background of the particular sample of this study could affect generalizability.

Consequently, a recommendation for future studies is to include language as another independent variable by studying children who are monolingual, bilingual, or who are learning English as a second language. In particular, children who are learning English as a second language may have difficulty with phonological awareness and emergent literacy in English (Lopez, 2000). Adding language as a variable would allow researchers to confirm whether or not this study’s results are generalizable to the overall population of five- and six-year-old children. The addition of this variable would allow researchers to investigate the role that language plays in the contribution of music perception to phonological awareness.

An issue related to language in this study was socio-economic status (SES). Participant diversity in regard to socio-economic status (SES) in the sample was evenly distributed. All of the children tested in this study attended public schools, and 48% of
the participants reported a combined household income of $50,000 or more, while 46% reported less than $50,000 combined income. An additional 6% did not report their income. Previous research has demonstrated a relationship between high SES and musical skill (Galliford, 2003). Children with high SES may also perform better than children with low SES in regard to phonological awareness (Korat, 2005), possibly due to receiving more educational opportunities and early stimulation.

The researcher observed that students at one of the three schools were more likely to be dual-language-learners and from lower SES households. Because children of low SES also tended to be dual language learners, they may have performed more poorly in phonological awareness measures that were administered in English. A second recommendation for future studies is to include SES as a variable which may contribute to predicting a larger amount of variance in phonological awareness.

A third recommendation involves an examination of the relationship between music perception, visual spatial skills, age, and phonological awareness, considering yet other contributing factors that were not investigated in the present study. These findings showed that the variables in the model, including music perception, visual spatial skills, and age combined, explained 30% of the variance in phonological awareness. That is, other factors involved in phonological awareness that were not included in this model account for the remaining variance. As mentioned earlier in this chapter, previous research has studied factors that appear to be influential in phonological awareness, including verbal intelligence, vocabulary size and speech perception (McBride-Chang, 1995; McDowell et al., 2007). Consequently, researchers may be better able to understand the relationship between music perception and phonological awareness by
also considering other related variables, such as vocabulary size and verbal intelligence, in addition to visual spatial skills and age, thus explaining more of the variance in phonological awareness.

To summarize, future research could examine the relationships between music perception and phonological awareness in other populations, such as children who are learning English as a Second Language. Researchers could include other variables, such as verbal intelligence and vocabulary size, that were not examined in this study. The discussion of the findings will proceed with an examination of theoretical and practical implications of this research.

**Implications of the Findings**

This study offers both theoretical and practical implications regarding the relationship between music perception and phonological awareness. Theoretical implications will focus on this particular study’s contribution to the understanding of the relationship between the constructs. Practical implications will focus on the importance of this basic evidence to explaining how music-based interventions may be effective in promoting phonological awareness.

**Theoretical implications.** In terms of theoretical implications, this study further elucidates the specific role of music perception in phonological awareness, while accounting for age and visual spatial skills, which appear to also have a relationship with phonological awareness. These findings give greater clarity to the relationship between the constructs, by showing that music perception makes a unique contribution to phonological awareness, separate from the contribution of age and visual spatial skills.
Results suggest a positive relationship between music perception and phonological awareness, and findings reveal that these two constructs share a certain amount of observed variance. This relationship and shared variance may reflect a parallel developmental progression and parallel neurological functioning involved in these two perceptual processes. The apparent overlap between these processes may be due partially to the fact that children perceive speech and music over time, requiring children’s use of auditory temporal processing skills and Gestalt perception, respectively. The parallel developmental progression for music perception and phonological awareness may be based on the fact that during both types of processing, children initially exhibit more global perception and with age and experience, their skills become more refined, allowing them to focus on local and specific elements.

This study’s findings regarding shared variance and the contribution of music perception to phonological awareness also support previous research showing that speech and music both have temporal and spectral qualities. Children appear to perceive these acoustic characteristics in parallel neuroanatomical structures, regardless of whether the stimuli consist of music or speech sounds. Therefore, this study’s results provide a theoretical contribution by supporting previous research showing parallel neuroanatomical structures involved in music perception and phonological awareness. Overall, theoretical implications support a role of music perception in phonological awareness based on parallel auditory processing mechanisms, developmental progressions, and neuroanatomical functioning.

**Practical implications.** In addition to theoretical contributions, this study also has clinical implications. Results showed that music plays a unique role in predicting
phonological awareness. This basic evidence furthers the understanding of music perception and phonological awareness in young children, as well as the relations between these constructs. This knowledge may benefit various professionals, from early childhood specialists and elementary teachers to reading specialists, special educators, and music therapists, all of whom work to promote children’s early literacy.

These results reveal a relationship that serves as the basis for future studies by providing necessary evidence regarding how music-based interventions may influence phonological awareness. This relationship allows researchers to proceed with an investigation of the effects of music to promote phonological awareness. Results also establish a foundation for the interpretation of findings from previous applied studies, as necessary for greater generalization of results. The relationship evident from this study’s results allows researchers who perform applied research to predict that music-based interventions may have a meaningful, therapeutic effect on phonological awareness.

