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THREE INVESTIGATIONS OF PHONOLOGICAL AWARENESS AND MUSIC APTITUDE

A Dissertation in
Music Education
by
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Abstract

Phonological awareness skills are important for success in language-related tasks, such as reading and speaking. Deficits in phonological awareness can lead to difficulties learning to read and are associated with speech perception and production problems. Children who have difficulty articulating the sounds of speech may have phonological awareness deficits and are more likely to experience delayed academic, communicative, and socioemotional development.

Relationships between music aptitude and phonological awareness have been reported among typically developing children and those with dyslexia. Further, musical participation has helped improve phonological skills in these populations during literacy/phonological programs or when students engage in general music activities. The majority of previous investigations have examined these relationships in preschool and kindergarten children, whose phonemic inventories are still developing. Little is known about the relationship between music aptitude and phonological awareness among children whose music aptitude is still developing, but whose mental representations of speech sounds are more nearly complete. The purpose of this dissertation was to examine the relationship between phonological awareness and music aptitude among children in grades 2 and 3, as well as children with speech sound disorders.

Three studies were conducted in which a phonological awareness test and a music aptitude test were administered to three groups of elementary students in Pennsylvania. In Study 1, I sought to understand this relationship among children in second grade ($N = 17$). Study 2 was a longitudinal investigation in which participants from Study 1 ($N = 7$) were re-tested in third grade. During Study 3, this relationship was examined among children with speech sound disorders ($N = 12$) who were in kindergarten, first grade, second grade, and third grade.
Findings indicated a significant, positive relationship between phonological awareness and music aptitude. Linear regressions determined music aptitude raw scores were reasonable predictors for phonological awareness standardized scores among typically developing children and children with speech sound disorders. Further, tonal music aptitude measured in second grade may predict phonological awareness measured in third grade. Results from these investigations indicate the auditory processing skills necessary for phonological awareness are related to those required for musical understanding.

*Keywords:* phonological awareness, music, special needs, speech and language impairments, speech therapy, reading
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Preface

I spent 5 wonderful years as a K-12 music educator in Michigan. I taught bands, choirs, and general music at varying levels. I was the music teacher. While the job was certainly a handful at times, it afforded me opportunities to teach students who represented a variety of ages and ability levels in multiple settings. However, when I first accepted the position, the workload was not my primary concern. As the school year approached, I learned I would have students labeled as “nonverbal” in my early elementary general music classrooms—and I was not confident I could effectively teach them.

Yet, my concerns were unfounded. School started and the students integrated rather seamlessly. The Curwen hand signs and sign language we used during regular classroom instruction proved both engaging and beneficial. Each semester the K-2 students incorporated sign language into a song for the holiday program, where one sign was typically used to represent each phrase of text. In the spring, these students would learn to sign an entire folk song, based on the Signing Exact English system, which is considered to be a representation of English vocabulary and grammar.

After a while, I started to notice the children who had been labeled as “nonverbal” verbalizing more and more in the music space. They were attempting to sing songs and executing melodic patterns in class songs correctly. It seemed their language skills had been improving, but I did not feel qualified to determine such development on my own. I invited the speech-language pathologist (SLP) to observe a class and provide her opinion. After observing one class, the SLP told me she had never seen the students so engaged or attempting some of the speech sounds that they had for me. We concluded that we did not know what features of my instruction were aiding
in the students’ success, but we both agreed that something about the music class was contributing and I needed to figure out what it was.

This exchange greatly altered my path as an educator. Inspired, I went back to school and chose to further investigate this phenomenon during my graduate studies. Over time, I have discovered music and language share many of the same neural processes, which may partially account for the benefits my students were realizing. Further, I learned many more students than I had previously known struggle with language-related skills, in numbers I had not fathomed. I also had not considered thoroughly how such difficulties could affect students’ participation in music. Therefore, the purpose of my research has been to understand the relationship between children’s ability to analyze and manipulate the sounds of language and their ability to understand the sounds of music.

While I am not a speech-language pathologist or reading specialist, I have spent a number of years deepening my understanding of concepts typically discussed in these fields (e.g., phonological awareness, speech development). My knowledge within these fields continue to grow and I am excited to share what I have learned so far on this journey in this dissertation. I hope the results of my investigations will shed light on the relationships between understanding features of language and music. These relationships may imply musical instruction has dual benefits for students in the areas of language and music, which could allow them to spend more time engaged in musical activities that will enhance skills naturally.
Acknowledgments

Words will never suffice to express how truly blessed I have felt to walk this path with so many amazing individuals. But, I suppose I can try. I would like to thank those who contributed to this journey: my family, friends, colleagues, and professors. This was not always easy and I certainly faced obstacles along the way. The support and encouragement from everyone spurred me on and helped to make this possible.

My colleagues, professors, and friends in State College have always pushed me to deepen my thinking and persevere. I have had the opportunity work with some of the most amazing and influential scholars—many of whom I recruited for my dissertation committee! Still, graduate studies can be trying, disheartening, enthralling, lonely, and joyful all at once. The relationships I built during my time at Penn State are those that will last a lifetime. You all have inspired me, pushed me, critiqued me, laughed with me, cried with me, and celebrated with me, but, above all, you have supported me. You made what could have been an arduous experience a true labor of love and joy.

Dr. Joanne Rutkowski took a risk on a girl from Michigan in 2005. During that summer, she agreed to work with the undergraduate on a single research project. Over a decade later, the skills acquired during that experience have culminated in my dissertation. I could not be more thankful for the time and energy she invested in me throughout this process. She has inspired me as a scholar and person in a number of ways. I hope to “pay it forward” by treating my future graduate students with the care and respect she has modeled for me over these many years.

Other individuals were willing to give their time to answer my, seemingly endless, stream of questions. First, the Institutional Review Board at Penn State is truly second to none. I want to
give a special thank you to Philip Frum, whose insights throughout this process served to streamline and focus many facets. Next, I have been so humbled by the amazing speech-language community who have really supported my efforts and embraced me as a colleague. Some notable individuals include Barbara Roberts (I had to track you down and now you’ll never get rid of me!), Monica Gastiger, Dayna Hughes, Joyce Hall, and Elaine Bernstorff. Last, but certainly not least, Patrick Gregorits was by my side for the majority of this wild ride. I could not have asked for a better proof-reader, study buddy, or partner. You, too, endured many 12-hour study/write days and worked alongside me through many. You pushed me to streamline, clarify, and expand my thinking, which led to some of my more notable insights along the way. You facilitated my growth as a scholar and a person and helped make my professional dreams come true. I am eternally grateful for the role you have played in my life.

I am forever thankful to my participants, their families, and the school districts who so graciously contributed to this important work. My ultimate goal is to help children succeed by understanding the underlying mechanisms that can support their progress. Thank you for helping make that possible for future children.

Finally, my mother—who claims to not understand my research when she reads it—was always a willing proof-reader and my biggest cheerleader. I could never thank her enough for the support and encouragement she and Steve (The Dad) gave me throughout this process. You always said I could, and would, do it. You believed in me from start to finish. This one’s for you.
Chapter 1: Introduction

Background of the Problem

The presence of students with special needs in general education classrooms, including music classrooms, continues to increase (McFarland et al., 2017, pp. 110-113). As mandated by federal law, “students must have equal access to all aspects of the curriculum, including music education programs” (Hammel & Hourigan, 2011, p. 174). Yet, student access to music education may be limited due to the teacher’s limited knowledge regarding best accommodation practices (Abramo, 2012; Nabb & Balcetis, 2010), removal from general education classes for individual support (American Speech-Language-Hearing Association [ASHA], 2014), or lack of room in their schedules for music classes (Elpus & Abril, 2011; Hoffman, 2013). Hence, it is imperative music educators consider innovative avenues to ensure all students are able to participate fully in music settings.

All students are expected to achieve goals for speech and language under the Common Core Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). However, speech and language impairments can hinder students’ success achieving these goals. In addition to communication difficulties, students with speech and language deficits may have more difficulties acquiring communication skills (Call, 1980), developing academically and socio-emotionally (Baker & McLeod, 2011), and learning to read (Anthony et al., 2011; Bird, Bishop, & Freeman, 1995; Carroll & Snowling, 2004; Larivee & Catts, 1999; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004). They may also have phonological awareness deficits (Anthony et al., 2011; Bird et al., 1995; Carroll & Snowling, 2004; Kleeck, Gillam, & McFadden, 1998; Larivee & Catts, 1999; Raitano et al., 2004; Rvachew & Grawburg, 2006).
Although the number of students identified with speech and language impairments in 2013-2014 had declined from a peak in the 2006-2007 school year (Snyder, de Brey, & Dillow, 2016, p. 119), speech and language impairments consistently represent the second most-prevalent disability category outlined in the Individuals with Disabilities Education Act (IDEA) (McFarland et al., 2017, pp. 110-113; Snyder, de Brey, & Dillow, 2016, p. 119). Since 2000, children with speech and language impairments have consistently represented nearly 3% of the total school enrollment (Snyder, de Brey, & Dillow, 2016, p. 119). During the 2014-2015 school year, children with speech and language impairments accounted for 20% of all students served under IDEA, Part B—a staggering 1.3 million (McFarland et al., 2017, pp. 110-113).

A student identified with a speech or language need is typically assigned to a speech-language pathologist (SLP) or therapist and is often removed from typical classroom settings to receive individual assistance. Many children treated for speech or language impairments are elementary (K-6) students (Mullen & Schooling, 2010) and 87% of students identified with a speech or language impairment spend the majority of their time in general education classrooms (McFarland et al., 2017, p. 112). The American Speech-Language-Hearing Association (ASHA) (2014) reported 30% of students receiving speech-language treatment were mildly impaired, 44% were moderately impaired, and only 26% were severely impaired. Further, elementary students represented the lowest percentage of severe impairments (21%) and the highest percentage of mild impairments (ASHA, 2014). The prevalence of students identified with speech or language impairments in typical classrooms may be attributed to these students having mild impairments and, consequently, receiving services for a single sound error, such as gliding an /r/. Given the prevalence and diagnoses of children with speech and language impairments, music educators are likely to encounter students with mild to moderate speech and language...
impairments.

Although children with speech and language impairments are likely to attend music classes, such students may also be absent from music education spaces. In my experience, students may be regularly or intermittently pulled out of entire class sessions or parts of class sessions for special assistance. Further, it is possible children with severe communication impairments may not accompany peers to music classes. Consequently, these children may be denied the same access to a music education as their typical peers. Moreover, removing students with speech and language impairments from music classrooms may not be warranted, as both musical and speech-language skills could be bolstered through musical participation (Degé & Schwarzer, 2011; Moreno et al., 2009).

**Music Education for Students with Speech and Language Impairments**

Music educators have demonstrated interest in the connections between language and music and improving both processes simultaneously. In a review of the literature, O’Herron and Seibenaler (2007) discussed the intersections between vocal music and language arts instruction. Hansen, Bernstorf, and Stuber (2014) highlighted the ways music and literacy are connected. Hall (2014) shared how preservice music teachers are prepared to enhance language arts skills in the elementary classroom. Culp (2013) and Mizener (2008) outlined the benefits of Orff Schulwerk for enhancing language skills; Culp (2013) also connected music learning to the *Common Core Standards* addressing speech and language skills. Cardany (2013) touted the benefits of nursery rhymes in both music and language literacy. Finally, Leung (1985) presented ways in which music and movement could help improve language development among children with communication disorders. Emerging themes from this growing body of literature include the use of movement, rhyme, reading, text, singing, and game/action songs (Culp, 2013;
Given the present literature on the subject, it is apparent that music educators are interested in better understanding the relationships between music and language-related skills; as well as helping students improve in both domains simultaneously.

Understanding the relationships between musical abilities and phonological abilities could help professionals identify ways children may build communication skills more expediently. Scholars outside the field of music education have discussed the utility of music for students with speech and language impairments (Bauman-Waengler, 2012; Kilcoyne, Carrington, Walker-Smith, Morris, & Condon, 2014; Leung, 1985; Lim, 2012; Zoller, 1991), yet music may not be used often as a part of standard therapeutic treatment for these students. Music educators have looked to the field of speech-language pathology to help students improve in musical settings. Culp and Roberts (2015) outlined ways music teachers and speech-language pathologists could collaborate to help students achieve musical and speech-related goals. Instrumentalists also have noted the utility of speech and language techniques in instrumental settings. For example, Schade (2007) published a review of speech therapy exercises that could be useful for wind instrument learning. Ayers (2004) examined tongue techniques used in speech and brass playing. Music educators could communicate with speech-language specialist to allow for music to be meaningfully incorporated into those settings. By incorporating musical practices, students could improve both musical and extra-musical skills in additional settings, which could lead to higher musical achievement, academic achievement, and earlier dismissal from therapy.

Music educators should continue to investigate and understand the ways music benefits students to help all students receive a complete music education. Of course, music training has
been shown to increase music skills (i.e., Runfola, Etopio, Hamlin, & Rosendal, 2012; Yang, Ma, Gong, Hu, & Yao, 2014), which is important for all students. Additionally, music study has benefited students in the areas of literacy (Standley, 2008), speech (Moreno et al., 2009), language (Yang et al., 2014), and phonological awareness (Degé & Schwarzer, 2011). Understanding the ways in which music study can help students achieve these extra-musical goals is particularly important, given the substantial number of students struggling in these areas (McFarland et al., 2017, pp. 110-113; National Center for Education Statistics [NCES], 2015).

Demonstrating benefits for students in these areas could lessen the need for students to be removed from music classes for individual assistance, allowing students to remain in musical settings to build musical skills while simultaneously improving in other domains. While previous research certainly established linkages between phonological awareness and musical abilities, a substantial portion has been conducted with children under age 7 whose phonemic inventories are still developing and, therefore, the most likely to experience growth. It is imperative that the nature of this relationship among older children and those with speech and language impairments be examined as these children may experience limited growth during phonological training alone. Knowledge of these relationships could serve in the development of methods to be used by speech-language pathologists and also allow children to remain in music education settings.

**Purpose of the Studies**

Therefore, the purpose of the investigations in this dissertation was to determine the nature of the relationship between phonological awareness and music aptitude. Over a period of 3 years, I examined the nature of this relationship in three populations: typically developing children in second grade, typically developing children in third grade, and children with speech sound disorders in grades K-3. The investigations were conducted using evidence obtained from
Gordon’s (1986) measures of music aptitude: The *Primary Measures of Music Audiation* (PMMA) and *Intermediate Measures of Music Audiation* (IMMA); and *The Phonological Awareness Test 2* (PAT-2) (Robertson & Salter, 2007). It was expected that music aptitude scores would demonstrate a moderate-strong, positive relationship with phonological awareness scores; and this relationship would be more robust between tonal music aptitude and phonological awareness scores. The studies also sought to determine whether musical aptitude could predict phonological awareness over and beyond what can already be anticipated by known demographic predictors.

**Constructs of Interest**

Music ability and language ability are complex constructs, consisting of unique behaviors and developmental trajectories. As it is beyond the scope of these examinations to investigate either in its entirety, the smaller constructs of music aptitude and phonological awareness were chosen as central to these studies. Because these constructs may not be familiar to music educators and/or they can have various meanings, I discuss each as operationalized in these studies. Further background and rationale for the studies follow.

**Phonological Awareness**

Phonological awareness represents a person’s ability to analyze and manipulate the sounds of language. In this way, phonological awareness skills allow a person to recognize different sounds in a language and reproduce those sounds in various ways. Reliant on the auditory modality (Bauman-Waengler, 2012, p. 146), phonological awareness can be measured using a variety of tasks at multiple levels.

**Skill development.** Phonological skill development follows a predictable developmental trajectory, beginning in utero (Moon & Fifer, 2000; Partanen et al., 2013). The phonemic
inventory is typically in place by age 7 (Bauman-Waengler, 2012). Still, phonological skills can be improved rather indefinitely, although most plateau by age 15 (Bauman-Waengler, 2012) (see Figure 1.1). Although phonological deficits can be remediated, phonological processing abilities have demonstrated stability throughout the early years of life (Torgesen, Wagner, & Rashotte, 1994). Given this stability, there is a need to understand other cognitive variables that could influence response to treatment for phonological processing (Blachman, 1994).

![Figure 1.1. Theoretical representation of phonological skill development. This figure represents a theoretical understanding of the development of phonological skills in relation to the theorized stabilization period of the phonemic inventory. Hence, the visual is symbolic rather than representative of actual growth rates between birth and age 7 or thereafter.](image)

**Levels.** Phonological awareness encompasses all sizes of linguistic units, including phonemes (e.g., /b/ vs. /k/), syllables (e.g., batt-le vs. catt-le), onset-rimes (e.g., b-at vs. c-at), and words (e.g., bat vs. cat) which can be referred to as levels. Hence, phonological awareness may be understood generally in terms of phonemic awareness, syllable awareness, onset-rime awareness, and/or word awareness, which describe a person’s abilities at each level. In this way, phonological awareness is a multilevel skill.
Skills. A person’s phonological awareness can be understood through a variety of phonological skills. Rhyming, segmenting, isolating, deleting, substituting, and blending the sounds of language can be used to ascertain overall phonological awareness (Frost & Katz, 1992, pp. 194–195; Robertson & Salter, 2007; Yeh & Connell, 2008; Yopp, 1988). Tests of sound-to-word matching, phoneme reversal, phoneme counting, and word-to-word matching have been used to assess phonological awareness (Frost & Katz, 1992, pp. 194–195; Yopp, 1988). Figure 1.2 provides a visual representation of phonological skills. Table 1.1 provides an example of various skills and also describes the level at which the skill is demonstrated.

![Phonological Awareness Skills Diagram](image)

**Figure 1.2.** Phonological awareness skills. Examples of phonological skills used to determine phonological awareness achievement.
Table 1.1

*Examples of Phonological Awareness Skills, Tasks, and Levels*

<table>
<thead>
<tr>
<th>Skill</th>
<th>Task</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segmentation</td>
<td>Clap each time you hear a syllable in this word</td>
<td>Syllable</td>
</tr>
<tr>
<td>Blending</td>
<td>What word is this: “en-gine” [pausing in-between syllables]</td>
<td>Syllable</td>
</tr>
<tr>
<td>Substitution</td>
<td>What word do we have if we change the /t/ in “tall” to /b/</td>
<td>Phoneme</td>
</tr>
<tr>
<td>Deletion</td>
<td>Say “umbrella” without the “um”</td>
<td>Syllable</td>
</tr>
<tr>
<td>Isolation</td>
<td>What is the ending sound in the word “dog”</td>
<td>Phoneme</td>
</tr>
<tr>
<td>Rhyming</td>
<td>Do these words rhyme: “bat” and “sat”</td>
<td>Word</td>
</tr>
</tbody>
</table>

**Speech and reading.** Phonological awareness shares a key similarity with speech sounds, the physical sound realities of phonemes first realized in the mind (Bauman-Waengler, 2012). Both phonological awareness and speech depend on the auditory modality. Researchers have suggested a shared underlying phonological system that assists in both phonological awareness and speech skills (Chiappe, Chiappe, & Siegel, 2001; Mann & Foy, 2003). This underlying system may also account for the assertion that phonological awareness is one of the best predictors of reading success (Ehri et al., 2001; Yeh & Connell, 2008; Yopp & Yopp, 2000), which may be due to the facility of phonological awareness to promote speech sound mapping onto text (Deacon, 2012). The shared underlying system may also help to explain why children with speech sound disorders may be at an increased risk for phonological awareness deficits (Bird et al., 1995; Carroll & Snowling, 2004; Kleeck et al., 1998).

The connection between both phonological awareness and speech, both relying on the auditory modality, is an important consideration for the current discussion. Music aptitude also relies solely on the auditory modality. Hence, music aptitude may have a relationship with both phonological awareness and speech due to this shared reliance.

**Measurement.** Phonological awareness assessments can be researcher-designed or
standardized and measure a single skill or multiple skills. Debate exists regarding its most appropriate measurement (Wilde, Goerss, & Wesler, 2003; Yeh & Connell, 2008; Yopp, 1988). To provide a more comprehensive understanding of phonological awareness, standardized tests, that measure several phonological skills (e.g., blending, rhyming) at multiple levels (e.g., phoneme, syllable, word), have been developed. Due to its comprehensive assessment, The Phonological Awareness Test 2 (PAT-2) (Robertson & Salter, 2007), was chosen for these investigations. The PAT-2 contains six tasks (i.e., rhyming, segmenting, isolating, deleting, substituting, and blending) measured at multiple levels (e.g., phoneme, syllable, word).

**Music Aptitude**

Gordon’s understanding of music aptitude was used to guide these investigations. Gordon (2012) defined music aptitude as “one’s potential to learn music” (p. 44) and “is based on how well a person can draw generalizations from specific information and experience” (Gordon, 2012, p. 46)–a sentiment that aligns with theories of intelligence outside the musical realm (Campione & Brown, 1978). Gordon further asserted that music aptitude is determined by the individual’s audiation ability, coining the term to describe how a person understands and assigns meaning to music. Gordon (2012) defined two types of music aptitude: developmental and stabilized. Although music aptitude is discussed in greater detail in the review of literature (Chapter 2), an explanation of the understanding of music aptitude chosen for the present investigations is provided below.

**Development.** Every person is born with a certain level of music aptitude, which has the capacity to be developed, and is one aspect that influences achievement. Hence, Gordon (1986, 2012) recognized the early years of a child’s life as important for influencing music aptitude. Until approximately age 9, a child’s music aptitude is *developmental*. During this period, the
child’s music aptitude is influenced by outside factors and fluctuates. After approximately age 9, music aptitude becomes stabilized, in that, it is no longer influenced by outside factors and remains relatively stable when compared to peers (Gordon, 2012).