More specifically, based on the established relationship, future studies could investigate music therapy interventions to promote phonological awareness. These interventions could be designed for children who have deficits in auditory temporal processing or speech perception, or who are at risk for reading disabilities, such as dyslexia. For example, rapid temporal processing supports children’s ability to perceive and manipulate rapidly-occurring sounds, such as consonants (Tallal et al., 1997). This skill can be especially difficult for some children with dyslexia. These children also tend to have problems with rhythmic skills, including the perception and production of rhythm patterns (Overy, 2003). Deficits in rapid, temporal processing and perception of rhythm may contribute to problems in phonological awareness, including difficulty in
segmenting speech. This study’s findings may provide a foundation for music-based interventions designed to activate, strengthen, and promote the development of auditory processing mechanisms, therefore improving phonological awareness.

This study may also provide support for neurologic music therapy techniques, such as, Developmental Speech and Language Training through Music (DSLM; Thaut, 2005) and Auditory Perception Training (APT; Gardiner, 2005). These techniques could be used to promote early literacy skills in children who have reading difficulties (e.g., dyslexia) or who are at risk for having a reading disability.

Developmental Speech and Language Training through Music (DSLM; Thaut, 2005) is a neurologic music therapy technique that uses musical strategies to foster speech and language development. Musical interventions including singing, moving, and playing instruments can be used to teach sounds, letters, and vocabulary. DSLM could also be used to teach children to make a connection between an auditory stimulus and a visual representation.

A second neurologic music therapy technique, Auditory Perception Training (APT; Gardiner, 2005) may be effective in promoting phonological awareness. APT consists of music-based exercises developed for improving auditory perception, including discrimination of various musical components, such as rhythm and pitch. This technique could be used to promote children’s development of phonological awareness skills, particularly elision, blending, and sound matching, by designing music interventions that parallel such skills. For example, to promote elision, children could listen to a melodic pattern and then sing the pattern while eliminating one of the notes. To foster blending, the child could listen to individual notes, then blend these sounds and sing back a
cohesive auditory Gestalt in the form of a melody. Last, to work on sound matching skills, music therapists could provide interventions in which children identify melodic patterns that begin or end on the same pitch.

In summary, this study’s results support a relationship between the constructs of interest, providing the necessary evidence for subsequent clinical studies to examine the effects of music-based interventions to promote five-and six-year-old children’s phonological awareness. Future research should investigate the relationship between music perception and phonological awareness in children who are at risk for reading disabilities, such as dyslexia, and the effects of music on phonological awareness in these particular children.

**Conclusions**

Based on this study’s results, several conclusions can be drawn. Music perception, visual spatial skills, and age predicted phonological awareness in the theorized manner for these five- and six-year-old children. More specifically, music perception predicted a larger change in phonological awareness than the other predictors. The data did not support a model that omitted music perception as a predictor of phonological awareness. The relationship between music perception and phonological awareness may be due to parallel developmental sequences for perceptual processes (i.e., from global to local perception) and parallel neuroanatomical functioning. This study supports further research regarding the contribution of music perception to phonological awareness. Furthermore, this study’s findings could be used to support the development of therapeutic interventions for children who are at risk for reading disabilities and dyslexia.
References


Mplus (Version 6) [Computer software]. Los Angeles, CA: Muthén & Muthén.


SPSS (Version 17.0) [Computer software]. Chicago: SPSS Inc.


Dear Parent,

Your child is invited to participate in a research study regarding music perception and speech perception, which is also known as phonological awareness. Music perception includes children’s ability to determine whether two musical sounds are the same or different. Phonological awareness refers to the way children hear sounds in speech. The project seeks to look into the relationship between music pattern discrimination and phonological awareness in five- and six-year-old children.

As part of this study, your child’s music perception and phonological awareness will be tested. Testing will take place at your child’s school during school hours. First, the researcher will measure your child’s music perception. Within two weeks, your child’s phonological awareness will be tested. Within two more weeks, your child’s visual-spatial perception will be tested.

If you would like your child to participate in this project, please sign the attached consent form and return it to your child’s teacher. Additionally, please fill out the attached demographic questionnaire. If you would like to discuss this project with me in greater detail, please do not hesitate to contact me. Thank you.

Sincerely,

____________________________
Linda M. Lathroum, MA, MT-BC
Appendix B: Informed Parental Consent Form


PURPOSE OF STUDY:
Your child is being asked to participate in a research study investigating music pattern discrimination and phonological awareness in children. Music pattern discrimination refers to children’s ability to discriminate whether two sets of music patterns are the same or different. Phonological awareness refers to the way children hear sounds in speech. The purpose of this study is to investigate whether a relationship exists between music pattern discrimination and phonological awareness skills in five- and six-year-old children. Your child is being asked to take part of this study because he or she is in kindergarten and is five or six years in age.

PROCEDURES:
Please read this form and ask any questions you may have before you agree to allow your child to participate in this study. The investigator, Linda M. Lathroum, will visit the school that your child currently attends. At your child's convenience and daily schedule of the school program, the investigator will arrange to test your child individually in a room at the school. Your child’s music perception, phonological awareness, and visual-spatial skills will be tested. All testing procedures will be completed by the investigator.