**Subdomains.** Many subdomains of musical abilities have been used to assess a person’s musical aptitude, such as volume, pitch, duration, tempo, rhythm, harmony, melody, mode, meter, phrasing, or cadence (Stevens, 1987). After many years of research, Gordon (1986) concluded “only the tonal and rhythm dimensions of developmental music aptitude can be measured with confidence” (p. 100), as illustrated in Figure 1.3. The tonal subdomain refers to pitches, determined by frequencies, and organized in groups of single tones rather than isolated tones. The rhythm subdomain is comprised of timing aspects of music, namely rhythmic patterns, groups of sounds characterized by the duration of each sound and time between the sounds.

![Figure 1.3](image_url)

*Figure 1.3. Developmental music aptitude subdomains. The two subdomains of developmental music aptitude that can be measured with confidence (Gordon, 1986).*
**Speech and reading.** Like speech and phonological awareness, music aptitude also relies on the auditory modality and the benefits of music on speech and oral language skills have been reported. Musical participation has helped children improve in the areas of speech perception (Moreno et al., 2009), second language acquisition (Yang et al., 2014), and phonological awareness among typically developing children (Degé & Schwarzer, 2011), English language learners (Fisher, 2001), or children with dyslexia (Overy, 2003). Further, Standley (2008) reported the benefits of musical activities on reading skills ($d = .32$). This strong relationship is also supported by researchers who reported individuals who have difficulty processing language may also have difficulties processing music (Jentschke, Koelsch, Sallat, & Friederici, 2008). Conversely, individuals with deficits in musical ability have been found to have deficits in phonological awareness abilities (Jones, Lucker, Zalewski, Brewer, & Drayna, 2009). Clearly, connections exist between the language and musical domains.

**Measurement.** Historically, music aptitude has been measured using a variety of tasks. Such tasks may include discrimination (i.e., indicate same/different); production/performance (i.e., perform a musical example); perception/awareness (e.g., distinguish a characteristic and identify the difference between higher/lower or louder/softer); musical literacy (i.e., read notation and/or write from dictation); preference (i.e., indicate which is more pleasing/appropriate); or memory/ recognition (i.e., recall previously heard sounds). Performance on each task is believed to help to determine a person’s music aptitude and tasks are often chosen based on the developer’s beliefs about the nature of music aptitude.

Music aptitude tests can be researcher-designed or standardized and can vary greatly in nature. Debate exists regarding the most appropriate way to assess music aptitude, but the purpose of aptitude testing should be to individualize instruction for each child (Gordon, 1986;
Stevens, 1987). To provide a reliable understanding of music aptitude, standardized tests have been developed. Such tests utilize tasks (e.g., discrimination) to measure musical domains (e.g., tonal, rhythm). Previous researchers investigating the relationship between phonological awareness and music aptitude have measured music aptitude in both the tonal and rhythmic domains using discrimination tasks (e.g., Forgeard et al., 2008; Rubinson, 2010). Still, others have examined this relationship by assessing a single musical subdomain (e.g., Loui, Kroog, Zuk, Winner, & Schlaug, 2011) or used multiple tasks in their measurements (e.g., Anvari, Trainor, Woodside, & Levy, 2002). Due to their research base, alignment with Gordon’s understandings of music aptitude, and proliferation previous research, the PMMA and IMMA (Gordon, 1986) were chosen for these investigations. The IMMA (Studies 1 & 2) is a more difficult measure of music aptitude than the PMMA (Study 3), but both contain two subtests (i.e., tonal and rhythm) that employ same/different discrimination tasks.

**Phonological Awareness and Musicality**

Relationships between musicality and phonological awareness have been reported from around the world (Bolduc & Montésinos-Gelet, 2005; Peynircıog˘lu, Durgunog˘lu, & O¨ney-Küsefog˘lu, 2002; Moritz, Yampolsky, Papadelis, Thomson, & Wolf, 2013; Rubinson, 2010). Although timbre discrimination abilities have not been reported to significantly correlate with phonological awareness skills (Lamb & Gregory, 1993), rhythmic abilities (Moritz et al., 2013), tonal abilities (Forgeard et al., 2008), and the combination of both the rhythmic and tonal domains (Rubinson, 2010) have positively correlated with phonological awareness skills. Further, musical training has benefited the phonological awareness skills of typically developing children (Degé & Schwarzer, 2011; Fisher, 2001) and children with dyslexia (Overy, 2003). Musical training has been found to exert a stronger positive influence on phonological awareness
development than language training alone (Bolduc & Lefebvre, 2012). Finally, tune deaf
individuals have been reported to have lower phonological awareness skills than typical peers
(Jones et al., 2009), suggesting a shared mechanism between the musical and phonological
domains.

**Phonological Awareness and Music Aptitude**

Varied relationships among phonological awareness and musical aptitude domains have
been reported. Relationships between music aptitude and phonological awareness have been
found when tonal and rhythm domains were combined into a single variable (Lathroum, 2011\(^1\);
Peynircioglu et al., 2002; Rubinson, 2010). Researchers have reported relationships between
phonological awareness and a single musical domain only, such as the tonal domain (Bolduc &
Montésinos-Gelet, 2005) or the rhythm domain (Moritz et al., 2013\(^2\)). Results of additional
studies indicated both the tonal and rhythm domains have been found to correlate with
phonological awareness, but separately (Forgeard et al., 2008; Rubinson, 2010). When
correlations among phonological awareness and both musical domains separately were reported,
tonal relationships were stronger (Anvari et al., 2002; Forgeard et al., 2008; Rubinson, 2010).
Further, findings from the studies utilizing Gordon’s measures of music aptitude indicated tonal
relationships have been more pronounced (Bolduc & Montésinos-Gelet, 2005; Forgeard et al.,
2008; Rubinson, 2010).

Additional evidence exists supporting the relationship between phonological awareness
and music aptitude for children with language-based impairments. Forgeard et al. (2008)

\(^1\) Also included a melodic measure.

\(^2\) Also included a tempo measure.
reported relationships between phonological awareness and music aptitude in children with
dyslexia, a language-based disability associated with deficits in phonological awareness (Regents
of the University of Michigan, 2017). Overy (2003) reported a specially-designed music program
had a significant positive effect on phonological ability in students diagnosed with dyslexia.
Given these previously established relationships, it is reasonable to assume the existence of a
similar relationship in older students and those with speech and language impairments. A more
detailed review of previous research is presented in Chapter 2.

**Rationale for These Investigations**

Investigations of music ability/aptitude and phonological awareness have been diverse in
both theoretical foundation and procedure. Correlational studies pertaining to music ability
and/or music aptitude and phonological awareness have been conducted with a variety of ages,
sample sizes, geographic locations, and languages spoken (i.e., Anvari et al., 2002; Lathroum,
2011; Peynirciog˘lu et al., 2002; Rubinson, 2010). Data collection tools, scoring methods, and
data analyses vary widely among these studies for both phonological awareness and music
aptitude. These variances are often due to the ways in which phonological awareness and music
aptitude are or are not defined and, consequently, measured. Measures for both constructs used
in previous research have been either designed by the researchers or standardized and vary in
length (e.g., number of items presented and time of administration). Some measures of
phonological skills in the literature reviewed may have targeted one phonemic skill (e.g.,
phoneme³ deletion), a combination of phonemic skills (e.g., phoneme blending and phoneme
elision), or a combination of phonemic and phonological skills (e.g., phoneme deletion and
rhyme production). Measures of music aptitude may utilize production tasks (e.g., reproduce a

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³ A phoneme is the smallest unit of sound in a language.
musical example), discrimination tasks (e.g., indicate whether two examples are same or different), or a combination thereof. Further, thresholds of significance ranged from \( p < .01 - p = .10 \) among studies examined and discussed further in Chapter 2. Such variation provides challenges when comparing previous literature and interpreting results.

Although previous researchers have investigated the topic of phonological awareness and music aptitude, no study could be located that examined this relationship in students in second or third grade or with speech sound disorders that employed standardized, multi-faceted assessment measures for both constructs. These populations are of particular interest because the phonemic inventory of second-grade students is nearly settled while music aptitude is still developing (Bauman-Waengler, 2012; Gordon, 2012). In students with speech and language impairments, processes that may regulate both language and musical skills have been shown to be impaired, indicating a shared relationship (Jentschke et al., 2008). Understanding this relationship may identify a cognitive variable that could influence a student’s ability to improve phonological skills using music-based instructional strategies. Such findings would be particularly relevant for children who may be resistant to typical phonological remediation (Blachman, 1994) or who have disordered speech (Jentschke et al., 2008; Moreno et al., 2009). Therefore, additional research that clearly defines and systematically, comprehensively, and reliably measures both phonological awareness and music aptitude in older children and those with speech and language impairments is warranted.

I contend that music should be used throughout every child’s education—early and often. Relationships between phonological awareness and music ability and the, presumably, consequential benefits of musical study on developing phonemic inventories has been demonstrated (Moritz et al., 2013). However, few researchers have examined the nature of this
relationship once the phonemic inventory is more nearly complete while music aptitude is still developing. If a relationship between developmental music aptitude and more stabilized phonological skills can be established, I assert that boosting musical aptitudes will help to bolster phonological awareness skills among children after age 7. Additional assistance at such a time would be exceedingly beneficial, as growth would be more difficult for children with and without identified phonological deficits. Because music aptitude is still developing between the ages of 7 and 9, providing instruction to help increase music aptitude could naturally bolster phonological awareness skills in a similar fashion to the results evidenced with younger children. Such a boost could lead to heightened overall phonological skills for typically developing children as well as those with phonological deficits. Figure 1.4 depicts the theoretical benefits of music instruction for children after age 7 if a relationship between phonological awareness and music aptitude exists.
Figure 1.4. Proposed utility of musical intervention after age 7. This figure represents the hypothesized benefit of increasing music aptitude between the ages of 7 and 9. The asterisk (*) represents a theoretical amount of additional growth that could be realized by increasing a child’s music aptitude and the effect such an increase could have on overall phonological skill development.

Guiding Ideas

As previously mentioned, relationships among musicality and phonological awareness have been reported from around the world. However, previous literature prompted me to raise additional questions. These “guiding ideas” emerged and were refined over three years of inquiry:

1. A number of previous reports included researcher-designed measures of either phonological awareness and/or music aptitude. To improve reliability and generalizability, I wanted to use only measures that had been standardized and used commonly to assess these specific constructs.
2. The majority of previous research reviewed was conducted with children younger than age 7. When reports included children older than 7, I found that some elements of the research made drawing conclusions to my questions difficult: research could have been: a) experimental in nature, wherein music acted as a treatment; b) conducted with children with an identified disability (e.g., dyslexia); c) included researcher-designed measures; d) did not overtly state music aptitude as a construct, instead indicating music ability, which can carry a different connotation; e) measured only a single domain/skill of either phonological awareness or music aptitude and/or f) included measures of music ability originally intended for adults. Hence, I felt I was not able to clearly understand the nature of the relationship between the constructs in children between the ages of 7 and 9. I aspired to systematically examine this relationship among this age group.

3. Given my previous experience with children with expressive language difficulties, I had hoped to discover research connecting music aptitude and phonological awareness among such children. Unfortunately, no such investigation was discovered. I sought to conduct such an investigation, hoping that a positive relationship could lead to the development of interventions used in therapeutic settings.

I hope sharing my wonderings will prompt readers to travel with me as I describe a multi-year, interdisciplinary journey wherein two separate, but not disparate, constructs were examined. This journey was both difficult and enlightening due to the inclusion of constructs from different fields of study and my ever-deepening conceptions of each. I hope my research brings individuals from both fields together to achieve the same goal of improving children’s lives.
Organization of the Dissertation

Given the depth and breadth of the information provided in this document, it is pertinent to provide a roadmap and explain its organization. Each chapter is self-contained, with a dedicated reference list and appendices as needed. In this chapter, Chapter 1, I introduced the topics that are reviewed more thoroughly in Chapter 2. The theoretical foundation for the three studies discussed within is also provided in Chapter 2. Chapters 3–5 are the self-contained research studies. Due to similarities amongst the investigations, the introductions and literature reviews in each are very similar, but focused on the population under investigation. In Chapter 6, I synthesize the information gleaned from each investigation to contribute to the knowledge base regarding relationships between music aptitude and phonological awareness.
References


National Academy of Sciences of the United States of America, 110, 15145–15150. doi:10.1073/pnas.1302159110


Chapter 2: Literature Review

Both music and language are multifaceted constructs, largely accepted as features of natural human behavior. Elements of these constructs have been investigated for many years. Experts have posited developmental trajectories and behaviors associated with each, known as *indicators*.

Within these larger constructs lay more discrete constructs. Phonological awareness may be considered an *indicator* of language ability and music aptitude is often considered an *indicator* of musicianship. Still multifaceted, music aptitude and phonological awareness are less complex than the constructs of “music” or “language,” making them more easily investigated as stand-alone constructs *and* as indicators of these larger constructs. Although it is beyond the scope of these investigations to discuss all relationships between music and language, a review of literature including these larger constructs is necessary to provide further context and support for relationships uncovered through the course of my investigations. For this reason, literature representing four broad categories is discussed herein:

1. Music and Language
2. Musical Development
3. Phonological Awareness
4. Music and Phonological Awareness

The four categories are viewed as a funnel. The literature reviewed begins with the broadest constructs (music and language) and ends with the narrower constructs under investigation: phonological awareness and music aptitude. Due to the length of each section, a summary is provided at the conclusion of each. The purpose of this literature review is to provide a theoretical foundation for the three investigations presented in Chapters 3-5 by offering
evidence to demonstrate relationships between many linguistic and musical subdomains. This discussion also highlights the difficulties in differentiating among research said to investigate music aptitude or ability—terms that are often used interchangeably and/or inconsistently—within the published literature, which poses challenges for proper analysis and interpretation.

Special considerations and reporting practices have been utilized throughout this discussion, affecting the music and phonological awareness section most notably. Phonological awareness is often measured alongside other literacy skills, such as reading words. Because phonological awareness relies primarily on the auditory modality, data from measures of print awareness (e.g., grapheme-awareness) are not reported where possible. It was simply beyond the scope of the current investigations to analyze such additional information. For individuals with an interest in data from such measures, I suggest obtaining copies of primary research reports listed in the references.

Finally, studies of music ability/aptitude and training reviewed for this discussion often contained several types of data analyses, reporting correlations and/or effects for different populations under different circumstances. To allow for more meaningful interpretation within these rather large subsections, findings relevant to a particular topic from an individual research study may be reported separately in related sections of this chapter. Therefore, a particular study may be cited in multiple subsections. As the three investigations in this dissertation did not seek to understand the effects of music on phonological awareness, this approach seemed most fitting. In this way, each section acts as an independent, yet interdependent, examination of literature regarding a particular topic. Hence, the conversation of music training can be separated from, but also connected to, the primary research question: the relationship between music aptitude and phonological awareness.
Music and Language

Language is a complex system humans use to communicate thoughts, ideas, and intentions. Language encompasses understanding word meanings, making and combining words, and selecting appropriate word combinations. This multidimensional system of socially shared rules governs how a person will communicate (expression) and whether a listener will understand accurately (reception).

Researchers have demonstrated that music and language share many of the same neural processes. Such findings may account for the benefits noted in regards to language acquisition from music study. In this section, I discuss previous research pertaining to music and language, particularly studies concerning neural processes, primary language acquisition (L1), second language acquisition (L2), speech perception, spelling, vocabulary, and reading.

Under the umbrella of language acquisition are many complex subsystems and tasks, which may include features of expressive and receptive communication related to language (cognitive) or speech (verbal). In this distinction, speech skills refer to a person’s ability to communicate verbally. As such, a person could have command of written forms of language, known as literacy (e.g., reading, writing, spelling), but be unable to speak. Hence, vocabulary, spelling, and reading can be considered features of language, rather than speech.

Shared Neural Processes

Although music recruits many areas of the brain for various musical tasks (Alluri et al., 2012), music and language share similar neural networks (Brown, Martinez, & Parsons, 2006). The auditory cortex, which processes auditory information in the temporal lobe, develops in utero and fetuses can respond to musical sounds (Kisielewsky, Hains, Jacquet, Granier-Deferre, & Lecanuet, 2004) and speech sounds (Birnholz & Benacerraf, 1983; DeCasper, Lecanuet, Busnel,
Granier-Deferre, & Maugeais, 1994). Fetuses register these sounds, which can affect behavioral (Moon & Fifer, 2000) and neural responses after birth for both music (Partanen, Kujala, Tervaniemi, & Huotilainen, 2013) and speech (Partanen, Kujala, Näätänen, Liitola, Sambeth, & Huotilainen, 2013), suggesting learning in the womb. After birth, infants do not consistently prefer spoken sounds to sung sounds (Costa-Giomi, 2014; Costa-Giomi & Ilari, 2014), which further indicates shared neural processes for speech and music.

Synaptic pruning, the elimination of unused synapses, also plays a role in the neurological development of musical and language abilities. The infant brain has more synaptic connections in the auditory cortex than it will as an adult (Gopnik, Meltzoff, & Kuhl, 2001). Synaptic connections for music and language processing may disappear altogether if the sounds associated with those neural pathways are never heard again (Hodges & Sebald, 2011). For example, infants 6–8 months of age are able to discriminate between two similar nonnative phonemes; but by 10–12 months of age, the ability essentially vanishes (Best & McRoberts, 2003).

Although unemployed synapses are gradually pruned away, repetition strengthens synapses (Gopnik et al., 2001). As learning continues, what is learned influences what can be learned at a neural level—in that, neural development in some regions of the brain depend on the prior development of others (Quartz, 2003, p. 295). Optimal or sensitive periods, different from stringent critical periods, refer to “growth phases during which learning may come more easily and more quickly” (Hodges & Sebald, 2011, p. 160). Flohr and Hodges (2006) explained that learning may be more difficult if appropriate experiences are not provided during optimal periods. Hence, future ability and achievement is influenced by early exposure to both music (Moore, Burland, & Davidson, 2003) and language (Kuhl, 2011).
The ways in which musical processing utilizes many areas of the brain (Alluri et al., 2012) may also have implications for improving impaired speech and language systems. During the 2015 biennial meeting of the Society for Music Perception and Cognition, American Speech-Language-Hearing Association (ASHA) leadership expounded on the ways music and speech may be related and employed in the therapeutic treatment of speech and language skills:

Like speech, music has rhythm, a pitch aspect, and spectral features. Research indicates that there are some shared neural networks between speech and music. However, there are also significant differences in the way speech and music are perceived and produced. Music engages broad neural networks, and can involve coordinated auditory motor patterns. It is hypothesized that for some patients, the therapeutic use of music can recruit intact neural networks to facilitate residual functions in damaged areas of the brain, which might improve speech production. (Rowden-Racette, as cited in Rogers, 2015, p. 36)

Rogers (2015), ASHA’s Chief Staff Officer for Science and Research, further advocated for more research investigating the connections between language and music as well as its therapeutic applications; particularly, research investigating personal factors of the people for which music is recommended for use (Rogers, 2015, p. 40).

**Effects of Music on Language**

Previous scholars have reported connections between music and language (Brandt, Gebrian, & Slevc, 2012; Call, 1980; Patel & Iversen, 2007). Some have even reported the benefits of music on linguistic abilities, in both written and oral forms (Butler, Marsh, Sheppard, & Sheppard, 1985; Cooper & Wang, 2012; Jentschke & Koelsch, 2009; Lorenzo, Herrera, 2009)...

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4 Rowden-Racette interviews Kate Gfellar, who provided this quote.
These studies provide evidence for shared relationships between the processing of music and language.

**Primary language (L1).** Previous research has suggested the benefits of musical experiences on primary language development. Lorenzo et al. (2014) examined the effect of music on language development in children aged 3 and 4 \((N = 213)\) over time. Children from a Head Start\(^5\) program in Puerto Rico were placed in experimental \((n = 80)\) or control groups \((n = 133)\). Children in the experimental group received formal music classes for 20 minutes, at least 3 times per week for 2 consecutive years. Students’ language achievement was measured at 6 points throughout the study, over the course of 18 months. Language performance improved statistically significantly for both groups, yet an ANOVA revealed the control and experimental groups differed \((p = .001)\), in that the scores for the experimental group were consistently higher.

**Secondary language (L2).** Some studies have examined the benefits of music instruction on second language acquisition; three are described here. Fisher (2001) sought to determine the effects of music on literacy performance of children in bilingual programs. Spanish-speaking kindergarten students \((N = 80)\), not fluent in English, were randomly placed into groups \((n = 20)\) with a teacher who instructed the students for 2 school years. Two teachers used music during the district’s 3-hour literacy block\(^6\) with students \((n = 40)\) and two teachers did not use music during this time with students \((n = 40)\). Teachers who incorporated music were not given prescribed methods, but music was typically incorporated by singing songs for the morning opening, identifying words in songs, and listening stations that included books accompanied by song CDs. Participants were tested at the beginning of kindergarten and at the end of first grade.

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\(^5\) Preschool program for children from low-income households.

\(^6\) It is assumed the literacy block was held daily.
(n = 71) and students in the music group outperformed students in the non-music groups on English oral language. Due to the relevance of Fisher’s (2001) findings to phonological awareness skills in particular, results will be revisited in a later section.

Cooper and Wang (2012) investigated the influence of musical training on Cantonese word learning. English (non-tone language) (n = 26) and Thai (tone language) (n = 28) speakers were divided into groups of musicians and nonmusicians and participated in Cantonese tone word training, wherein participants learned to identify Cantonese words distinguished by tones. Those with a tone language background (Thai) or musical experience demonstrated significantly better word learning proficiency. Previous musical experience was more advantageous for phonemic tone identification than having a tone language background. Finally, musical aptitude was a significant predictor of word learning success for English listeners ($R^2 = .452, F(1, 24) = 19.817, p < .0001$). These findings demonstrate the influence of musical experience on linguistic processes.

In a longitudinal investigation, Yang, Ma, Gong, Hu, and Yao (2014) examined the relationship between music training and language development in Chinese children (N = 250). Students were tested on first language (Chinese, L1) and second language (English, L2) over 11 semesters, from age 6 to 12. By the end of the study, students who received music training (n = 77) out-performed the non-music group (n = 173) on L2 ability. However, music training did not contribute to L1 development independently. The finding that music training did not relate to L1 development could be due to several factors. First, materials for L1 included measures of written language skills, whereas L2 measures assessed only “listening comprehension and knowledge of phonology and word meaning” (p. 5), which may have more in common with the auditory elements of music. Further, because students were already proficient in L1, but still developing
in L2, the L2 measure may have been more sensitive to language learning in this group of students. Results indicate that musical training enhances L2 development and researchers suggested, “[f]uture longitudinal research should also examine children’s music aptitude” (p. 5).

**Speech perception.** Seeking to determine the effects of musical training on linguistic pitch processing, Moreno et al. (2009) analyzed data from behavior and event-related brain potentials (ERP) from nonmusician Portuguese students in third grade ($n = 32$). After 6 months of general music training, students in the music group showed statistically significant gains in speech processing. Results indicated that musical training enhanced pitch discrimination abilities in speech. These results speak to the positive transfer effects from music to speech, indicating the brain plasticity of 8-year-olds is such that “relatively short periods of training have strong consequences on the functional organization of the children’s brain” (Moreno et al., 2009, p. 712). Further, results support the hypothesis that improving basic auditory analysis via musical training “also improves the development of … phonological representations” (p. 719). Results of this study “should help develop new methods to improve the abilities of children with abnormal development” (p. 721) in the areas of speech and language.

**Literacy.** Literacy typically refers to skills such as reading, writing, and/or spelling. Vocabulary has also been associated with reading skills (Walley, Metsala, & Garlock, 2003) and can also be considered as an important factor in literacy development. In this section, relationships reported among features of literacy and musicality are discussed.

**Spelling and vocabulary.** The benefits of music have been reported for spelling and vocabulary, both of which are related to reading skills (Rapp & Lipka, 2011; Walley et al., 2003). Dolean (2013) reported findings of a study that determined pitch perception was related to spelling ability for aurally presented words in Romanian elementary students in third and fourth
grade \((N = 51)\). In a study of Spanish-speaking preschool students \((N = 30)\), increases in receptive vocabulary were reported for children who participated in activities designed to enhance rhythmic and melodic discrimination (Moyeda, Gómez, & Flores, 2006). Piro and Ortiz (2009), in reporting their study wherein English-speaking second-grade students \((N = 103)\) served as participants, described the positive effects of musical training on the vocabulary and verbal sequencing skills of who children had received musical training since kindergarten. Other researchers working with preschool students \((N = 165)\) found growth in vocabulary and grammatical understanding for those who participated in a music intervention program (Runfola, Etopio, Hamlin, & Rosendal, 2012). Results of these studies highlight the benefits of music participation on spelling and vocabulary achievement.

**Reading.** Researchers have also illustrated the relationships between music and reading skills (Anvari, Trainor, Woodside, & Levy, 2002; Barwick, Valentine, West, & Wilding, 1989; Hester, 2005; Rubinson, 2010); as well as benefits of musical training on pre-literacy and reading abilities (Butzlaff, 2000; Fisher, 2001; Moreno et al., 2009; Pane & Salmon, 2011; Register, 2004; Runfola et al., 2012; Standley, 2008; Standley, & Hughes, 1997; Walton, 2014). The corollary and predictive nature of rhythmic abilities for reading skills in kindergarten (Butler et al., 1985; Moritz, Yampolsky, Papadelis, Thomson, & Wolf, 2013) and students in first grade (David, Wade-Woolley, Kirby, & Smithrim, 2007) have been reported previously. Moritz et al. (2013) concluded that rhythm skills measured in kindergarten correlated with reading skills as measured when the students were in second-grade. In a 7-year longitudinal investigation with children during grades 1–6 (grades 1–3 \(N = 320\); grade 6 \(n = 286\)), Butler et al. (1985) asserted that a kindergartener’s ability to produce rhythms was a predictor for later reading achievement in grades 1–3, contributing a small, but statistically significant amount of variance. David et al.
(2007) reported that rhythm skills measured in first grade correlated with reading abilities in grades 1–5 ($r's = .28-.5, p's < .05$), with relationships ranging from weak to moderate. Rhythm was a predictor for reading ability at each level, but when phonological awareness was controlled, rhythm was only a predictor of reading abilities in grade 5. These investigations provide evidence of a shared relationship between musical abilities and reading abilities among elementary children.

More generally, researchers have used meta-analyses to explore the effect of music training on reading skills (Butzlaff, 2000; Standley, 2008). Butzlaff (2000) concluded that correlational studies of music and reading seemed to connect the phenomena, but the correlational nature of the studies made it difficult to establish causation. Generalizations about the effects of music on reading could also not be made after an analysis of quasi- and experimental designs, due to the large variation in effect sizes and methods utilized. In a later meta-analysis, Standley (2008) found an overall effect size of $d = .32$ for music on reading skills. Standley (2008) further reported musical intervention was more effective with younger students (Pre-K $d = .62$; elementary $d = .25$), indicating younger children benefited most. Music programs lasting four weeks to an entire year had similar effects, indicating, “[a]ll schedules of music intervention can function equally well to improve reading” (p. 27). Studies that sampled participants in special education ($d = .81$), English for speakers of other languages (ESOL) ($d = .96$), and at-risk children ($d = .55$) had higher effect sizes than studies of typically developing children ($d = .14$) (p. 29). Overall, musical intervention was more effective when reading tasks were embedded in music content ($d = .44, p = .001$). When assessed according to the specific skill taught, specific reading skills showed greater benefit from music instruction than did skills when globally assessed, which points to the need for training for transfer through music. Finally,
adapting music instruction to improve reading showed greater benefit when added to an ongoing music education curriculum. Results from meta-analyses point to the difficulties in interpreting findings from many studies with varied approaches to understanding a particular phenomenon (Butzlaff, 2000). Still, musical interventions have demonstrated efficacy in aiding reading skills, particularly among young children and children with particular needs (Standley, 2008).

**Disordered speech- and language-related processes.** Music has been used to remediate speech- and language-related processes for over a century. In a study about music in special education before 1930 with hearing and speech impaired students, Solomon (1980) reported music was commonly used as a stepping stone to speech. Prior to 1930, “singing [was] used to involve the nonspeaking child in speech, to improve breathing, and to develop proper articulation” (Solomon, 1980, p. 241). In addition to singing programs tailored to the needs of students with hearing and speech disabilities, such programs advocated humming; purposeful movement (including eurhythmics); ear-training; breathing exercises; and playing pitched and un-pitched instruments.

Over time, scholars have expounded upon music’s applications for individuals with a variety of speech and language needs. Music has been beneficial for individuals with aphasia (Rowden-Racette, 2012; Polovoy, 2014), muscle tension dysphonia (Goffi-Fynn & Carroll, 2013), and autism (Mogharbel, Sommer, Deutsch, Wenglorz, & Laufs, 2006; Lim, 2012). It has also been motivational for children with cleft palate and velopharyngeal dysfunction to help them work toward therapy goals (Kilcoyne, Carrington, Walker-Smith, Morris, & Condon, 2014). Results of these investigations indicate the therapeutic potential of music for students with speech and language deficits.
**Specific language impairment.** Children with specific language impairment may also have difficulty processing music (Jentschke, Koelsch, Sallat, & Friederici, 2008). Jentschke et al. (2008) found that German kindergarten children with specific language impairment (SLI) \( n = 15 \) demonstrated difficulties processing syntax in both language and music. These findings support the hypothesis of shared neural resources for the two domains. Understanding this relationship “opens a new perspective for a more effective treatment for language-impaired children, which includes musical training. Such training might perhaps even prevent the development of SLI, particularly in children at risk for the development of SLI” (Jentschke et al., 2008, p. 1949).

**Dyslexia.** A language-based learning disability, dyslexia is characterized by literacy difficulties despite otherwise normal intelligence (ASHA, 2017b). Other associated problems include deficits in auditory perception and phonological awareness (Overy, 2003; Regents of the University of Michigan, 2017). Loui, Kroog, Zuk, Winner, and Schlaug (2011) suggested dyslexia may share neural processes with tone-deafness. When compared to typical peers, individuals with dyslexia have been reported to have poorer rhythmic skills (Forgeard et al., 2008; Goswami et al., 2002; Huss, Verney, Fosker, Mead, & Goswami, 2011; Overy, 2003) and melodic skills (Forgeard et al., 2008). In an investigation conducted by Forgeard et al. (2008)\(^7\), typically developing children \( n = 10 \) outperformed those with dyslexia \( n = 5 \) in tasks of melodic and rhythmic discrimination. Still, in a separate investigation reported in the same publication, Forgeard et al. (2008)\(^8\) reported a predictive relationship between phonemic awareness and music aptitude/ability among participants diagnosed with dyslexia \( N = 31 \).

\(^7\) Study 4 of four investigations described in a single publication.

\(^8\) Study 3 of four investigations described in a single publication.
Utilizing the *Auditory Analysis Test* (TAAS) (Rosner & Simon, as cited in Forgeard et al., 2008) as a measure of phonemic awareness, phonemic awareness was predicted by the *Intermediate Measures of Music Audiation* (IMMA) tonal subtest \((partial r^2 = .12, p = .07)\) and rhythm subtest \((partial r^2 = .10, p = .10)\). The rhythmic and melodic discrimination measures developed by the researchers also predicted phonemic awareness \((partial r^2 = .11, p = .08; partial r^2 = .19, p = .02, \text{ respectively})\). Further, music has been shown to be beneficial in helping students with dyslexia improve phonological skills. Overy (2003) reported that a specially-designed music program had a significant positive effect on phonological ability for children diagnosed with dyslexia \((n = 9)\). Results of these investigations espouse the connections between music and language-related abilities for individuals with dyslexia and the benefits musical participation could provide. Due to the implications of these studies regarding relationships between phonological awareness and music aptitude/training, they will be discussed in further detail in later subsections.

**Summary of Music and Language**

Music and language share neural processes used to interpret sound (Brown et al., 2006), which has implications for language acquisition. Both musical and speech sounds can be stored before birth (Birnholz & Benacerraf, 1983; DeCasper et al., 1994; Kisilevsky et al., 2004). After birth, neural pruning leads to the refinement and retention of commonly heard sounds (Gopnik et al., 2001). These shared neural processes, as well as music’s ability to recruit additional areas of the brain (Alluri et al., 2012) indicate language development can be enhanced through musical training for typically developing individuals and those with impaired language systems (Rogers, 2015). Empirical evidence supports the assertion that music training can enhance language development, particularly in the areas of primary language development (Lorenzo et al., 2014), secondary language acquisition (Cooper & Wang, 2012; Fisher, 2001; Yang et al., 2014), and
speech perception (Moreno et al., 2009). Previous investigations also indicate music may be beneficial for persons with disordered speech and language-related processes, including individuals diagnosed with aphasia (Rowden-Racette, 2012; Polovoy, 2014), muscle tension dysphonia (Goffi-Fynn & Carroll, 2013), autism (Lim, 2012; Mogharbel et al., 2006), cleft palate and velopharyngeal dysfunction (Kilcoyne et al., 2014), specific language impairment (Jentschke et al., 2008), and/or dyslexia (Overy, 2003).

Musical Development

Clearly, the relationships between music and language have implications for both educational and therapeutic practice. Yet, to utilize music in the most beneficial manner, understanding musical development is crucial. Recognizing the ways in which musical skills progress will allow music to be incorporated in developmentally appropriate ways in a variety of settings.

Musical development refers to the growth in musical skills over time. Musical development begins in utero with the development of the auditory cortex, which allows newborns to recognize and respond to sounds heard in the womb (Moon & Fifer, 2000; Partanen, Kujala, Tervaniemi, & Huotilainen, 2013). Remarkably, musical development can be evidenced in the neural processes of musicians vs. nonmusicians (Schlaug, Jäncke, Huang, & Steinmetz, 1995), further illustrating the mind-body musical connection.

Musical aptitude, achievement, exposure, and training are associated with musical development, in either its prediction or measurement. Musical development is often traced by musical achievement assessments. Assessments of how well a person performs musically (musical achievement) over time provide a developmental trajectory for that individual. Musical training has been shown to effect musical development in a longitudinal study that connected the
weekly amount of practice and the duration of training to positive musical development in elementary students (Yang et al., 2014). Listening (musical exposure) has been connected to increased musical sensitivity for the particular musical style in which the listener is enculturated (Wong, Perrachione, & Margulis, 2009). Still, some research has demonstrated that a person’s music achievement is connected to their pre-training music ability (Yang et al., 2014), or music aptitude (Gordon, 1967, 1984). Hence, musical experiences and predispositions influence musical development.

**Music Aptitude**

Scholars have discussed several approaches to understanding the construct of music aptitude, indicating that *aptitude* has also been referred to as talent (pre-existing ability), intelligence, or ability (Nardo & Reiterer, 2009; Stevens, 1987). Although *aptitude* and *ability* may be used interchangeably among scholars, psychologists, and test publishers, the two are not always used synonymously (Müller, 2011; Nardo & Reiterer, 2009). Music ability may be understood as “a complex skill stemming from the interaction between innate and acquired factors” (Nardo & Reiterer, 2009, p. 245), more akin to musicality; whereas music aptitude typically refers to innate components of one’s ability to intuitively learn music (Müller, 2011; Nardo & Reiterer, 2009). In fact, when discussing psychological testing, the American Educational Research Association (AERA), American Psychological Association, and National Council on Measurement in Education (1999) isolate the terms, indicating that the *Standards* apply “most directly to standardized measures generally recognized as "tests," such as measures of ability, aptitude, achievement, attitudes, interests,” personality, cognitive functioning, and mental health” (p. 3). For these reasons, it is important to clearly define the constructs of interest.
Although ability and aptitude appear quite similar, using *ability* may obfuscate whether an author is intending to find relationships between acquired knowledge or innate potential. Aptitude is understood, rather unilaterally, as innate, inborn, intuitive, or natural (Gordon, 1986, 2012; Müller, 2011; Nardo & Reiterer, 2009; Nichols, 1999; Stevens, 1987). Conversely, ability has many connotations, which could refer to something that is natural *or* acquired, such as a skill (Merriam-Webster, Incorporated, 2017; Nardo & Reiterer, 2009). Despite these distinctions, an essential purpose of a test of ability or aptitude is often to predict future behavior (Gordon, 1986; Kaplan & Saccuzzo, 2005; National Research Council, 1982; Stevens, 1987; Wigdor, 1982). In this way, a subtle distinction between aptitude and ability seems to exist and the purpose of testing should also be made apparent.

This discussion provides a thorough understanding of music aptitude: the role it plays in musical development and how music achievement and training relate to it. In discussing music aptitude, ways in which music aptitude has been defined and measured are provided. The rationale for the selection of music aptitude definitions and assessments used in my investigations is also included. Due to the tenuous nature of separating studies seeking to measure current achievement or one’s potential to achieve, studies examining musical aptitude and/or musical ability are included in this review of literature.

**Nature of Music Aptitude**

Culp (in press) provided a substantial explanation of music aptitude that reflected the current investigations. Within her discussion, the differing viewpoints regarding the nature of music aptitude were provided (e.g., Gordon, 1986; Stevens, 1987). Given the relevance to the present discussion, much of Culp’s (in press) explanation of the operationalization and assessment of music aptitude is summarized here and expounded upon.
Aptitude can be thought of as a person’s natural propensity toward a chosen feat, activity, or endeavor. Nichols (1999) defined *aptitude* as “[a] natural talent or ability; quickness in learning or understanding” (p. 15). Hence, aptitude represents a person’s *natural ability* to understand or learn. In this way, *music aptitude* affects the ease with which a person understands musical information.

As a construct, music aptitude can be operationalized and measured. Stevens (1987) developed a music aptitude test for children, defining music aptitude as “potential talent in music” (p. 3). Gordon (2012), who also developed measures of music aptitude for children, defined music aptitude as, “one’s potential to learn music” (p. 44). Each scholar’s understanding of the nature of music aptitude helped determine how it was operationalized and subsequently measured (Gordon, 1986; Nardo & Reiterer, 2009; Stevens, 1987).

Gordon’s (2012) and Stevens’ (1987) understandings of music aptitude share similarities. Both scholars included *potential* in their definitions, recognizing that *potential* has “the capacity to be developed” (Nichols, 1999, p. 195) and can lead to high achievement. Both indicated music aptitude can be improved in the early years of life through appropriate instruction, noting that a purpose of measuring music aptitude should be to more appropriately tailor instruction for the child. Lastly, both highlight the ability to draw generalizations as the determinate of music aptitude—a sentiment echoed by general understandings of intelligence (Campione & Brown, 1978). In these ways, the two scholars shared common ground.

Yet, differences are noted between the scholars’ understanding of the construct of music aptitude. While both designate an important window of development during the early years of life, Stevens (1987) believed music aptitude stabilizes around age 6 or 7. Conversely, Gordon (1986, 2012) asserted music aptitude stabilizes at approximately age 9, drawing on previous
research (e.g., Gordon, 1967; Stanton & Koerth, 1933; Wing, 1968). Furthermore, Stevens (1987) asserted a person’s “ability to aurally perceive music” (p. 194) determined music aptitude. Gordon (2012) advanced the concept of perception through the construct of *audiation*. These disparities mark important distinctions between the schools of thought.

**Definition.** Gordon’s understanding of music aptitude, its development, and measurement were used to guide my discussion. His extension of the cognitive process of perception in *audiation* and the supporting empirical evidence influenced this decision. Hence, for the purposes of this discussion and as a construct to be measured, music aptitude “is based on how well a person can draw generalizations from specific information and experience” (Gordon, 2012, p. 46). As previously mentioned, audiation has an important role in Gordon’s understanding of music aptitude. Audiation and the two types of music aptitude described by Gordon are further discussed below.

**Audiation.** Sound exists in many forms and becomes music when people translate sounds in their minds and assign meaning–through audiation. More complex than perceiving music, audiation is a process of understanding and predicting music and musical events. Gordon (2012) stated that “[a]udiation is the process of assimilating and comprehending (not simply rehearing) music momentarily heard performed or heard sometime in the past” (p. 3). Every person is born with a unique potential to audiate and audiation *potential* cannot be taught (Gordon, 2012, p. 3). Using audiation as a construct to be measured, Gordon sought to discover how well individuals understand and assign meaning to music. The ability to audiate is determined by music aptitude (Gordon, 2012).

**Developmental music aptitude.** Developmental music aptitude is, “ever changing, moving up and down as it develops” (Gordon, 2012, p. 46). It can be influenced by outside
factors until age 9. Musical experiences can influence students’ developmental music aptitude and impact overall achievement. Developmental music aptitude should be assessed so appropriate experiences can be provided to help students increase their music aptitudes and achieve to their fullest potential (Gordon, 2012).

**Stabilized music aptitude.** A person’s stabilized music aptitude is essentially unchanging (stabilized) in relation to the aptitude of others. It cannot be influenced by outside factors after age 9. A low music aptitude does not necessarily mean students will always demonstrate low levels of music achievement. After music aptitude has stabilized, musical experiences will not influence students’ aptitude, but could impact overall achievement. Like developmental music aptitude, stabilized music aptitude should be assessed so appropriate experiences can be provided to help students achieve to their fullest potential (Gordon, 2012).

**Measurement.** Much of the initial research in music aptitude and its measurement is attributed to Carl Seashore, who published a measure of musical talent during the first part of the twentieth century (Stevens, 1987). Interested in the psychology of speech and stuttering, Seashore is also credited with helping to form the field of speech-language pathology as it is known today. His initial conversations with Lee Edward Travis led to the first clinic and establishment of the Communication Sciences and Disorders department at the University of Iowa; and to the formation of the organization that became the American Speech-Language-Hearing Association (ASHA) (Rogers, 2015; Van Riper, 2004). Seashore’s contributions in the fields of music and language greatly influenced thought and development in both.

Since Seashore’s early work, many measures of music aptitude have been developed, each reflecting the author’s underlying beliefs and views about the nature of music aptitude. At times, it is difficult to parse out the differences between a test of musical achievement and music
aptitude because, although they are different constructs, they cannot be completely separated when measuring music aptitude. Gordon (1986) stated, “all developmental music aptitude tests are to some degree elemental (basic) music achievement tests and all stabilized music aptitude tests are to some degree formal (advanced) music achievement tests” (p. 100). The test’s emphasis on a given construct (music aptitude or music achievement) ultimately determines whether it is a test of music aptitude or music achievement. Consequently, the validity of a music aptitude test will be determined by the degree to which it favors the construct of music aptitude.