On the first day of the study, your child will listen to musical sounds and decide if they are the same or different. This test takes 25 minutes.

Within two weeks, your child will listen to speech sounds and complete various tasks, such as repeating parts of words, combining sounds to create words, and matching words that contain similar sounds. This test takes approximately 20 minutes.
Within two more weeks, your child will look at a shape and various parts of shapes. Your child will then determine which shape parts form the original shape. This test takes approximately 15-20 minutes.

**RISKS:**
No foreseeable risks or discomforts are anticipated for your child by participating in this study.

**BENEFITS:**
No direct benefit can be promised to your child by participating in this study. This study’s findings could be used to develop therapeutic interventions for children who are at risk for reading disabilities.

**ALTERNATIVES:**
You have the alternative for your child not to participate in this study. You and your child have the right to refuse to participate and nothing will happen to you and your child as a result. Your child's care at his/her school will not be affected. If you do not allow your child to participate in this study, your child will continue with his/her daily school routine.

**INCENTIVES:**
No monetary payment will be given for participation in this study. Your child will receive stamps, stickers, or a small toy after testing.

**CONFIDENTIALITY:**
The researcher will consider your child's records confidential to the extent permitted by law. That is to say, any information obtained about your child from this study including answers to questionnaires, performance on a test, etc., will be kept strictly confidential. The U.S. Department of Health and Human Services (DHHS) may request to review and obtain copies of these records. Your child's records may also be reviewed for audit purposes by authorized University of Miami employees or other agents who will be bound by the same provisions of confidentiality.

We will protect your child’s confidentiality by coding your child’s information with a number so no one can link your child with his/her answers, by disposing of paper records, and by storing data in secure areas. The collected data will not hold any information that will
identify your child. Data will be coded by special number rather than by your child's name. Hard copies or discs containing your child's records will be secured in a locked file cabinet to which the investigator, Linda M. Lathroum, will have the only access.

**VOLUNTARY NATURE OF THE STUDY:**
Your agreement for your child's participation is voluntary. You are free to choose not to participate in the study without any penalty. You and your child have the right to withdraw from this study. If you do not want your child to participate or your child does not follow the procedures, the researcher can also remove your child from the study without your consent. During the study, you may stop your child's participation at any time by contacting the investigator or the school teacher. If you or your child decide to stop participating in the study, the information gathered will be destroyed. If your child does not cooperate or does not want to participate in the study, the investigator will stop the testing.

**OTHER PERTINENT INFORMATION:**
Dr. Shannon de l’Etoile (305) 284-3943 will gladly answer any questions you may have concerning the purpose, procedures, and outcome of this project. If you have any question concerning the research study or your child's participation in this study, please contact Linda M. Lathroum, MA, MT-BC via e-mail at lindalath@gmail.com. The researchers can also be contacted at P.O. Box 248165, Coral Gables, FL 33124. If you have any question about your child's rights as a research participant in this research, you can contact University of Miami, Human Subjects Research Office at (305) 243-3195 or the Miami Dade Schools Research Review Committee at 305-995-7529.
Please sign and turn in this page and the demographic questionnaire on the following page.

PARTICIPANT AGREEMENT:
I have read the information in this consent form and agree to allow my child to participate in this study. I have had the chance to ask any questions I have about this study, and they have been answered for me. I am entitled to a copy of this form after it has been read and signed.

Child’s Name: ________________________________________________________________

If you give permission for your child to participate in this study, please sign below.

Parent’s (Caregiver’s) Name: _________________________________________________

Parent Signature: __________________________________________ Date: __________
I give permission for my child to participate in this study.

If you refuse your child’s participation in this study, please sign below.

Parent’s (Caregiver’s) Name: _________________________________________________

Parent Signature: __________________________________________ Date: __________
I do NOT give permission for my child to participate in this study.

Researcher’s Name: __________________________________________________________

Researcher Signature: __________________________________________ Date: __________
Appendix C: Demographic Questionnaire

Today’s Date: ____________________________

Child’s code: _______ Child’s date of birth: ________________ Child’s gender: ____

Child’s Primary Language: ____________________________________________

Is your child bilingual? YES  NO

If you answered yes, what is your child’s first language? __________________

If you answered yes, what is your child’s second language? ________________

Language spoken most frequently in the home: ____________________________

Which of the following best describes your household income before taxes?

_____ below $25,000
_____ $25,000 - $50,000
_____ $50,000 - $75,000
_____ over $75,000

Please check all that apply:

_____ Child receives group music class at school:
    _____ once a week    _____ more than once a week    _____ daily

_____ Child attends a group music class outside of school:
    _____ once a week    _____ more than once a week    _____ daily

_____ Child receives individual music lessons to play a musical instrument.

_____ Child sings in a choir (i.e., church choir or community children’s chorus)

_____ Child’s parents or siblings are active, performing musicians.

Other: (Please describe.)
________________________________________________________________________
________________________________________________________________________