Although discussed in relation to music aptitude measures, Stevens’ (1987) descriptions indicated some tests sought to measure ability, such as Gaston’s *A Test of Musicality* or Lundin’s *Tests of Musical Ability*, by measuring skills typically taught in music theory classes rather than innate musical abilities (Stevens, 1987).

The nature of many music aptitude tests was reviewed for the purposes of this discussion in order to gain a general understanding of their design and format. These assertions are also reported in Culp (in press). Based on this analysis, music aptitude tests may be atomistic or
gestalt in nature, including assessments that measure different subdomains of music, such as volume, pitch, duration, tempo, rhythm, harmony, melody, mode, meter, phrasing, and/or cadence. It is my opinion that test materials are generally organized in terms of tonal (e.g., tonal, melody, harmony), rhythmic (e.g., tempo, rhythm, duration), and other (e.g., volume, phrasing) subdomains. Test materials may contain questions regarding personal interest in music or family background; preference tasks (i.e., indicate which is more pleasing/appropriate); discrimination tasks (i.e., indicate same/different); musical literacy tasks (i.e., read notation and/or write from dictation); perception/awareness tasks (e.g., distinguish a characteristic and identify the difference between, e.g., higher/lower, louder/softer); memory/recognition tasks (i.e., recall previously heard sounds); and/or production/performance tasks (i.e., perform a musical example) (Culp, in press). However, these terms were not always used interchangeably among tests. This analysis revealed substantial variation among music aptitude tests.

**Gordon’s measures of music aptitude.** Because Gordon’s understanding of music aptitude was used to guide my investigations reported in this dissertation, his measures of music aptitude were also used. The prevalence of Gordon’s tests in previous literature also justified their employment. In addition to the *Musical Aptitude Profile* previously mentioned, Gordon developed other measures of music aptitude appropriate for use with children. The *Primary Measures of Music Audiation* (PMMA) and the *Intermediate Measures of Music Audiation* (IMMA) were designed as measures of audiation abilities appropriate for students with developmental music aptitude (Gordon, 1986). Both tests utilize discrimination to measure a student’s ability to audiate, reflective of developmental music aptitude. The IMMA can also be used to measure the stabilized aptitude of students in grade 4, who are 9 years of age or older (Gordon, 1986). To measure developmental music aptitude, the IMMA was employed Studies 1
and 2; the PMMA was utilized in study 3. Reasons for selecting which particular test are included in the report of each study (Chapters 3, 4, and 5).

**Music Achievement**

Achievement is the outward manifestation of what students are able to do. An achievement is generally considered a culmination of one’s efforts. Nichols (1999) defined *achieve* as “[t]o set or reach by trying hard” (p. 4); and *achievement* as “[s]omething achieved by work, courage, or skill” (p. 4). Combining these ideas, achievement may be understood as *something accomplished by trying*. Gordon (2012) defined *music achievement* as “a measure of what has been learned in music” (p. 44). After learning has taken place, students demonstrate their ability by *trying* to reach an achievement. Therefore, achievement is a measure of what has been learned.

Music achievement is influenced by many factors including music aptitude, environment, personal characteristics, quality of music instruction (Gordon, 1986), amount of practice, and duration of training (Yang et al., 2014). Music aptitude is a measure of one’s *potential* music achievement; it is not the sole determinate of *actual* music achievement. Students of varying aptitudes achieve at varying levels. Given appropriate instruction, it is possible for students with low music aptitudes to achieve higher than students with average music aptitudes who receive inappropriate instruction. Music aptitude tests should never be used to exclude children from music instruction. Music aptitude tests should help teachers tailor instruction so students receive what they need to develop to their fullest potential (Gordon, 1986).

**Music Training**

Distinct from musical *aptitude or achievement*, musical training is often investigated in the literature. Musical *training* often refers to a quantifiable amount of previous musical
experience (measured in minutes, weeks, years, etc.); or to a type of musical training (e.g., instrumental, tonal, Kodály, etc.). The type of music training could also refer to private instruction or participation in group musical experiences (e.g., school). Musical training could act as an independent variable used to delineate groups (e.g., musician vs. nonmusician) to allow for between-group comparisons on dependent variables. However, previous research has not consistently defined the amount of music training required to create musician vs. nonmusician groups. Finally, music training could also serve as a treatment in an experimental study, where participants’ performance on a task is measured before and after the musical intervention.

Music training, or previous musical experience, can influence music aptitude until about age 9 (Gordon, 2012). However, no reliable measure for assessing the music experiences of students in their home lives could be located. The difficulty in measuring musical experiences at home is likely attributable, at least in part, to differences in definitions of musical behaviors held among music educators and those outside music education (Lenzo, 2014). Therefore, data pertaining to previous music experience was not routinely collected as a part of these investigations; providing a musical treatment was also beyond the scope.

**Summary of Musical Development**

Musical development is influenced by a number of factors. Musical aptitude (Gordon, 1986, 2012), exposure (Wong et al., 2009), and training (Yang et al., 2014) influence musical development and affect overall achievement. Assessments of musical achievement can often track musical development. Understanding the factors that influence musical development is crucial in order to provide developmentally appropriate experiences.

The nature and appropriate measure of music aptitude is a subject of debate (Nardo & Reiterer, 2009; Stevens, 1987). Often, the terms aptitude and ability are used synonymously,
creating ambiguities in interpretation; yet, tests of either ability or aptitude often seek to predict future behavior. Tests of music aptitude reflect the author’s underlying beliefs and views about the nature of music aptitude. Gordon (2012) defined music aptitude as “one’s potential to learn music” (p. 44), determined by a person’s ability to draw generalizations from and understand music. Gordon’s (1986, 2012) understanding of music aptitude was used to guide the investigations reported in this dissertation due to its foundation in previous research (Gordon, 1967, 1975, 1981; Stanton & Koerth, 1933; Wing, 1968), and use in previous research. Consequently, his measures (PMMA and IMMA), which utilize discrimination tasks, were used to assess developmental music aptitude in my investigations.

Music achievement and training can affect music aptitude until age 9 (Gordon, 1986). Music achievement is a demonstration of what students are able to do at the time of measurement. Musical training may refer to a quantifiable amount of previous musical experience or a type of musical preparation. It may also be used to delineate groups (e.g., musician vs. nonmusician; instrumental vs. choral), or serve a treatment in an experimental study. Understanding the differences and inter-relatedness of these various constructs is crucial to inform meaningful analysis.

**Phonological Awareness**

Just as music aptitude influences musical development, phonological awareness influences language development. Dependent on input from the auditory domain, both music aptitude and phonological awareness skills develop over time. This aural reliance may help explain connections between the two constructs and provide a common ground for instruction to assist in concurrent growth.
The purpose of this section is to introduce the construct of phonological awareness and provide a theoretical foundation for its use in the present investigations. Features of phonological awareness and skill development are discussed in terms of essential characteristics and ages of acquisition. Relationships reported between phonological awareness and the constructs of reading and speech are also discussed. The section ends with a discussion of measurement practices and a summary highlighting the relevance of previous literature to the present investigations.

**Phonemes and Phonemic Awareness**

Phonemes are the smallest units of sound in a language. When combined with other units, phonemes establish word meanings and distinguish between words. For example, *bat* and *cat* differ by only the initial phoneme and have different meanings. Speech sounds are physical sound realities of phonemes, in that they are the final products of articulatory motor processes to create sounds first realized in the mind (Bauman-Waengler, 2012). Phonemic awareness is a feature of phonological awareness, but refers only to the phoneme level, and requires individuals to understand that words are made of individual sounds.

**Nature of Phonological Awareness**

Phonological awareness is an awareness of the sound structure of language. Phonological awareness is characterized by a person’s ability to analyze and manipulate language, including individual sound units within a word and/or an entire word (ASHA, 2017a). It is a feature of phonological processing, which also includes phonological working memory, and phonological retrieval (ASHA, 2017a). As a general, over-arching term, phonological awareness encompasses all sizes of sound units, such as phonemes, syllables, onset-rimes (e.g., *b*-at vs. *c*-at), and words. Often described in terms of phoneme awareness, syllable awareness, onset-rime awareness, and
word awareness, phonological awareness is a multilevel skill in which individuals break down words into smaller units.

Phonological awareness uses a single (auditory) modality and has a reliance on speech and language (Hester & Gonzales, 2006). In reviewing literature in both phonological awareness and speech perception, Hester and Gonzales (2006) indicated that phonological awareness includes psychophysical and linguistic aspects. The psychophysical aspect is characterized by speech perception, a necessary ability in order to hear and organize the sound patterns of language. Language, particularly phonology, which grounds the perceptual input, forms the basis of the linguistic aspect. In this way, phonological awareness has a strong relationship with speech understanding (Hester & Gonzales, 2006).

**Skill Development**

Phonological skill development begins in utero and continues over time. A person’s phonemic inventory begins developing before birth and is typically in place by age 7, although some data indicate age 9 (Bauman-Waengler, 2012, p. 139). Phonological skills can be improved rather indefinitely, but most plateau by age 15 (Bauman-Waengler, 2012). Phonological awareness skills develop in a rather predictable progression (Moats & Tolman, 2015). From most basic to most advanced, phonological skills include: word awareness, responsiveness to rhyme and alliteration, syllable awareness, onset and rime manipulation, and phoneme awareness; and represent aspects of a person’s overall phonological awareness. Understanding the developmental trajectory can provide a basis for sequencing teaching skills and tasks from easy to difficult (Moats & Tolman, 2015).

Although phonological skills can be remediated with success, Torgesen, Wagner, and Rashotte (1994), in their longitudinal investigation, found that phonological processing abilities
were stable among children in the early elementary grades (K-2) \((n = 244)\). After a factor analysis, phonological awareness measured in kindergarten was divided into two constructs: phonological synthesis and phonological analysis. Both correlated with phonological awareness measured in second grade (analysis \(r = .66\), synthesis \(r = .49^9\)). Torgesen et al. (1994) indicated that individual differences in phonological processing abilities were stable in the early elementary grades; such that, “phonological processing skills should be considered to be important human abilities in their own right, similar to the intellectual abilities assessed on measures of general intelligence” (p. 282). In reviewing Torgesen et al.’s (1994) article, Blachman (1994) asserted that due to the stability of individual differences in phonological processing, further research should address cognitive variables that could influence a student’s response to treatment for phonological processing. Phonological processing skills are important, as deficits in phonological awareness have been associated with deficits in the areas of reading and speech.

**Reading**

Phonological awareness is considered a building block of reading (Bauman-Waengler, 2012). It has been positively correlated with reading acquisition (Ehri et al., 2001; Kleeck, Gillam, & McFadden, 1998; Torgesen et al., 2001; Wagner & Torgesen, 1987; Yeh & Connell, 2008; Yopp & Yopp, 2000) and is one of the best predictors of future reading success (Ehri et al., 2001; Yeh & Connell, 2008; Yopp & Yopp, 2000). Torgesen et al.’s (1994) longitudinal analysis indicated “that phonological awareness was the phonological variable most strongly

\[\text{It is assumed alphas were set to at least .05, based on other analyses in this study.}\]
related to subsequent reading skill” (p. 284). Consequently, students with poor phonological awareness may be more likely to struggle with reading skills.

The strong relationship between reading ability and phonological awareness has been explained among reading experts who asserted that phonological awareness promotes the mapping of speech sounds onto printed letters (Deacon, 2012). Deacon (2012), who examined the relationship between phonological awareness and word reading accuracy among children in first and third grade ($N = 202$), supported the “utility of phonological skills in helping children map speech sounds onto printed letters” (p. 467); noting the contribution of phonological awareness as independent from orthographic (print) or morphological (word structure) awareness. Hence, the initial comprehension of speech sounds assists in one’s ability to associate printed text with aural images.

**Speech**

Yet, the contributions of phonological awareness to speech (e.g., production, perception) has not been thoroughly examined (Cheung, 2007). It has only recently become a topic of interest (Hester & Gonzales, 2006). Speech perception is primarily concerned with recognizing the sounds of language; speech production refers to one’s ability to execute the sounds of language. Whereas phonology is theoretical, speech is actualized in real time. Understanding such relationships (conceptual vs. actual) could provide insights into the mental processes that govern the execution of sounds first realized in the mind and how aural input is organized in the mind to create meaning. Researchers have reported relationships between phonological awareness and speech (i.e., perception and production) and selected studies are discussed below.

**Speech perception.** Both phonological awareness and speech perception may rely on a common internal representation of phonological structure (Chiappe, Chiappe, & Siegel, 2001). In
this understanding, one’s ability to represent the sounds of language in the mind is related to one’s ability to understand the sounds of language as they are spoken. Mann and Foy (2003) determined rhyme awareness, a feature of phonological awareness, was closely linked to speech perception, whereas phoneme awareness was more closely associated with the products of literacy experience among preschool students \((n = 99)\). In a study that examined the phonological awareness and speech perception abilities of poor readers \((n = 26)\) and good readers \((n = 36)\), Chiappe et al. (2001) suggested impaired speech perception played a causal role in phonemic awareness deficits that characterize reading disability. Further, variance in speech perception explained group differences in phonemic awareness: good readers outperformed poor readers. Hence, speech perception should be associated with phonological awareness.

**Speech production.** Researchers have demonstrated that poor readers also have difficulties with speech production, which may be explained by a deficit in the underlying phonological representations necessary for both reading and speech. Snowling (1981) reported that dyslexic readers \((n = 20)\) had more difficulty reading and repeating (verbalizing) multisyllabic nonsense words than normal readers \((n = 22)\), suggesting a shared underlying phonemic deficit affecting the ability to process both spoken and written words. The frequency with which words commonly appear in texts may also play a role in the ability of dyslexic children to verbally repeat nonwords. Snowling, Goulandris, Bowlby, and Howell (1986) reported that children with dyslexia \((n = 19)\) had more difficulty with low-frequency words as compared to controls \((n = 38)\). Children with dyslexia also had difficulty with phoneme segmentation involved in verbal repetition. Finally, Catts (1986) concluded speech production difficulties of adolescents with reading disorders reflected deficits in phonological processing. Results indicated speech production correlated with reading ability for adolescents with reading
disorders. Adolescents with reading disorders \((n = 20)\) made significantly more speech production errors than typically developing adolescents \((n = 20)\) when producing multisyllabic words and phonologically complex phrases (Catts, 1986). Results of these investigations provide evidence to suggest an underlying phonological system influences both speech and reading.

Children with identified speech and language disorders have also been found to have deficits in reading and phonological awareness. Bishop and Adams (1990) reported that children with persistent phonological deficits from age 5;6 \(^{10}\)(\(n = 44\)) scored lower than controls on measures of reading ability (i.e., accuracy and comprehension) and verbal language ability at 8;6. Expressive phonological abilities (i.e., percent consonants correct) accounted for a small but significant proportion of the variance in reading accuracy and comprehension measured at age 8;6 (pp. 1041–1042). Silva, Williams, and McGee (1987) reported early language delay as a predictor of lower than average reading ability, as well as lower intelligence and increased behavioral problems. Mean reading scores at age 11 for those whose language had been delayed since age 3 (comprehension delayed group \(n = 21\), expressive-delayed group \(n = 14\), general language (expressive and comprehension) delay group \(n = 19\)) increased at a significantly slower rate than children in the control group \((n = 806)\). Children with general language impairment were most disadvantaged in terms of reading. Additionally, Stothard, Snowling, Bishop, Chipcase, and Kaplan (1998) reported findings from a longitudinal study using adolescents with a history of speech-language impairment since age 4 \((N = 71)\). At age 15, children whose impairments had resolved \((n = 23)\) performed significantly less well than the control group on the phonological awareness measure (spoonerism). Those with residual language difficulties (impaired speech language \(n = 34\), general delay \(n = 14\)) performed less well than those whose

\(^{10}\) Years;months.
language problems had resolved and the control group on the phonological awareness measure. Results of these investigations illustrate a relationship between impaired speech production and deficits in phonological awareness deficits. Moreover, deficits in phonological awareness can persist into adolescence even after language impairment has resolved.

**Measurement**

To determine achievement levels for the purposes of tracking progress or identifying individuals in need of specialized assistance, phonological awareness can be reliably operationalized and measured. A person’s ability to rhyme, segment, isolate, delete, substitute, and blend phonemes and syllables can be used to ascertain overall phonological awareness achievement (Frost & Katz, 1992, pp. 194–195; Robertson & Salter, 2007; Yeh & Connell, 2008; Yopp, 1988). Sound-to-word matching, word-to-word matching, recognition or production of rhyme, phoneme counting, specifying deleted phonemes, and phoneme reversal have all been used to measure phonological awareness (Frost & Katz, 1992, pp. 194–195; Yopp, 1988). Because various skills and tasks can be used to measure phonological awareness it is important to clearly operationalize the construct to ensure reliable and valid measurement.

Debate exists as to which skills are most relevant when measuring phonological awareness (Wilde, Goerss, & Wesler, 2003; Yeh & Connell, 2008; Yopp, 1988), largely because phonological awareness has been so largely associated with reading success. Wilde et al. (2003) asserted that a test utilizing deletion tasks had a stronger correlation with reading achievement than a phoneme segmentation test. Yeh and Connell (2008) stated, “phoneme segmentation skill is a better predictor of early progress in learning to read than rhyming skill…or vocabulary knowledge” (pp. 243-244). Yopp (1988) examined 10 tests of phonemic awareness, representing various phonological skills and/or tasks (i.e., rhyming, auditory discrimination, blending, word-
to-word matching, isolation, counting segmentation, and deletion) and found correlation coefficients ranging from low \((r = .11)\) to high \((r = .82)\) among the tests themselves. Yopp (1988) further concluded that a test of segmentation and deletion together would yield “greater predictive validity for the initial steps in reading acquisition than does any test alone” (p. 175). Hence, the purpose of assessing phonological awareness will likely influence how it is measured and instruments should be selected carefully.

To provide a broader understanding of a child’s phonological skills, standardized tests have been developed to measure several skills (e.g., blending, rhyming) using various tasks (e.g., clapping, verbal production, object manipulation) at multiple levels (e.g., phoneme, syllable). Such tests often provide standardized scores and norms by age and/or grade for comparison. *The Phonologic Awareness Test 2* (PAT-2) (Robertson & Salter, 2007) was chosen for the present investigation based on professional recommendation, its measurement diversity, and its use in previous literature. By providing a multifaceted measurement, this standardized test provides a comprehensive, reliable, and valid assessment of a child’s overall phonological awareness with implications beyond reading development alone.

Standardized tests provide an objective means of measuring phonological awareness achievement in order to compare individuals and track progress over time. When interpreting the results of phonological awareness tests over time, certain considerations must be made. Kantor (2010) reported initial levels of phonological awareness were negatively related to rate of growth in phonological awareness: students with higher rates grew less, whereas students with lower rates grew more. In this way, younger students are likely to experience more measurable growth from year to year.
Summary of Phonological Awareness

Phonological awareness is a multilevel skill that represents an individual’s ability to analyze and manipulate the sounds of language (ASHA, 2017a). Phonemes are the smallest unit of sound and phonemic awareness is a feature of phonological awareness. Often discussed in terms of phoneme, syllable, and word awareness (Moats & Tolman, 2015), phonological awareness is a feature of phonological processing (ASHA, 2017a).

Phonological awareness skills are developed in a predictable fashion and development begins before birth (Moon, & Fifer, 2000; Partanen, Kujala, Näätänen et al., 2013). Progress can be measured in a variety of ways (Wilde et al., 2003; Yeh & Connell, 2008; Yopp, 1988), ranging from simple (single skill at a single level) to complex (multiple skills at multiple levels). Because individual differences in phonological processing abilities may be stable throughout a child’s early years (Torgesen et al., 1994) there is a need to understand cognitive variables that could influence response to treatment for phonological processing (Blachman, 1994), such as music aptitude.

Phonological awareness is one of the best predictors of reading success (Ehri et al., 2001; Yeh & Connell, 2008; Yopp & Yopp, 2000), which has been attributed to its promotion for speech sound mapping onto text (Deacon, 2012). In fact, phonological awareness shares a key similarity with speech sounds, in that they both depend on the auditory modality. Children identified with reading deficits have been found to have deficits in phonological processing (Catts, 1986; Snowling, 1981; Snowling et al., 1986). Conversely, children with impaired speech and language have had difficulties with reading (Bishop & Adams, 1990; Silva et al., 1987; Stothard et al., 1998) and phonological awareness (Stothard et al., 1998). These findings suggest
a shared underlying phonological system that assists in both speech and phonological awareness skills (Chiappe et al., 2001; Mann & Foy, 2003), which both rely on the auditory modality.

**Music and Phonological Awareness**

The interconnected relationship between phonological awareness and speech lends support to the notion that music aptitude may be related to phonological awareness as well. Phonological awareness, speech, and music aptitude all rely on the auditory modality and consist of mental operations that can be measured by observable behaviors. Thus, music aptitude may be a cognitive variable that could influence a child’s response to phonological intervention and stimulate phonological development. For this reason, investigating the relationship between music aptitude and phonological awareness is warranted.

Relationships between phonological awareness and musicality have been investigated. Research studies examining correlations between the two constructs mainly fall into two categories: aptitude/ability and training. Since ability is often used interchangeably with aptitude in educational testing, studies of such are discussed together in terms of the musical subdomains measured: rhythmic, tonal, or both. Because music training can influence music aptitude before age 9 (Gordon, 1986), the effects of musical training on phonological awareness are also discussed. In that section, music training is organized in terms of musical training as a grouping variable (i.e., musician vs. nonmusician) or treatment. Finally, studies investigating the interrelatedness of musical deficits and phonological awareness are examined. In these rather large subsections, data from measures of print awareness (e.g., grapheme-awareness) are not reported and a research study may be referenced in multiple areas, based on its relevance to the topic. A summary is provided at the end of the larger subsections (music aptitude and phonological awareness, music training and phonological awareness).
Music Aptitude and Phonological Awareness

Researchers have reported statistically significant relationships between music aptitude and phonological awareness. Before examining previous studies in-depth, general characteristics of the reviewed literature should be addressed as they provide important context. Although demographic variables were not consistently reported, subjects represented diverse geographic regions and were most often typically developing English-speaking children. Both standardized and researcher-designed tests of music aptitude and phonological awareness were utilized. However, neither construct was consistently defined throughout the literature, explaining the differences in measurement and interpretation among researchers. Some studies included measures of a single musical subdomain (e.g., tonal or rhythmic) or phonological skill (e.g., deletion), whereas others assessed multiple subdomains of music and phonological skills. With these considerations in mind, studies of music aptitude and phonological awareness are discussed here. Studies are organized in terms of the musical subdomains assessed and the tasks used to measure the subdomain.

Rhythmic subdomain. Rhythm is considered a non-pitched subdomain, comprising timing aspects of music: tempo (speed), beat (pulse), rhythm pattern (arrangements of intervals between sounds), and meter (groupings). Rhythm patterns and tempo are physical manifestations of sound in the real world. Since some beats have no underlying physical sound, such as rests, beat is partially a mental concept. Meter is a mental construct as it represents groupings of beats (Moritz, 2007). For the purposes of the present investigations, studies wherein the timing aspects of music were exclusively examined in relation to phonological awareness abilities are discussed here.
**Rhythmic production.** David et al. (2007) measured the phonological awareness and rhythmic abilities of first-grade students \(N = 53\) to investigate relationships between current and future reading ability. Musical rhythm was assessed using *Rhythmic Competency Analysis*\(^{11}\) (as cited in David et al., 2007), which contained five rhythm production tasks at two different tempos. Phonological awareness was measured by five phonological skills (i.e., sound oddity, sound isolation, blending phonemes, blending onset and rime, phoneme elision) used in previous research studies (i.e., Bradley & Bryant; Wagner, Torgesen, Laughon, Simmons & Rashotte, as cited in David et al., 2007) that were not necessarily standardized. Due to intercorrelations among phonological assessments, scores were combined. Findings indicated that rhythm production was correlated with phonological awareness ability in first grade students \(N = 53, r = .41, p < .01\), supporting the notion that rhythm production is related to phonological awareness abilities.

**Tempo production, rhythmic production, and rhythmic discrimination.** In two separate investigations presented in one publication, Moritz et al. (2013) outlined their investigations of relationships between phonological awareness and rhythm skills among elementary children in the United States. In the first investigation, authors sought to determine the effect of intensive music instruction on the phonological awareness abilities of kindergarten children. Baseline

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\(^{11}\) As what seems to be the author of the *Rhythmic Competency Analysis*, David et al. (2007, p. 182) cites: Weikart, P. (1989a). *Rhythmically moving*, Vol. 1. Ypsilanti, MI: High/Scope Educational Research Foundation. However, that citation refers to a song collection, rather than a test. After further investigation, it seems the *Rhythmic Competency Analysis* used in the study was a modified version of the *Beat Competence Assessment* (BCA).
correlations are discussed here and year-end results are discussed in a later section of this chapter. Children from the first study served as participants in the second investigation and phonological awareness was measured again in second grade to examine correlations between kindergarten rhythm skills and second-grade reading skills. Rhythmic skill assessments were administered in kindergarten, adapted from the *Music Aptitude Test* (MAT) (as described in Overy, Nicolson, Fawcett, & Clarke, as cited in Moritz et al., 2013), consisting of tempo copying, rhythm pattern copying, and rhythm pattern discrimination tasks. Performance on the MAT was assessed using computer-produced and human-rater scores. For production/copying measures, a negative sign of the correlation designated a positive relationship due to scoring procedures, wherein a low score indicated better performance. Intelligence (*Kaufman Brief Intelligence Test*) and vocabulary (*Peabody Picture Vocabulary Test-3a*) were also measured in kindergarten.

In Moritz et al.’s (2013) first study of kindergarten children (*N* = 30; *mean age* = 5;6), phonological awareness skills were measured using subtests of *The Phonological Awareness Test* (rhyming, segmentation, isolation, deletion) (Robertson & Salter, as cited in Moritz et al., 2013). Raw scores on phonological awareness and music tests were used in the analysis. Because data did not meet parametric assumptions, Kendall’s tau b (τ) was used to determine correlational agreement. Tempo copying (computer-produced score) correlated with segmentation of sentences (computer τb = -.37, *p* < .01) and rhythm pattern copying correlated with segmentation of syllables (computer τb = -.27, *p* < .05). Further, rhythm pattern copying correlated at a marginally significant level (*p* < .075) with segmentation of sentences (human τb = -.25, computer τb = -.26), isolation of initial phonemes (human τb = -.33), and deletion of compounds/syllables (computer τb = -.28). In this first investigation, scores on rhythm
production measures significantly, positively correlated with phonological awareness at baselines, whereas scores for rhythmic discrimination measures did not ($p’s > .075$).

In Moritz et al.’s (2013) second investigation, correlations between kindergarten rhythm skills and second-grade reading skills were examined ($N = 12$; mean age = 8;1). Subtests of the Comprehensive Test of Phonological Processing (elision, blending, nonword repetition) (Wagner, Torgesen, & Rashotte, as cited in Moritz et al., 2013) measured phonological awareness in second grade. After controlling for cognitive ability measured in kindergarten, rhythm pattern discrimination was positively correlated with blending nonwords ($r_{partial} = .64$, $p < .05$) and nonword repetition ($r_{partial} = .63, p < .05$). Rhythm pattern copying (production) as scored by computers or human raters was correlated with blending nonwords (computer $r_{partial} = -.77$, $p < .01$, human $r_{partial} = -.72, p < .05$, respectively) and nonword repetition (human $r_{partial} = -.62, p < .05$). Results of this study indicate that discrimination abilities measured early in life are positively associated with later phonological awareness ability, as are rhythm pattern production abilities. However, rhythm pattern production skills may have stronger relationships with phonological awareness than discrimination skills.

Results of these studies indicate scores derived from rhythm-based production tasks may be more closely related to phonological awareness skills than rhythm discrimination tasks. In fact, rhythm discrimination measured in the fall of kindergarten did not correlate with phonological awareness (Moritz et al., 2013). Rhythm production correlated with phonological awareness skills later in life, as did rhythm discrimination abilities (Moritz et al., 2013). Hence, rhythm discrimination skills measured early in life may be related to phonological skills developing later in life.
**Tonal subdomain.** The term *tonal* is related to frequency and pitch. Such skills include aspects of *tone* (single pitch) and *harmonics* (simultaneous combination of pitches), which can be devoid of an underlying steady pulse or meter. Although timbre is related to the quality of a musical sound, it is grouped in the tonal subdomain for the purposes of these discussions due to the perceived absence of underlying rhythmic elements. Hence, tonal musical abilities can be measured as an independent construct, separate from rhythmic abilities. For the purposes of the present investigations, studies wherein the pitched aspects of music were exclusively examined in relation to phonological awareness abilities are discussed here.

**Pitch and timbre discrimination.** Lamb and Gregory (1993) examined the relationship between musical ability and phonemic awareness in kindergarten students (*N* = 18; *mean age* = 5;1) in England. Musical ability was determined by researcher-designed measures of pitch and timbre awareness, measured using same/different discrimination tasks. Phonemic awareness was assessed by alliterations and rhymes, using a shortened version of the *Test of Phonemic Awareness* used in previous research (i.e., Stuart-Hamilton, as cited in Lamb & Gregory, 1993). After controlling for age and nonverbal ability, phonemic awareness correlated with pitch awareness (*r*\(_{\text{partial}}\) = .65, *p* < .01), but not with timbre awareness (*r*\(_{\text{partial}}\) = .38, *p* > .05). Results support the existence of a relationship between the tonal subdomain of music aptitude and phonological awareness that does not include one’s ability to discriminate timbre.

**Pitch perception and production.** Loui et al. (2011) reported findings from their study investigating the relationship between pitch perception (i.e. higher/lower) and production with phonological awareness in English-speaking children (*N* = 32; *mean age* = 7;7) in the United States. Loui et al. (2011) also examined the relationship of music training to phonemic awareness; those results are discussed in a later section of this chapter. Pitch perception and
production performance were assessed by researcher-designed measures intended to reveal “mismatched pitch perception and production abilities in the tone-deaf adults” (p. 2). The Sound Categorization Test (Bradley & Bryant, as cited in Loui et al., 2011), comprised of oddity tasks, and the Auditory Analysis Test (Rosner & Simon, as cited in Loui et al., 2011), comprised of deletion tasks, were administered to assess phonemic awareness. Pitch perception-production performance was significantly correlated with phonemic awareness scores represented by performance on both tasks ($r = .800, p < .01$). Researchers further explained, “[p]artial correlations revealed significant correlations between Pitch Perception–Production and Phonemic Awareness even after partialing out the effects of intelligence, age, SES, and musical training ($r_{\text{partial}} = 0.586, p = 0.008$)” (p. 3). Pitch production or pitch awareness scores separately did not correlate with composite phonemic awareness scores or to subtests of phonemic awareness. Results indicated that the combination of perception and production accounted for individual differences in phonological awareness. In that, one’s ability to perceive tones as higher or lower and produce musical tones that match the contours presented is related to phonological awareness. Further, these relationships remained present after controlling for age, intelligence, SES, and musical training. Although researchers attempted to provide an unbiased internal consistency measure of children’s perception and production skill, results are attenuated by the use of a test originally designed for adults and used with children.

**Tonal and rhythmic subdomains.** Investigations were located wherein researchers examined both the tonal and rhythmic subdomains for relationships with phonological awareness. In some investigations, each subdomain was examined separately for its unique contribution to the construct of phonological awareness. When measured separately, the two subdomains may have been combined to create a single variable for comparison—often when the
musical subdomains were significantly related. For the purposes of this investigation, measures of *melody* (a combination of pitch and rhythm) represented a concurrent measurement of tonal and rhythmic features. Hence, studies wherein both the tonal and rhythmic subdomains of music were examined in relation to phonological awareness are discussed here. As in previous sections, studies are organized in terms of the tasks used to measure said musical abilities.

**Production.** Peynirciog˘lu, Durgunog˘lu, and O¨ney-Küsefog˘lu (2002) investigated the relationship between phonemic awareness and music aptitude in two investigations reported in a single publication utilizing deletion tasks. Music aptitude was used as a grouping variable (i.e., high or low) and determined using a shortened version of a test given to “musically naïve children of similar ages for admission to the state and municipal conservatories in Turkey” (p. 71), wherein children vocalize aurally presented melodies, intervals, and rhythms. Phoneme awareness and music ability were measured using researcher-designed musical tone and phoneme deletion tasks. In the musical tone deletion test, participants could sing, hum, or whistle their response.

In study 1, preliterate Turkish students (*N* = 32; *age range* = 4;9–6;1) were separated into groups of high (*n* = 16) or low music aptitude (*n* = 16). In the phoneme deletion task, music aptitude demonstrated a main effect (*F*(1,30) = 11.91, *MSe* = 8.61, *p* < 0.01). Overall, those who performed better on the phonological tasks had higher music aptitude, but the level of music aptitude did not demonstrate an effect on positionality\(^\text{12}\) of the phoneme. Hence, music aptitude was not linked to participants’ success on phoneme deletion tasks when phonemes were in different word positions. In study 2, preliterate American children (*N* = 40; *age range* = 3;6 - 6;10) were divided into groups of high (*n* = 20) and low music aptitude (*n* = 20). Similarly, a

\(^{12}\) The phoneme’s position in the word: initial or final.
main effect of music aptitude was observed in phoneme deletion skill \( F(1,38) = 52.35, MSe = 5.20, p < 0.001 \); participants with high musical aptitude scored better on every phonological deletion task. In this investigation, positionality was also found to be a main effect \( F(1,38) = 3.97, MSe = 1.89, p = .05 \); participants deleted phonemes in final position most successfully. Participants with high music aptitude had no main effect for position and executed initial and final phonemes equally well. Results indicated that musical aptitude as determined by a child’s ability to vocalize melodies, intervals, and rhythms exerted influence on phonological deletion skills. The difference found in the influence of positionality between Turkish and English speakers is likely due to phonological features of the languages. Hence, results indicate English-speaking children with lower music aptitudes may have lower achievement on phonological tasks due to phoneme positionality; whereas phoneme positionality will not affect the achievement of peers with high music aptitudes.

**Discrimination, production, and perception.** Anvari et al. (2002) reported phonological awareness was positively correlated with music ability among children in Canada \( N = 100; \) mean age = 5;5). The phonemic awareness tasks were taken from *The Rosner Test of Auditory Analytic Skills (Standardized)* (deletion) (as cited in Anvari et al., 2002) and developed in part by the researchers (i.e., rhyme generation, oddity, blending), which were ultimately combined into a single phonemic awareness variable. The researchers developed a music perception measure containing discrimination (melody, rhythm, chord), production (rhythm), and perception (i.e., chord analysis—determine whether a sound is one or more tones) tasks, assessing primarily tonal and rhythmic subdomains. Measures for reading, vocabulary, auditory memory (*Digit Span*), and math were also employed. Scores for 4-year-olds \( n = 50 \) on musical tasks were combined into a single variable as the result of a principle component factor analysis. For this group, music
ability combined as a single variable correlated with phonemic awareness \(r = .59, p < .01\). For 5-year-olds \(n = 50\), a principle component factor analysis revealed two factors, corresponding to pitch and rhythm. Therefore, pitch and rhythm factors of musical ability were examined separately; both correlated with phonemic awareness, \(r = .36, p < .01\); \(r = .33, p < .05\), respectively). Overall, pitched tasks were reported to “relate more consistently to phonemic awareness” (p. 126) than rhythmic tasks. Results of this study indicate the relationship between phonological awareness and music ability in this age group is not understood by examining musical perception, as determined by an individual’s ability to identify a characteristic of musical sound, alone. Rather, the combination of perception, discrimination, and production skills may have more pronounced relationships with phonological awareness than a single skill.

**Discrimination.** A number of investigations have utilized only discrimination tasks to assess musical ability. Among the assessments used in previous literature located for these examinations, Gordon’s (1986) tests of music aptitude were employed most frequently. Because Gordon’s measures were used in my investigations, studies utilizing his measures are discussed together to allow more meaningful comparisons in the future.

Two studies utilizing solely musical discrimination tasks other than those designed by Gordon were identified. Lathroum (2011) investigated the ability of music perception to predict phonological awareness for kindergarten children \(N = 119; \text{mean age} = 5;9\). The *Children’s Music Aptitude Test* (Stevens, as cited in Lathroum, 2011) was used to measure music aptitude through same-different discrimination. The *Comprehensive Test of Phonological Processing* (Wagner, Torgesen, & Rashotte, as cited in Lathroum, 2011) was used to assess phonological awareness. Visual-spatial skills were also assessed and all assessments were given within 5 weeks. All phonological subtests (i.e., blending, elision, and sound matching) correlated with one
another; all music subtests (i.e., rhythm, pitch, melody) correlated with one another; and all phonological subtests correlated with all music subtests. Of the bivariate correlations between phonological and musical subtests, rhythm had slightly stronger observed relationships with phonological skills ($r's = .31-.39$, $p's < .001$), as compared to pitch ($r's = .22-.36$, $p's < .05$) or melody ($r's = .20-.35$, $p's < .05$). When combined into latent variables, music perception (i.e., combination of pitch, rhythm, melody) correlated with phonological awareness ($r = .46$, $p < .001$). Further, the two latent variables shared 21.16% of the observed variance. Findings indicated that, “music perception plays a unique role in predicting phonological awareness, above and beyond the contribution made by visual spatial skills and age” (p. ii) and has a stronger relationship with phonological awareness than visual spatial skills or age. Forgeard et al. (2008) completed an investigation of music discrimination and phonemic awareness, wherein participants diagnosed with dyslexia and above average intelligence ($N = 31$; mean age = 10.1) completed the IMMA and researcher-designed melodic and rhythmic discrimination tasks to measure music discrimination. The Auditory Analysis Test, utilizing deletion tasks, measured phonemic awareness. After controlling for age and SES, phonemic awareness was predicted by the researcher’s melodic ($partial r^2 = .19$, $p = .02$) and rhythmic ($partial r^2 = .11$, $p = .08$) discrimination tasks. Results of the IMMA are discussed later in this chapter.

The results from these studies indicate that tonal and rhythmic discrimination abilities relate to phonological abilities. Lathroum (2011) reported a slightly stronger observed relationship between phonological awareness skills and rhythmic discrimination abilities; whereas Forgeard et al. (2008) found a stronger observed relationship with melodic discrimination, with a less stringent threshold of significance. Lathroum (2011) also reported a study of four investigations described in a single publication.
stronger observed relationship between musical ability and phonological awareness when the musical subdomains were combined. However, Lathroum’s (2011) findings are attenuated by the fact that all musical subtests correlated with one another. Hence, it cannot be clearly determined if they were indeed acting independently of one another and measuring separate constructs in this population. Because Lathroum (2011) found the strongest relationship with phonological awareness when the musical abilities were combined, it seems that these results support the notion that the combination of tonal and rhythmic abilities explain more of the variance in phonological awareness than a single musical subdomain alone. However, this relationship is likely influenced by the intercorrelations among the subtests.

Primary Measures of Music Audiation (PMMA). Gordon’s PMMA was used most frequently in the literature located. Each study is presented separately. Implications are discussed at the end of this section.

Rubinson (2010) examined the relationship between music aptitude and phonemic awareness in kindergarten students (N = 64; mean age = 5;5). The PMMA assessed music aptitude. Phonemic awareness was assessed using two subtests of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS), 6th edition (Good & Kaminski, as cited in Rubinson, 2010): Initial Sound Fluency (ISF) and Phonemic Segmentation Fluency (PSF). Data analysis revealed a significant correlation between PMMA composite raw scores and DIBELS ISF (r = .39, p = .002) and DIBELS PSF (r = .323, p = .009) scores. Scores on the PMMA tonal subtest also correlated with scores on the DIBELS ISF (r = .37, p = .003) and DIBELS PSF (r = .32, p = .010). A significant relationship was also found between PMMA rhythm and DIBELS ISF (r = .31, p = .014) scores. Although weak relationships were reported, results indicate that the combination of the rhythm and tonal musical subdomains (composite music aptitude) relates to
phonological skills; and that both individual musical subdomains (tonal and rhythmic) relate to phonological awareness skills. Given that tonal music aptitude correlated with both phonological skills and rhythmic music aptitude did not, it appears tonal music aptitude had a stronger, more pronounced relationship with certain phonological skills when measured independently. However, correlations between phonological and musical constructs were slightly stronger when both rhythm and tonal music aptitude scores were combined.

Bolduc and Montésinos-Gelet (2005) utilized the PMMA as a measure of pitch processing in their pilot study. The tonal test of the PMMA (in French) was administered to French-speaking kindergarten students ($N = 13$; mean age = 5;6) enrolled in a preschool program in Quebec, Canada. The PMMA rhythm subtest was utilized as a control. Phonological awareness was measured by *l'Épreuve de métaphonologie*\(^{14}\) (Armand & Montésinos-Gelet, as cited in Bolduc & Montésinos-Gelet, 2005), a computerized test, previously designed by the researcher for preschool students that contained six subtests (i.e., non sequential syllable identification, initial sequential syllable identification, initial phoneme identification, categorization of the initial phoneme, initial phoneme suppression, rhyme identification). Results indicated that tonal subtest scores correlated with phonological awareness scores ($r = .975, p < .001$). No significant correlation was found between rhythmic subtest scores and phonological awareness abilities ($r = -.072, p = .815$). In summarizing that study in a later publication, Bolduc (2008) reported that tonal scores were more closely correlated with syllabic and rhyme identification tasks, although that information was not found in the original publication. These findings indicate a very strong, near perfect relationship between phonological awareness and

\(^{14}\) Translated as “The Test of Metaphonology.”
tonal music aptitude among French-speaking children; and no significant relationship with rhythmic music aptitude.

In a longitudinal investigation, Forgeard et al. (2008) also found relationships between PMMA scores and phonemic awareness, as measured by the Auditory Analysis Test, among students with and without musical training ($N = 44$; mean age = 6;6). At baseline, phonemic awareness correlated with both subtests ($r$’s not reported, $p$’s < .01). After 31 months and controlling for age, verbal IQ, and SES, improvement in phonemic awareness was not predicted by the PMMA rhythm subtest, but was predicted by improvement in the PMMA tonal subtest (partial $r^2 = .09$, $p = .06$), as measured by change scores. The comparisons of the relationships noted between children with and without musical training are discussed in a later section of this chapter. Although both rhythmic and tonal music aptitude correlated with phonemic awareness scores at baselines, the finding that only tonal music aptitude predicted phonemic awareness scores later in life suggests a stronger relationship between phonemic awareness and tonal music aptitude, as measured by the PMMA.

Given the findings of studies utilizing the PMMA as a measure of music aptitude, phonological awareness skills may be more closely related to tonal music aptitude than rhythmic music aptitude. When independent significant correlations were found for both music subtests with phonological awareness, tonal relationships were more pronounced (Forgeard et al., 2008; Rubinson, 2010). Further, Bolduc and Montésinos-Gelet (2005) did not find a significant correlation between rhythmic music aptitude and phonological awareness skills. Still, the

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15 Study 1 of four investigations described in a single publication.
combination of both musical subdomains may explain more variance among phonological awareness scores than a single musical subdomain.

**Intermediate Measures of Music Audiation (IMMA).** As alluded to in a previous section in regards to dyslexia, Forgeard et al. (2008)\(^\text{16}\) reported correlations between phonemic awareness and music aptitude among children diagnosed with dyslexia and above average intelligence. Participants (\(N = 31; \text{mean age} = 10;1\)) completed the IMMA and the Auditory Analysis Test and phonemic awareness scores correlated with music aptitude scores. Scores on both the IMMA tonal subtest (\(partial r^2 = .12, p = .07\)) and rhythm subtest (\(p = .10, partial r^2 = .10\)) predicted phonemic awareness after partialing out SES and age. Researchers also noted that children in the study showed deficits in both melodic and rhythmic discrimination abilities, using the norms provided in the IMMA. Although the thresholds of significance are rather high, these findings provide preliminary evidence that a relationship may exist between phonological skills and music aptitude in children with dyslexia, who often have deficits in their phonological awareness. Additionally, while the relationship between phonological skills with tonal music aptitude may be slightly stronger than rhythmic music aptitude in this sample, there is reason to believe that rhythmic skill may also be related to phonological skill in such a population.

**Summary of music aptitude and phonological awareness.** Findings from empirical research demonstrate the existence of relationships between music aptitude and phonological awareness. It should be noted that ages, grade levels, music experience, socioeconomic status (SES), IQ, and languages spoken were not uniformly reported. However, it seems participants in these studies ranged from ages 3-10 and were sampled from populations who were typically

\(^{16}\) Study 3 of four investigations described in a single publication.
developing, or diagnosed with dyslexia. Geographic regions included Canada (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005), the United States of America (Forgeard et al., 2008; Lathroum, 2011; Moritz et al., 2013; Peynircioğ˘lu et al., 2002; Rubinson, 2010), and Turkey (Peynircioğ˘lu et al., 2002). Most studies utilized English-speaking students, except one that examined French-speaking students (Bolduc & Montésinos-Gelet, 2005) and one that included Turkish students (Peynircioğ˘lu et al., 2002). Overall, participants were most often in preschool or kindergarten, typically developing, and spoke English.

In these studies, music aptitude scores were determined using standardized tests (e.g., Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Lathroum, 2011; Rubinson, 2010), researcher-designed measures (e.g., Anvari et al., 2002; Loui et al., 2011; Peynircioğ˘lu et al., 2002), or those adapted from standardized measures (e.g., Moritz et al., 2013). Measures of music aptitude may assess only the tonal subdomain (e.g., Loui et al., 2011), which includes timbre (Lamb & Gregory, 1993); the rhythmic subdomain, which includes tempo (e.g., Moritz et al., 2013); or the combination of the tonal and rhythmic subdomains simultaneously (melody) (e.g., Lathroum, 2011). Overall, measures of music aptitude typically assessed both the rhythm and tonal subdomains; but studies varied in how those subdomains were measured. Some studies utilized same-different music discrimination assessments only (e.g., Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Lathroum, 2011; Rubinson, 2010); production only (Peynircioğ˘lu et al., 2002); production and perception (e.g., Loui et al., 2011); production and discrimination (e.g., Moritz et al., 2013); or production, perception, and discrimination (e.g., Anvari et al., 2002).

Measures of phonological awareness also varied throughout the literature. Researchers utilized researcher-designed measures (e.g., Peynircioğ˘lu et al., 2002), standardized measures
Lathroum, 2011; Moritz et al., 2013; Rubinson, 2010), or a combination (e.g., Anvari et al., 2002). When phonological awareness was measured, it was measured using a single phonological skill, such as deletion (e.g., Forgeard et al., 2008; Peynirciog˘lu et al., 2002), or multiple skills (e.g., Lathroum, 2011; Moritz et al., 2013).

Findings from studies investigating only the rhythmic subdomains of music indicate that rhythmic production abilities correlated with phonological skills (David et al., 2007; Moritz et al., 2013) more so than rhythmic discrimination tasks (Moritz et al., 2013). Investigations of the tonal subdomains only reported relationships with phonological awareness skills that excluded timbre (Lamb & Gregory, 1993). Results indicated that phonological awareness skills correlated with tonal discrimination (Lamb & Gregory, 1993), perception-production skills (Loui et al., 2011), and a combination of perception-production-discrimination skills (Anvari et al., 2002). However, phonological awareness did not independently and consistently correlate with pitch perception, when the musical task involved identifying a characteristic, such as higher/lower (Loui et al., 2011) or number of sounds (i.e., one or more) (Anvari et al., 2002).

Researchers reported varied relationships between phonological awareness and music aptitude when both the tonal and rhythmic subdomains were assessed. It should be noted that most studies investigating both rhythmic and tonal subdomains utilized discrimination tasks. A relationship with phonological awareness was found with the tonal subdomain only (Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008); with both the tonal and rhythmic subdomains independently (Anvari et al., 2002; Forgeard et al., 2008; Rubinson, 2010); or with the combination of the tonal and rhythm subdomains as a single variable (Anvari et al., 2002; Lathroum, 2011; Peynirciog˘lu et al., 2002; Rubinson, 2010). The general consensus gleaned from studies reporting correlations among phonological awareness and both musical subdomains
separately indicated tonal relationships were stronger (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Rubinson, 2010). Only one study indicated that rhythmic discrimination might have a slightly stronger relationship than tonal or melodic discrimination, a finding attenuated by the correlations reported among the subtests (Lathroum, 2011). Rubinson (2010) reported a slightly stronger correlation between phonological awareness and music aptitude composite scores. Still, when relationships among the musical subtests were found, the relationships among phonological awareness and music aptitude scores were stronger when the musical subdomains were combined as a single variable (Anvari et al., 2002; Lathroum, 2011).

Based on these investigations, important implications for my three investigations reported in this dissertation can be drawn. First, while rhythmic discrimination skills may correlate with phonological awareness skills, rhythmic production skills seem to be more consistently correlated. Second, the tonal and rhythmic subdomains of music aptitude operate independently in students above age 4, and thus should be measured separately. Finally, relationships between the tonal subdomain and phonological awareness are more consistently pronounced, and observably stronger, than relationships found with rhythmic abilities—particularly in regards to rhythmic discrimination. Although the tonal and rhythm subdomains can function independently, it is worth noting that when the scores in the two subdomains correlate, relationships between phonological awareness and music aptitude have been stronger when both the rhythm and tonal subdomains are combined into a single variable. In light of these implications, measuring both the tonal and rhythmic subdomains of music aptitude is warranted; tonal relationships will likely be more pronounced. Further, relationships between the two subdomains need to be established prior to further comparisons with phonological awareness abilities.
Music Training and Phonological Awareness

Musical training can influence developmental music aptitude and achievement. Appropriately-tailored instruction can improve developmental music aptitude (Gordon, 1986); practice (e.g., minutes spent working on music) and duration of training (e.g., number of years of musical study) can affect musical achievement (Yang et al., 2014). Hence, an examination of literature pertaining to the effects of music instruction on phonological achievement is needed. Because the influence of music training on phonological awareness is not a primary focus of the current investigations, a general overview will be provided wherein studies are discussed in less detail than in the previous section.

A number of researchers have investigated the effects of musical training on phonological awareness. In such studies, music training is often used as a categorical variable to separate groups or as a treatment. In addition to relationships drawn from correlational data analyses, quasi-experimental and experimental studies have examined the effects of music on the phonological awareness of children from various parts of the world. In these investigations, children participated in general musical experiences (e.g., drumming, singing, rhythmic exercises, dancing, music notation, listening) or musical activity was added to literacy/phonological programs. Because programs targeting literacy, preliteracy, and phonological awareness skills often involve exercises presented aurally that enhance phonological awareness, such studies are included as literacy/phonological programs. In this section, studies are grouped by grade level or age ranges and discussed in terms of musical training as general music activities or as a part of a literacy/phonological program.

Preschool. Music training has demonstrated positive effects on the phonological awareness of preschool children (Degé & Schwarzer, 2011; Herrera, Lorenzo, Defior,
Fernandez-Smith, & Costa-Giomi, 2011). In a study wherein German-speaking preschool children in kindergarten aged 5–6 years served as participants ($N = 41$), Degé and Schwarzer (2011) found statistically significant gains in phonological awareness among children who participated in a music program ($n = 13$). The music program took place over 20 weeks for 10 minutes per day (100 sessions) and used typical music-related activities (e.g., drumming, singing, rhythmic exercises, dancing, music notation). Phonological awareness did not significantly improve among children in the control group ($n = 14$), who participated in sports training (Degé & Schwarzer, 2011). Contrarily, Runfola et al. (2012) did not report statistically significant differences on measures of phonological aspects of oral language between children in musical and non-musical conditions. In Runfola et al.’s (2012) study of emergent literacy skills among English-speaking preschool students aged 3–5 in the United States ($N = 165$), classroom teachers ($n = 7$)\(^{17}\) of children in the experimental groups used music daily in circle time for 10–20 minutes for 1 school year; whereas classroom teachers ($n = 4$) of children in control groups were encouraged to maintain the status quo. However, Runfola et al. (2012) indicated findings may also be explained by the attrition of the control group teachers and their students throughout the study as well as differing literacy instruction provided by the teachers to participants: all students did not receive the same literacy instruction. Herrera et al. (2011) noted phonological training that included music activities was effective for developing phonological awareness skills in Spanish-speaking children aged 4–5 ($N = 97$), whose first language was either Spanish ($n = 45$) or Tamazight ($n = 52$). In this study, a treatment group received phonological training accompanied by music two times per week for 2 hours over the

\(^{17}\) $N$’s for child participants in experimental and control groups were not found in the report.
course of 8 weeks. Six months later, the process was repeated. Results of these investigations indicate that musical participation may be beneficial for the phonological skills of preschool children, when added to a training program or when students participate in general music activities (Degé & Schwarzer, 2011; Herrera et al., 2011).

**Kindergarten.** A number of researchers have examined the relationship between phonological awareness skills and music training among kindergarten students (Gromko, 2005; Moritz et al., 2013; Register, 2004; Richards, 2011; Walton, 2014). Primarily, researchers have investigated how music effects phonological skills when children participate in general music activities (with no underlying phonological training intent) or when music is added to a literacy/phonological program. Both types of studies are discussed in this section.

**General music.** Three investigations were located that examined the effect of general music activities on the phonological awareness skills of children in kindergarten. Gromko (2005) found that kindergarten children\(^\text{18}\) \(N = 103\) who participated in music classes utilizing typical music activities weekly for 30 minutes \(n = 43\) for 4 months had significantly greater gains in phoneme segmentation fluency than children who did not participate in the music classes \(n = 60\). Richards (2011) investigated the effects of separate pitch and rhythm training on the phonological awareness skills of kindergarten students\(^\text{19}\) \(N = 38\), pitch group \(n = 12\), rhythm group \(n = 11\), control group \(n = 15\). Experimental groups participated in sixteen 40-minute music sessions for 8 weeks. Participants with low phonological awareness at the beginning of the

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\(^{18}\) Ages not specified.

\(^{19}\) Ages not specified. Based on discussion and test materials, it is assumed participants were between 5-7 years of age.
study in the pitch intervention group showed statistically significant gains in phonological awareness skills. Moritz et al. (2013) determined that the phonological awareness skills of kindergarten children \((N = 30; \text{mean age} = 5;6)\) who received more intensive musical training \((n = 15)\) were better at the end of the school than those of children who received less intensive music training \((n = 15)\). The intensive musical training group participated in daily music instruction for 45 minutes by a Kodaly-trained music teacher, while the other group was taught from a music textbook once per week for 35 minutes. Results indicate participating in typical music activities positively influences phonological awareness skill development among kindergarten children. Further, more intensive music training (Moritz et al., 2013) as well as activities that focus on pitch (Richards, 2011) may expedite the development of phonological awareness skills.

**Music added to literacy/phonological training.** Researchers have also investigated the effects of music on phonological awareness when music was added to preliteracy, literacy, or phonological awareness programs targeting these skills. Participants in these investigations had a first language of English (Register, 2004; Walton, 2014), French (Bolduc, 2009; Bolduc & Lefebvre, 2012); or Spanish and were English-language learners (Fisher, 2001). These investigations are discussed below.

Register (2004) examined the effects of a music therapy program to teach reading skills versus a television program focused on early literacy skills, using kindergarten children aged 5–7 from low socioeconomic backgrounds \((N = 86)\) as participants. Over the course of 3 months, participants in treatment conditions met at least 15 times for 25–30 minutes in one of three groups (music/video \(n = 23\), music-only \(n = 22\), video-only \(n = 21\)). The control group \((n = 20)\) did not view the video or receive music instruction. All groups showed significant progress from
pre to posttest on a measure of phonemic awareness (i.e., initial sound fluency), with no statistically significant differences noted among groups (p. 14). The phoneme segmentation test was given as a posttest only and statistical differences were not found among groups (p. 16). Although the training conditions did not improve phonological awareness over and beyond typical development without training, results indicate music does not inhibit phonological awareness development.

Walton (2014) investigated the effectiveness of singing and movement to teach word reading and pre-reading skills to kindergarten students (N = 93; mean age = 5;6) in British Columbia, Canada. Experimental conditions were randomly assigned to intact classes (treatment group n = 44, control group n = 49). The treatment group was taught phonological and literacy skills using group singing and movement for approximately 20 minutes twice per week for 12 weeks. Both groups demonstrated comparable gains in rhyming and phoneme identification (initial, final), as measured by an isolation test. Yet, differences in scores from pre to posttest on medial phoneme identification approached significance (p < .05)\(^20\), favoring the experimental group. Though the difference may be slight, music during literacy training may help improve phonological skills by improving accuracy of phonemes in all word positions.

Bolduc (2009) examined the effect of two music programs on the development of phonological awareness among Franco-Canadian kindergarten children (N = 104; mean age =

\(^{20}\) A separate analysis of covariance (ANCONVA) was used to analyze treatment effects for each measure. A Bonferroni family-wise error correction was used to control for type I error, setting significant levels at p < .01 for each test. Medial phoneme identity was significant at the p < .05 level and the Bonferroni correction created a more stringent significance level of p < .01.
Children in the experimental group ($n = 51$) participated in an adapted music program originally intended to increase interest in reading and writing using musical activities, while the control group ($n = 53$) participated in a music curriculum that was musically equivalent. After 15 weeks of 60-minute daily music lessons participants in both musical conditions improved in phonological awareness. However, students who participated in the experimental music program aimed at increasing pre-literacy skills outperformed the control group on the measure of phonological awareness ($p < .01$). Hence, music as part of phonological awareness training program may be more effective for improving phonological awareness skills than music training alone.

Bolduc and Lefebvre (2012) examined the efficiency of music to develop phonological and musical processing skills using a set of 10 nursery rhymes for French-speaking kindergarten children aged 4-6 ($N = 100$) in four conditions (music group $n = 22$, language group $n = 26$, combined music and language group $n = 28$, passive listening/control group $n = 24$). Groups in all conditions met for 40 minutes once per week for 10 weeks and the first 10 minutes of each session were the same across conditions. In the musical conditions, nursery rhymes were supplemented with musical activities. Large effect sizes ($> .50$) were noted for participants in the music, combined, and language groups. The magnitude effect of the music and the combined (music and language) condition was greater than the language condition (music $z = -4.12$, $p < .001$, $r = .62$; combined $z = -4.65$, $p < .001$, $r = .62$; language $z = -3.71$, $p < .001$, $r = .51$) (p. 499). A significant difference in the phonological awareness measure was reported across the four conditions. Post-test and post-hoc comparisons indicated the music, combined, and language

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21 Alphas in Bolduc and Lefebvre (2012) were set to .01.
groups scored higher than controls. These results suggest that music when added to phonological training may be more beneficial than language training alone.

Fisher (2001), as discussed previously, also included measures of phonological awareness in a study of the effects of music on literacy performance for Spanish-speaking kindergarten students in bilingual programs (N = 80). In this study, two teachers used music during the district’s 3-hour literacy block\(^{22}\) with students (n = 40) and two teachers did not use music during this time with students (n = 40) over the course of 19 months. Participants who received music training as part of their 3-hour daily literacy block outperformed students who did not receive music on measures of English phonemic awareness (p < .05). Hence, music as part of literacy training enhances phonological awareness beyond typical literacy activities alone.

These studies illustrate the benefits of music for phonological awareness when added to literacy/phonological programs for kindergarten students who speak English, Spanish, or French as a first language. Regarding English-speaking students, results indicate music can be equally beneficial, if not more beneficial, for helping students improve phonological skills when added to literacy/phonological programs (Walton, 2014). Further, music is effective for helping improve phonological skills for Spanish-speaking English-language learners (Fisher, 2001) and French-speaking kindergarten children (Bolduc, 2009; Bolduc & Lefebvre, 2012), possibly better than language training alone (Bolduc & Lefebvre, 2012) when added to literacy/phonological training programs.

**Grade levels not reported (ages 4-10).** Three publications outlining four studies were located wherein participants represented multiple grade levels or grade levels were not reported.\(^{22}\) It is assumed the literacy block was held daily.
Because school training has a direct effect on phonological abilities, it was not deemed appropriate to discuss these studies in the context of other studies wherein grade levels were reported, regardless of age similarities. Hence, these studies were grouped to allow for more appropriate analysis and comparison of reported findings. Due to the small number of studies in this category, studies were not further subcategorized.

Loui et al. (2011), as alluded to previously, reported musical training correlated with phonemic awareness among English-speaking children \((N = 32; \text{mean age} = 7;7)\) in the United States. The length of musical training outside typical school education ranged from 0–3 years among participants \((M = .4 \text{ years})\). However, the type of musical training was not specified. In this sample, musical training correlated with phonemic awareness \((r = .582, p < .01)\), as measured by sound categorization and deletion tasks. Results support the notion that more musical training is associated with increased phonemic awareness skill.

Moreno, Friesen, and Bialystok (2011) investigated the effect of music training toward fostering preliteracy skills in English-speaking children aged 4–6 \((N = 60)\) recruited from Toronto, Canada. Participants were divided into two groups. One group received visual arts training \((n = 30)\); the other received musical training \((n = 30)\) over the course of 4 weeks for 2 hours each day, 20 days in total. Both trainings were primarily computer-based and led by teachers. At the end of the study, both groups made statistically significant gains in phonological awareness from pre to posttest, as measured by rhyming tasks (i.e., production and discrimination) \((p < .001)\). Although authors indicated that results should be taken as “preliminary and suggestive” (p. 170), these findings seem to indicate the music delivered in a computerized form may not have additional benefits for phonological awareness skills beyond art training.
Results of Overy’s (2003) study, as briefly noted in regards to studies involving individuals with dyslexia, indicated that typical music activities help improve phonological skills among children with dyslexia. In this study, Overy (2003) designed a music program consisting of musical games that focused on rhythm and timing skills to improve language and literacy development in children with dyslexia ($n = 9$; mean age $= 8;10$). Participants received regular school music lessons and high levels of literacy support. In lieu of a control group, improvement was analyzed by comparing development during a 15-week control period where children did not receive the specialized music instruction; and a subsequent 15-week treatment period (three 20-minute music sessions per week). Overy (2003) reported that the music program had a significant positive effect on phonological ability ($p < .01$), as measured the Phonological Abilities Test (Muter, as cited in Overy, 2003). These findings indicate that music activities targeting language and literacy skills can help improve phonological skills for children with dyslexia.

Colwell (1988) examined the effects of a music therapy program to improve phonological awareness abilities when paired with a beginning reading phonics program. All subjects ($N = 23$), children aged 4–6 in the United States in preschool ($n = 14$) and kindergarten ($n = 9$), participated in music and non-music phonological training sessions targeting specific phonemes and letters for 15 minutes 5 days per week for 8 weeks, where music was used to assist in learning four of the eight targets. Both conditions significantly improved phonological skills on targets from pre to posttest ($p < .05$) and there were no statistically significant differences between groups ($p > .05$). Regarding phonological tasks, the highest percentage correct scores on posttests were noted in the areas of auditory discrimination and initial phonic identification. Although significant differences were not found between conditions, teachers reported the
program increased students’ attention, interest, and knowledge; parents reported the program seemed to improve motivation, interest, and enjoyment among their children. Hence, results indicate that even if music does not offer additional benefits in the area of phonological development beyond standard training, music may enhance perceived attention, interest, motivation, and enjoyment among learners.

The results of studies where children aged 4–10 served as participants support the notion that adding music to programs targeting literacy/phonological skills can be advantageous. Musical training was positively related to phonemic awareness (Loui et al., 2011) and Overy (2003) indicated music training was beneficial for phonological awareness development when compared to no specialized music instruction. However, Colwell (1988) did not report significant differences when children received musical and nonmusical phonics instruction; Moreno et al. (2011) did not demonstrate that music training led to increased scores on measures of phonological awareness beyond increases realized during visual arts training. Although Moreno et al. (2011) and Colwell (1988) did not report statistically significant differences between groups, scores for children in the music conditions improved significantly on measures of phonological awareness. Further, Colwell (1988) indicated that parents and teachers reported improved attention, participation, motivation, interest, and enjoyment among students during sessions that used music. Hence, it can be concluded that music training does not hinder phonological awareness development (Colwell, 1988; Moreno et al., 2011), is associated with higher levels of phonemic awareness (Loui et al., 2011), and may provide advantages when used to improve literacy/phonological skills with this age group (Colwell, 1988; Overy, 2003).

**Instrumental training.** In two independent investigations described in a single publication, Forgeard et al. (2008) examined the effects of musical training on phonemic
awareness by comparing children with instrumental training to those without instrumental training. The fourth study described by Forgeard et al. (2008) detailed an investigation of the relationship between music discrimination skills and phonemic awareness. Participants were English-speaking children \( (N = 15^{23}) \) with at least 1 year of instrumental music training (music group \( n = 5 \)), without instrumental music training (control group \( n = 5 \)), or identified with dyslexia and above average intelligence \( (n = 5) \). Regarding phonemic awareness scores, participants in the control and music groups had higher scores than children with dyslexia \( (p < .01) \), but no significant differences were found between the control and music groups. The music group surpassed the control group and children with dyslexia on measures of melodic discrimination \( (p < .01) \). The music and control groups did not differ significantly on rhythm discrimination, but both groups outperformed children with dyslexia \( (p < .05) \).

In a separate longitudinal investigation\(^{24}\), previously summarized, Forgeard et al. (2008) examined the relationship between phonological awareness and music discrimination among children \( (N = 44; \text{mean age} = 6;6) \) with instrumental music training \( (n = 32) \) and without instrumental music training \( (n = 12) \). Participants in the instrumental music group had an average 35 weeks of musical training. After controlling for age, verbal IQ, and SES, phonemic awareness correlated with the melodic discrimination tests as well as the rhythmic subtest of the PMMA at baseline \( (p < .01) \). After 31 months, improvement in rhythm discrimination scores did not predict improvement in phonemic awareness \( (p > .1) \). Phonemic awareness improvement was predicted

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\(^{23}\) Specific age ranges of participants in the study were not reported. It is assumed participants were between 6–10 years of age based on the description (p. 387).

\(^{24}\) Study 1 of four investigations described in a single report.
by improvement on the PMMA tonal subtest \((partial r^2 = .09, p = .06)\) for all participants.

However, improvement on the researcher’s melodic discrimination task predicted phonemic awareness improvement for the music group \((r = .54, partial r^2 = .18, p = .04, n = 27)\), but not the control group \((r = -.24, partial r^2 = .02, p = .76, n = 10)\).

Findings of these investigations indicate children with compromised phonemic inventories may have poorer rhythmic and tonal discrimination abilities than typically developing peers, regardless of the peer’s previous instrumental musical experience. Further, findings support the notion that phonological abilities correlate more strongly with tonal, rather than rhythmic abilities, and that these relationships are more pronounced among children with musical training. However, instrumental training alone may not bolster phonological awareness skills over and beyond typical development.

**Summary of music training and phonological awareness.** Findings from studies examining the effects of music training on phonological awareness indicate benefits of music participation for children who speak a variety of languages. General music activities have been beneficial for preschool children who speak German (Degé & Schwarzer, 2011) as well as English-speaking kindergarten children (Gromko, 2005; Moritz et al., 2013; Richards, 2011). Music has been beneficial when added to literacy/phonological programs for preschool students for whom Spanish or Tamazight was the first language (Herrera et al., 2011); as well as kindergarten children for whom their first language was English (Walton, 2014) or French (Bolduc, 2009; Bolduc & Lefebvre, 2012), and also Spanish-speaking English language learners (Fisher, 2001). Hence, music seems to also have phonological benefits for children with experiences in more than one language (e.g., Fisher, 2001; Herrera et al., 2011). Further, participating in general musical activities has been more beneficial for phonological awareness.
than language training alone (Bolduc & Lefebvre, 2012). Yet, instrumental training may not provide additional benefits to the development of awareness skills (Forgeard et al., 2008).

Music training is related to phonological awareness (Loui et al., 2011). Even though researchers did not always report music groups performed significantly better on phonological measures, music groups were not significantly outperformed by control groups (Colwell, 1988; Forgeard et al., 2008; Moreno et al., 2011; Runfola et al., 2012) and their phonological awareness skills improved significantly during the course of such investigations (e.g., Colwell, 1988; Moreno et al., 2011; Register, 2004). Hence, music activities do not hinder phonological growth and may provide natural benefits for phonological awareness development (Degé & Schwarzer, 2011; Gromko, 2005; Moritz et al., 2013; Richards, 2011). Yet, musical activities with the intent of phonological training may be more beneficial than music training alone to enhance phonological skills (Bolduc, 2009; Bolduc & Lefebvre, 2012) and also improve attention, participation, motivation, interest, and enjoyment (Colwell, 1988) when working on phonological skills.

Musical Deficits and Phonological Awareness

A deficit in musical ability, sometimes referred to amusia or tone-deafness, has been connected to deficits in phonological awareness. Individuals with congenital amusia, also known as music agnosia, note-deafness, tune deafness, or dysmelodia, often have deficits in musical pitch perception (Jones, Lucker, Zalewski, Brewer, & Drayna, 2009; Sun, Lu, Ho, & Thompson, 2017); sometimes, rhythm perception (Sun et al., 2017). Jones et al. (2009) investigated phonological processing abilities in adults with deficits in musical pitch recognition. English-speaking adult participants \( N = 69 \) were placed in a tune deaf \( n = 35 \) or control group \( n = 34 \). Groups were determined using scores from the Distorted Tunes Test (DTT), wherein
individuals listen to popular melodies and indicate whether the tune is played correctly and whether the tune is familiar. Individuals who scored in the lowest 10th percentile were placed in the tune deaf group. The CTOPP was used to assess phonological and phonemic awareness. The control group outperformed the tune deaf group on all measures of phonological and phonemic awareness tests of phonological awareness ($p’s < .0001$). These results indicate that deficits in musical ability may be associated with deficits in phonological awareness, supporting the assertion of a shared underlying system for both musical and phonological understanding.

Sun et al. (2017) also revealed the importance of pitch discrimination in phonological processing in a study involving English-speaking adults ($N = 40$) with congenital amusia ($n = 20$) and without amusia ($n = 20$). Groups were identified using scores from The Montreal Battery of Evaluation of Amusia (MBEA), where listeners judge whether pairs of melodies are the same or different. The Elision subtest of the CTOPP was used to assess phonological awareness. To determine musical discrimination abilities, participants completed a pure-tone pitch discrimination task (i.e., indicate which of three tones is different) and a rhythm discrimination task (i.e., indicate whether a third rhythmic sequence is the same as or different from the previous two rhythmic sequences). Scores on tonal and rhythmic discrimination tests correlated ($r = -.51, p = .001$) among all participants. However, individuals with amusia who had severe pitch impairment ($n = 8$) scored significantly lower on the phonological awareness assessment than other participants ($p’s < .005$). Results of a hierarchical regression indicated that phonological awareness was predicted by pitch discrimination thresholds for all participants and rhythm discrimination “did not predict phonological awareness beyond that predicted by pitch discrimination thresholds” (p. 1). These findings highlight the relationship between musical pitch
perception and phonological awareness among individuals with and without amusia: pitch perception is critical for phonological processing.

**Summary of Music and Phonological Awareness**

Although music aptitude and phonological awareness have not been consistently defined and measured throughout the literature, relationships between music ability and phonological awareness among elementary-aged students have been reported from around the world (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Lathroum, 2011; Peynircioğlu et al., 2002; Moritz et al., 2013; Peynircioğlu et al., 2002; Rubinson, 2010). The rhythmic and tonal subdomains of music aptitude should be measured separately in children older than 4 years of age because the two constructs operate independently by this time (Anvari et al., 2002). When both rhythm production and discrimination were measured, rhythm production had more pronounced relationships with phonological awareness skills (Moritz et al., 2013). Still, relationships with tonal subdomain were more consistently pronounced and stronger than relationships noted with the rhythmic subdomain (Anvari et al., 2002; Forgeard et al., 2008; Rubinson, 2010). Relationships with the tonal subdomain were particularly pronounced when discrimination abilities were assessed (Forgeard et al., 2008; Rubinson, 2010), rather than perception abilities, as measured by identification tasks (Anvari et al., 2002; Loui et al., 2011). Yet, timbre discrimination abilities were not found to significantly correlate with phonological awareness skills (Lamb & Gregory, 1993). Although the tonal and rhythm subdomains can function independently, the combination of both subdomains may have stronger relationships with phonological awareness than a single subdomain (Rubinson, 2010), particularly when the scores in the musical subdomains are related (Anvari et al., 2002; Lathroum, 2011).

Findings from studies wherein researchers examined the effects of music training on
phonological awareness indicate benefits of music participation for typically developing elementary-aged children who speak a variety of languages (Bolduc, 2009; Bolduc & Lefebvre, 2012; Degé & Schwarzer, 2011; Fisher, 2001; Gromko, 2005; Herrera et al., 2011; Moritz et al., 2013; Richards, 2011; Walton, 2014) and children with dyslexia (Overy, 2003). Although instrumental training alone may not enhance phonological awareness skills beyond typical development (Forgeard et al., 2008), empirical evidence illustrates that musical activities can exert a stronger positive influence on phonological awareness development than language training alone (Bolduc & Lefebvre, 2012). Although general music activities have been beneficial for phonological awareness growth (Bolduc & Lefebvre, 2012; Degé & Schwarzer, 2011; Gromko, 2005; Moritz et al., 2013), musical activities added to phonological training may be more beneficial than music training alone to improve phonological awareness skills (Bolduc, 2009; Bolduc & Lefebvre, 2012).

Further, results of empirical research where individuals with musical deficits served as participants have implications for understanding relationships between phonological and musical processing. Relationships between musical deficits and deficits in phonological awareness have been noted among adults identified with amusia (Jones et al., 2009; Sun et al., 2017). This relationship is more pronounced among individuals with the greatest deficits in pitch processing (Jones et al., 2009; Sun et al., 2017). Hence, individuals with amusia may have lower phonological awareness skills than typical peers (Jones et al., 2009; Sun et al., 2017). Overall, pitch discrimination abilities, or pitch processing, is a more relevant predictor of phonological awareness abilities than rhythmic discrimination (Sun et al., 2017). These findings indicate the presence of a shared mechanism that assists in musical and phonological processing.
Chapter Summary

The processes by which language and music are experienced, both neurologically and aurally, have implications for concurrent skill development. Neural pruning, a process evidenced for both music and language acquisition, refines the neural pathways for the retention and recognition of sounds heard commonly in one’s environment (Gopnik et al., 2001). Further, music and language share neural processes for interpreting sounds (Brown et al., 2006), which may explain the benefits of musical training on language acquisition for typically developing individuals (Cooper & Wang, 2012; Fisher, 2001; Lorenzo et al., 2014; Moreno et al., 2009; Yang et al., 2014) and individuals with disordered speech and language systems (Rowden-Racette, 2012; Goffi-Fynn & Carroll, 2013; Kilcoyne et al., 2014; Lim, 2012; Mogharbel et al., 2006; Overy, 2003; Polovoy, 2014). Because music is related to language, understanding features of musical development can have important implications for remediating speech and language skills; more research is needed in this area (Rogers, 2015).

Music aptitude can influence musical development, although its nature and measure practices are not consistently agreed upon (Gordon, 1986; Nardo & Reiterer, 2009; Stevens, 1987). Hence, varied measures of music aptitude exist, which represent developers’ beliefs about the nature of music aptitude. Although aptitude and ability are often used synonymously, in both test development and measurement in research studies, they may not necessarily represent the same construct (Gordon, 1986; Müller, 2011; Nardo & Reiterer, 2009). Ultimately, aptitude tests should be used to predict future behavior (Gordon, 1986; Kaplan & Saccuzzo, 2005), rather than assess a current state. Discrepancies between what a test seeks to measure and what the researcher is intending to measure can cause misinterpretations. Still, the two constructs are similar enough to allow literature purporting to investigate either to be compared. Researchers
should clearly define all constructs under investigation and the intended use of such information (e.g., measure current achievement or predict future behavior). Based on previous research, Gordon’s understandings of music aptitude and audiation (Gordon, 1967, 1975, 1981) were chosen to guide the three investigations that comprise this dissertation.

Phonological awareness, an individual’s ability to analyze and manipulate the sounds of language (ASHA, 2017a), follows a rather predictable developmental trajectory. Yet, differences in phonological processing abilities can be relatively stable throughout a child’s early years (Torgesen et al., 1994). When deficits are identified, phonological skills can be remediated with success, but other cognitive variables that could influence a child’s response to treatment should be investigated (Blachman, 1994). Strong phonological awareness skills are important because, phonological awareness is a predictor of reading success (Ehri et al., 2001; Yeh & Connell, 2008; Yopp & Yopp, 2000); and related to speech perception (Chiappe et al., 2001; Mann & Foy, 2003) and production (Stothard et al., 1998). Although there is a general consensus among scholars regarding indicators of phonological awareness, disagreement remains regarding the best means of assessment (Wilde et al., 2003; Yeh & Connell, 2008; Yopp, 1988), which may explain the various measurement procedures employed throughout the reviewed literature.

Although music aptitude and phonological awareness were not consistently defined and measured throughout the literature, relationships between musical ability and phonological awareness among elementary-aged students have been reported (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Lathroum, 2011; Loui et al., 2011; Moritz et al., 2013; Peynircioğlu et al., 2002; Rubinson, 2010). Most participants in previous investigations were in preschool or kindergarten, with developing phonemic inventories. Among previous investigations, tonal abilities have demonstrated more consistent and pronounced relationships
with phonological awareness skills than rhythmic abilities (Anvari et al., 2002; Forgeard et al., 2008; Rubinson, 2010). Yet, the combination of the rhythmic and tonal subdomains may have stronger relationships with phonological awareness skills (Rubinson, 2010).

Findings from studies examining the effects of music training on phonological awareness indicate benefits of musical participation for elementary-aged children (Bolduc, 2009; Bolduc & Lefebvre, 2012; Dégé & Schwarzer, 2011; Fisher, 2001; Gromko, 2005; Herrera et al., 2011; Moritz et al., 2013; Richards, 2011; Walton, 2014). Musical training outside of school is related to phonological awareness skills (Forgeard et al., 2008; Loui et al., 2011) and musical participation in educational settings can exert a stronger positive influence on phonological awareness development when compared to language training alone (Bolduc & Lefebvre, 2012). To wit, general music activities, without a specialized focus on literacy/phonological development, have been beneficial for phonological awareness growth (Bolduc & Lefebvre, 2012; Dégé & Schwarzer, 2011; Gromko, 2005; Moritz et al., 2013; Richards, 2011). Still, musical activities added to phonological training may be more beneficial than music training alone (Bolduc, 2009; Bolduc & Lefebvre, 2012).

For these reasons, results of empirical research reveal the presence of a relationship between phonological awareness and music ability. The poorer phonological skills of individual with deficits in pitch perception (Jones et al., 2009; Sun et al., 2017) further support the assertion of an underlying mechanism shared between the two constructs. Future investigations could help identify features of music ability that may assist most successfully in concurrent musical and phonological development to assist individuals in improving phonological awareness skills more expediently and pleasantly (Colwell, 1988).
Implications for the Current Investigations

Speech, phonological awareness, and music aptitude share important similarities. First, all three constructs rely on the auditory modality. Given that phonological awareness and speech are related (Chiappe et al., 2001; Mann & Foy, 2003; Stothard et al., 1998), the probability that music aptitude is also related to these constructs is high. Secondly, scholars suggest the presence of an underlying system of phonological representations that assists in both speech and phonological awareness (Mann & Foy, 2003). Given the neurological evidence supporting music training’s ability to aid the development of phonological representations (Moreno et al., 2009), I hypothesize the underlying system that assists in speech and phonological awareness also plays a role in music aptitude. In this way, a person’s ability to make sense of the sounds of language would be related to a person’s ability to make sense of the sounds of music. Understanding the interrelatedness of these three systems could lead to the development of remediation tools that incorporate music for children who are resistant to phonological training alone. Further, music teachers could incorporate elements of such tools in ways that naturally promote musical development. Such practices could simultaneously bolster speech, phonological awareness, and musical skills.

Because varied relationships have been reported between the tonal and rhythmic subdomains of music ability, measuring the subdomains separately is important (Anvari et al., 2002). Gordon’s (1986) PMMA and IMMA are comprised of independent tests of the tonal and rhythmic subdomains measured via discrimination tasks. Although each can be understood as a stand-alone measure of a music aptitude subdomain, together they represent an individual’s composite music aptitude (i.e., the combination of tonal and rhythmic audiation abilities). In the literature reviewed, relationships between phonological awareness and the tonal subdomain have
been more pronounced than relationships with the rhythmic subdomain (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Rubinson, 2010; Sun et al., 2017). Further, tonal discrimination abilities were consistently correlated with phonological awareness skills (Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Rubinson, 2010; Sun et al., 2017). Although rhythmic discrimination abilities were not always significantly correlated with phonological awareness skills (Bolduc & Montésinos-Gelet, 2005; Moritz et al., 2013), significant correlations have been reported (Forgeard et al., 2008; Rubinson, 2010). Still, the combination of both the tonal and rhythm subdomains may have a stronger relationship with phonological awareness than a single subdomain (Rubinson, 2010). For these reasons, examining the relationships between phonological awareness and the subdomains of music aptitude, as well as the combination of the two, is warranted.

Hypotheses

Given previous findings, several hypotheses can be put forth. First, phonological awareness skills will correlate with tonal music aptitude as measured by the PMMA or IMMA. Second, phonological awareness skills may correlate with rhythmic music aptitude, as measured by the PMMA or IMMA. Third, phonological awareness skills may correlate with composite music aptitude, as measured by the combination of the PMMA or IMMA subtests. Fourth, if phonological awareness skills correlate with both the tonal and rhythm subdomains, relationships with the tonal subdomain will be stronger. Fifth, if phonological awareness skills correlate with either musical subdomain and composite scores, relationships with the composite scores (the combination of both musical subdomains) will be stronger.
References


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*The Relationship Between Phonological Awareness and Music Aptitude

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Abstract

The purpose of this study was to investigate the relationship between phonological awareness and music aptitude. *The Phonological Awareness Test 2* (PAT-2) and the *Intermediate Measures of Music Audiation* (IMMA) were administered to second-grade students in a rural elementary school in Pennsylvania (\(N = 17\)). Speech-language specialists administered a hearing screening and the PAT-2 individually to participants and scored the measures. The primary researcher administered the IMMA to participants in groups and scored the measure. Findings indicate a moderate, positive relationship between PAT-2 standardized composite scores and IMMA raw tonal subtest scores (\(r = .485, p = .048\)). A linear regression indicated IMMA raw tonal subtest scores predicted PAT-2 standardized composite scores (\(F(1,15) = 4.624, p = .048, SE = 6.560\)). The relationship between music aptitude and phonological awareness has implications for students, music teachers, and professionals who remediate literacy skills, such as reading specialists, speech-language pathologists, and music therapists.

*Keywords:* phonological awareness, music aptitude, general music, special needs, literacy
The Relationship Between Phonological Awareness and Music Aptitude

**Introduction**

Students are expected to achieve literacy outcomes under the new *Common Core Standards* (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Yet, 31% of American children cannot read at a basic level by fourth grade (National Center for Education Statistics [NCES], 2015, p. 3) and only 36% of fourth-grade students read at or above the proficient level (NCES, 2015, p. 4). When students do not meet standards for reading they may require one-on-one instruction (Elbaum, Vaughn, Hughes, & Moody, 2000) and, consequently, be removed from typical classroom settings (Hurt, 2012). Although deficits in reading ability often manifest early in life, problems can persist into adolescence. These statistics are alarming and the need for a variety of effective strategies to assist students is clear.

Reading development can be influenced by many factors, including language development, disability status, home literacy environment, and phonological awareness (Snow et al., 1998). Phonological awareness, considered a building block of reading (Bauman-Waengler, 2012), has been shown to correlate positively with reading acquisition (Ehri et al., 2001; Kleeck, Gillam, & McFadden, 1998; Torgesen et al., 2001; Wagner & Torgesen, 1987; Yeh & Connell, 2008; Yopp & Yopp, 2000) and is one of the best predictors of future reading success (Ehri et al., 2001; Yeh & Connell, 2008; Yopp & Yopp, 2000). Students with deficits in phonological awareness may be more likely to have reading deficits; a deficit in phonological awareness represents a robust and specific correlate of reading disability (Morris et al., 1998, p. 368).
Phonological Awareness

A person’s phonemic inventory begins developing before birth and is generally in place by age 7 (Bauman-Waengler, 2012). Phonological awareness, a type of phonological processing (Wagner & Torgesen, 1987), is a person’s ability to analyze and manipulate language, including individual sound units within a word and/or an entire word (Degé & Schwarzer, 2011). Phonological awareness can be measured by a person’s ability to rhyme, segment, isolate, delete, substitute, and blend phonemes and syllables (Frost & Katz, 1992, pp. 194–195; Robertson & Salter, 2007; Yeh & Connell, 2008; Yopp, 1988). Phonemic awareness is a feature of phonological awareness, but refers only to the phoneme, or single sound, level (Bauman-Waengler, 2012). Through the elementary years, students with phonological deficits may be more resistant to phonemic awareness training alone and may respond better to more complex treatments (Blachman, 1994). Previous researchers have demonstrated the relationship between phonological awareness and music aptitude, a cognitive variable that may be influenced up to age 9 (Gordon, 2012).

Music Aptitude

Aptitude is generally viewed as a person’s natural ability for a particular activity, feat, or endeavor; however, approaches to the understanding of music aptitude and its measurement vary (Nardo & Reiterer, 2009; Gordon, 1986; Stevens, 1987). Nichols (1999) defined aptitude as “[a] natural talent or ability; quickness in learning or understanding” (p. 15). Summarizing this sentiment, aptitude may be understood as a person’s natural ability to learn or understand something. Hence, music aptitude may affect how easily a student learns from and understands musical information. In discerning the differences between understandings of music aptitude,

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25 The smallest unit of sound in a language.
Nardo and Reiterer (2009) identified that music aptitude has also been referred to as talent (pre-existing ability) or intelligence. In 1987, Stevens constructed a test of musical aptitude for young children and defined music aptitude as “potential talent in music” (p. 3). Gordon (2012), who also developed measures of music aptitude for children, defined music aptitude as, “one’s potential to learn music” (p. 44).

Stevens’ (1987) and Gordon’s (2012) definitions share similarities. The word potential is included in both definitions, which is important because potential has “the capacity to be developed” (Nichols, 1999, p. 195). Both authors noted that potential can lead to high achievement, but marked the difference between the two. Both recognize that music aptitude can be improved through appropriate instruction in the early years of a student’s life, noting a purpose of aptitude testing, and hence identification of aptitude, should be to individualize instruction for each child. Finally, both asserted a person’s music aptitude is determined by an ability to draw generalizations, which aligns with general understandings of intelligence outside the musical realm (Campione & Brown, 1978).

However, differences exist in how they viewed the construct of music aptitude and its consequent measurement. While both indicated a window of development—recognizing the early years of a child’s life are important years for developing of music aptitude—Stevens (1987) ascribed to the assertion that music aptitude stabilizes around age 6 or 7 if not before. Drawing on previous research (e.g., Gordon, 1967; Stanton & Koerth, 1933; Wing, 1968), Gordon (1986, 2012) asserted music aptitude stabilized at approximately age 9. Additionally, Stevens (1987) indicated music aptitude was determined by a person’s “ability to aurally perceive music” (p. 194). Gordon (2012) furthered this concept through his construct of audiation. Gordon (2012) stated that “[a]udiation is the process of assimilating and comprehending...music momentarily
heard performed or heard sometime in the past” (p. 3). Using audiation as a construct to be measured, Gordon sought to discover how well students understand and assign meaning to music. The ability to audiate is determined by music aptitude (Gordon, 2012). Hence, as a construct to be measured, music aptitude “is based on how well a person can draw generalizations from specific information and experience” (Gordon, 2012, p. 46).

Although music aptitude is not the sole determinant of final achievement, music aptitude can provide information regarding the person’s potential to achieve and ability to derive meaning from musical events (Gordon, 1986). Every person is born with a certain level of musical aptitude and potential to learn music, known as developmental musical aptitude. Developmental musical aptitude is “ever changing, moving up and down as it develops” (Gordon, 2012, p. 46). It can be influenced by outside factors, such as musical experiences, until age 9 and is stabilized thereafter.

**Measuring music aptitude.** Music aptitude is a construct not reliably observable, but it can be operationalized and measured through the use of specialized tests. Upon reviewing the literature, tests of music ability and/or music aptitude may include assessments that measure different dimensions of music, such as volume, pitch, duration, tempo, rhythm, harmony, melody, mode, meter, phrasing, or cadence. Test materials are often organized in terms of tonal (e.g., tonal, melody, harmony), rhythmic (e.g., tempo, rhythm, duration), and other (e.g., volume, phrasing) domains. To measure these musical constructs, test materials could contain questions about family background or personal interest in music; production/performance tasks (i.e., perform a musical example); discrimination tasks (i.e., indicate same/different); notation tasks (i.e., read notation and/or write from dictation); perception/awareness tasks (i.e., distinguish a characteristic and identify the difference between, e.g., higher/lower, louder/softer); preference
tasks (i.e., indicate which is more pleasing/appropriate); or memory tasks (i.e., recall previously heard sounds) (Nardo & Reiterer, 2009; Gordon, 1986; Stevens, 1987).

Gordon’s understanding of music aptitude and its measurement were chosen for this investigation for several reasons. Empirical evidence exists supporting Gordon’s understandings of music aptitude and audiation (Gordon, 1967, 1975, 1981). Among the literature examined pertaining to the measurement of music aptitude and its relationship with phonological awareness, Gordon’s (1986) tests (Primary Measures of Music Audiation [PMMA] and Intermediate Measures of Music Audiation [IMMA]) were the most frequently used standardized measures of music aptitude. Further, Gordon’s understanding of music aptitude pertains to deriving meaning from musical events based on analysis, which align with current understandings of phonological awareness based on a person’s ability to analyze language. Therefore, a comparison of Gordon’s understandings of music aptitude may more directly relate to the construct of phonological awareness and provide more useful insight into the relationship between the two.

**Music Aptitude and Phonological Awareness**

Music ability often encompasses a person’s current level of achievement and researchers have reported statistically significant correlations between musical abilities and phonological awareness in children, aged approximately 3:9-10;1\(^{26}\) (Anvari, Trainor, Woodside, & Levy, 2002; Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Lamb & Gregory, 1993; Lathroum, 2011; Loui, Kroog, Zuk, Winner, & Schlaug, 2011; Moritz, 2007; Moritz, Yampolsky, Papadelis, Thomson, & Wolf, 2013; Peynirciog˘lu, Durgunog˘lu, & O’ney-Küsefog˘lu, 2002). However, some researchers reporting to have measured a particular musical

\(^{26}\) Years;months.
ability utilized tests of music aptitude to measure said abilities (e.g., Forgeard et al., 2008; Moritz, 2007). Because music aptitude is not synonymous with musical ability it is not necessarily assessed in the same manner (Gordon, 1986). Utilizing measures intended to assess a construct different from the construct under investigation could make interpreting results problematic.

When measures of music aptitude were utilized in previous investigations employing correlational data analyses, researchers reported varied relationships among phonological awareness and musical domains. Relationships between phonological awareness and music aptitude were found when the tonal and rhythm domains were combined into a single variable (Lathroum, 2011\(^{27}\); Peynirciog˘lu et al., 2002; Rubinson, 2010). Other researchers found relationships between phonological awareness and a single musical domain (Bolduc & Montésinos-Gelet, 2005; Moritz, 2007\(^{28}\)). Bolduc and Montésinos-Gelet (2005) reported a correlation between phonological awareness and the tonal domain only, finding no correlation with the rhythm domain. Conversely, Moritz (2007) identified relationships between phonological awareness and the rhythm domain, but the tonal domain was not measured. Researchers have also reported that both the tonal and rhythm domains correlated with phonological awareness separately (Forgeard et al., 2008; Rubinson, 2010). Yet, studies reporting correlations among phonological awareness and both musical domains separately indicated tonal relationships were stronger (Forgeard et al., 2008; Rubinson, 2010).

\(^{27}\) Also included a melodic measure.

\(^{28}\) Also included a tempo measure, which is considered of rhythm subdomain for the purposes of this discussion.
Of the investigations previously discussed, four utilized the PMMA and/or IMMA to examine relationships between phonological awareness skills and music aptitude. Findings from these studies indicate that music aptitude, as determined by Gordon’s tests, has a relationship with phonological awareness; tonal relationships have been more pronounced. Further, these studies provide evidence supporting the relationship among music aptitude with the phonological tasks of initial sound fluency, segmentation (Rubinson, 2010), deletion (Forgeard et al., 2008), syllabic identification, and rhyming (Bolduc, 2008). Due to their direct connection to the concept under investigation, they are discussed in greater detail, highlighting the specific phonological skills measured.

Rubinson (2010) found a relationship between PMMA composite scores and phonological awareness in kindergarten students \((N = 62, \text{Mean Age} = 5;5^{29})\), as measured by initial sound \((r = .39, p = .002)\) and phoneme segmentation \((r = .323, p = .009)\) fluency. Rubinson (2010) also found relationships between phonological awareness scores and the tonal and rhythm subtests separately. Raw scores on the PMMA tonal subtest also correlated with initial sound \((r = .37, p = .003)\) and segmentation \((r = .32, p = .010)\) fluency. A significant correlation was also found between PMMA rhythm and initial sound fluency \((r = .31, p = .014)\).

Bolduc and Montésinos-Gelet (2005) reported a very strong correlation between PMMA tonal subtest scores and phonological awareness among kindergarten students \((N = 13, \text{Mean Age} = 5;6, r = .975, p < .001)\). Bolduc (2008) reported relationships with music aptitude were most pronounced among syllabic and rhyme identification tasks. No significant correlation was found

\(^{29}\) Age converted from the reported 5.42 years within the original manuscript to allow consistent age reporting within the current manuscript.
between phonological awareness and PMMA rhythm subtest scores \( r = -.072, p = .815 \).

Researchers did not report comparing PMMA composite scores to phonological awareness scores.

In a longitudinal investigation, Forgeard et al. (2008) also found relationships between PMMA scores and phonemic awareness, as measured by deletion tasks among children \((N = 44; \text{Mean Age} = 6;6^{30})\). At baseline, phonemic awareness correlated with both subtests \((r's \text{ not reported, } p's < .01)\). After 31 months and controlling for age, verbal IQ, and SES, improvement in phonemic awareness was not predicted by the PMMA rhythm subtest, but was predicted by improvement in the PMMA tonal subtest \((\text{partial } r^2 = .09, p = .06)\), as measured by change scores. In another investigation, Forgeard et al. (2008) examined music discrimination and phonemic awareness among students diagnosed with dyslexia and above average intelligence \((N = 31; \text{Mean Age} = 10;1^{31})\). Music aptitude scores, as measured by IMMA, correlated with phonemic awareness scores; and phonemic awareness was predicted by both the IMMA tonal subtest \((p = .07, \text{partial } r^2 = .12)\) and rhythm subtest \((p = .10, \text{partial } r^2 = .10)\) after partialing out age and SES.

Music training may also be effective for helping improve phonological awareness. In addition to correlational designs, researchers have also employed quasi-experimental and experimental designs to examine the effects of music on children’s phonological awareness.

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\(^{30}\) Age converted from the reported 6.52 years within the original manuscript to allow consistent age reporting within the current manuscript.

\(^{31}\) Age converted from the reported 10.05 years within the original manuscript to allow consistent age reporting within the current manuscript.
Typical music activities, such as singing or playing musical games, have been connected to improvement in phonological awareness among preschoolers (Degé & Schwarzer, 2011) and kindergarten students (Gromko, 2005; Moritz et al., 2013; Richards, 2011). Music experiences have also been shown to help improve phonological awareness when added to preliteracy or phonological training programs for these age groups (Bolduc, 2009; Bolduc & Lefebvre, 2012; Herrera, Lorenzo, Defior, Fernandez-Smith, & Costa-Giomi, 2011; Walton, 2014).

**Rationale**

Previous research investigating music aptitude and phonological awareness vary greatly and young children with developing phonemic inventories have often been the focus of study. Differences among approaches may be due to the ways in which phonological awareness and music aptitude are defined and, consequently, measured. Including children younger than age 7 in studies may be problematic in interpreting results. Their phonemic inventories are largely unsettled potentially resulting in inaccurate measurement. Additionally, improvement in phonological awareness may be easier to achieve due to natural developmental processes.

When measuring psychological constructs, using standardized tests helps ensure reliability and validity of the results. Only one study could be located that overtly purported to measure both phonological awareness and music aptitude using standardized tests designed to measure the constructs reported (Rubinson, 2010). This study was completed with kindergarteners (*Mean Age* = 5;5), whose phonological awareness and music aptitude are still developing (Bauman-Waengler, 2012; Gordon, 2012). No study could be located that utilized standardized measures to examine the relationship between music aptitude and phonological awareness among students whose phonemic inventory is more complete (age 7 and older) and whose music aptitude is still developing.
Demonstrating a positive relationship between developmental music aptitude and phonological awareness in students whose phonemic inventory is more nearly complete could serve several important functions. Through the elementary years, students with phonological deficits may be more resistant to phonemic awareness training alone and may respond better to more complex treatments (Blachman, 1994). Music aptitude, a cognitive process that involves deriving meaning from musical events, can still be influenced by outside experiences until age 9. Moreno et al. (2009) found that music training enhanced the neural responses, as measured by event-related brain potentials, of 8-year-old children for both speech and music and indicated that musical training may help students improve their phonological representations of speech. Hence, music aptitude is a cognitive variable that can be improved even after the phonemic inventory is nearly complete and the transfer effects of that training could have positive implications for students with phonological deficits (Moreno et al., 2009). Rather than being removed from typical classroom settings for individualized services, students could participate in group musical experiences that would improve phonological and musical domains simultaneously. Further, this information could improve the educational experience for all students by promoting the need for more time spent improving music skills in music classrooms.

Purpose

The purpose of this study was to determine the nature of the relationship between phonological awareness and music aptitude. The study also sought to examine whether musical aptitude can predict phonological awareness in second-grade students after ensuring normal hearing acuity. Given that music aptitude scores have predicted phonemic awareness skills in previous investigations (Forgeard et al., 2008), it is reasonable to assume that musical aptitude could predict phonological awareness skills in the age group under investigation. Therefore, it is
also expected that a reliable formula for predicting phonological awareness scores using IMMA scores can be determined. The questions that guided this study were:

1. What is the nature of the relationship between phonological awareness and music aptitude as measured by *The Phonological Awareness Test 2* and the *Intermediate Measures of Music Audiation*?

2. Can potential to achieve in music predict phonological awareness achievement using evidence obtained from *The Phonological Awareness Test 2* and the *Intermediate Measures of Music Audiation*?

**Method**

**Design**

The study utilized a correlational design. Evidence was obtained from standardized measures of music aptitude and phonological awareness: *Intermediate Measures of Music Audiation* (IMMA) (Gordon, 1986) and *The Phonological Awareness Test 2* (PAT-2) (Robertson & Salter, 2007). Demographic information was also gathered in order to determine variance contributed and to further define the sample.

**Participants**

The sample was comprised of second-grade students enrolled in an elementary charter school in rural Pennsylvania. All students in the two second-grade classrooms were invited to participate in the study (*N* = 28) and 18 students returned consent forms. One student was removed from the study because music aptitude data was not collected due to the student’s absence on testing days. Remaining participants (*n* = 17; 7 female; 10 male) were between 6:9–8:0 years of age (*M* = 7:5). Ten students were in Class A and seven students were in Class B. Demographic information reported from guardians indicated all participants spoke English and
no additional languages, were Caucasian not Hispanic, and had no identified disabilities. Due to the homogeneity among the sample pertaining to languages spoken, race, ethnicity, and disability status, only the variables of gender and classroom teacher were examined to determine the amount of variance they contributed to IMMA and PAT-2 scores.

**Instruments**

Measures for hearing, phonological awareness, and music aptitude were chosen based on recommendations from speech-language pathologists and experts in children’s musical development. The use of standardized measures provides valid and reliable assessments of student performance and allows for interpretation compared to national norms and to results from previous studies.

**Hearing screening.** Hearing loss impacts the perception of speech and other sounds and could negatively affect scores on phonological awareness and musical aptitude tests, which require normal aural acuity. Speech-language professionals administered hearing screenings at the research site, following school parameters and those set by the Department of Health (2001). Each ear was tested individually and lack of participant response at any frequency in either ear would constitute a failure. Although no participants failed the hearing screening, failure would have been grounds for exclusion from the study.

**Phonological awareness.** The PAT-2 was utilized as a measure of phonological awareness. Appropriate for students in grades K–4, ages 5–9, the standardized measure of phonological awareness takes approximately 30 minutes to complete. Graduate students in speech-language pathology administered the six subtests (rhyming, segmentation, isolation, deletion, substitution, and blending), which contain 10–30 items each, to each participant on a one-to-one basis. To ensure reliability, the certified speech-language pathologist at the research
site oversaw test administration and scoring. Standardized scores are used to identify students with deficits and were, therefore, used in the present analysis. Standard scores range from 55-145, $M = 100$, $SD = 15$.

**Music aptitude.** The IMMA was utilized as a standardized measure of developmental musical aptitude and is suitable for students in grades 1–6 (Gordon, 1986, 2012). The IMMA utilizes same/different discrimination tasks in the tonal and rhythm domains and produces three scores: Tonal, Rhythm, and Composite (the combined total of the tonal and rhythm subtests). The IMMA. Each subtest contains 40 items and the test takes approximately 40 minutes to complete in its entirety. Raw scores were used for analysis based on previous analyses (e.g., Rubinson, 2010) and recommendations in the test materials.

**Demographic information.** Guardians completed a questionnaire (see Appendix A-3) that was included with the consent form. In previous research, relationships between music aptitude/ability and phonological awareness remained present even after controlling for factors of age, SES, musical training/ability, and/or intelligence (Forgeard et al., 2008; Loui et al., 2011; Moritz et al., 2013). Although music aptitude can be influenced by outside sources until age 9, understanding the factors that contribute to music aptitude was not an aim of this study. Therefore, demographic information regarding SES and previous musical training was not collected.

**Procedure**

After approval from the appropriate Institutional Review Board (IRB), second-grade classroom teachers distributed consent forms. The speech-language pathologist at the research site collected signed parental consent forms. Participants were pulled from general education
classrooms to complete hearing screenings and phonological assessments on an individual, rolling basis as consent forms were returned.

The hearing screening and PAT-2 were administered by speech-language specialists less than one month before IMMA testing and in accordance with standardized administration procedures. All students passed the hearing screening; failing would have been grounds for removal. The last participant was tested 15 days after the first participant.

The IMMA was administered within 1 month after the phonological testing to each intact classroom, a timeframe that follows precedents set in previous research (Lathroum, 2011). Test materials indicate that IMMA measures aptitude best when subtests are completed on separate days. Due to time constraints and scheduling at the research site, the primary researcher (a music specialist) administered both subtests on the same day. After the tonal test, students participated in a short movement call-and-response activity for approximately 3 minutes before completing the rhythm subtest. Otherwise, the IMMA was administered and scored in accordance with standardized procedures. Class A was tested prior to Class B and students absent from Class A during the initial test, were tested with Class B.

**Data Analysis**

The speech-language specialists scored the hearing screening (pass/fail) and the PAT-2. Standardized scores on subtests and a composite score were determined for each participant. The primary researcher scored the IMMA, yielding raw numerical scores for subtests and a composite score. In addition to participants’ materials, IMMA answer sheets for non-participants were also blind-scored by the primary researcher and provided to the music teacher at the research site.
Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software. All alphas were set to .05. T-tests examined mean differences among groups (i.e., sex, classroom) on measures of music aptitude and phonological awareness. Pearson product-moment correlation coefficients examined relationships among scores obtained from the IMMA and PAT-2 subtests and composite scores. Partial correlations were also computed, controlling for sex. Finally, a regression with IMMA scores (i.e., composite, rhythm, tonal) was used to develop a mathematical model for predicting PAT-2 composite scores.

**Results**

Means, standard deviations, and ranges obtained from measures are reported in Table 3.1. All PAT-2 composite scores were within normal ranges (85-115) and all subtest scores were within 2 SD of the mean. With a skewness of -1.99 (SE = .55) and kurtosis of 5.16 (SE = 1.06) the rhyming subtest was non-normally distributed. The isolation subtest was also non-normally distributed with a skewness of -1.24 (SE = .55) and kurtosis of 1.32 (SE = 1.06). The relatively high skewness and kurtosis on PAT-2 rhyme and isolation subtests may be related to the age of the sample. Both are early developing phonological skills, typically in place before age 6 (Moats & Tolman, 2015) and all participants were 6 and older. The IMMA scores were rather low when compared to percentiles provided in test materials. All composite scores and most scores on subtests met assumptions for normality.
Table 3.1

Means, Standard Deviations, and Ranges

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<th>Mean</th>
<th>SD</th>
<th>Range</th>
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<tbody>
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<td>79-113</td>
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<td></td>
</tr>
<tr>
<td>Tonal Subtest</td>
<td>29.1</td>
<td>5.6</td>
<td>18-37</td>
<td>40</td>
</tr>
<tr>
<td>Rhythm Subtest</td>
<td>25.9</td>
<td>4.4</td>
<td>20-35</td>
<td>40</td>
</tr>
<tr>
<td>Composite</td>
<td>55.5</td>
<td>7.9</td>
<td>43-69</td>
<td>80</td>
</tr>
</tbody>
</table>

Note. PAT-2 standardized $M = 100$, $SD = 15$.

Classroom teacher and sex were examined to determine any relationships with the constructs. Because instruction is directly related to student achievement, comparisons between classroom teachers were considered; no differences between groups on either assessment were found. Although sex has not been reported as a significant contributor of variance in either PAT-2 or IMMA test manuals, sex was examined because this study sought to determine whether the sample exhibited similar characteristics. No significant differences were found between males and females ($p’s > .05$) among PAT-2 scores. However, independent samples t-tests revealed mean differences between males and females on IMMA rhythm subtest scores ($t = 2.320$, $p = 0.028$, $df = 15$, $d_{Cohen} = -1.142$) and IMMA composite scores ($t = 3.317$, $p = 0.004$, $df = 15$, $d_{Cohen} = -1.635$), favoring males. On the rhythm subtest, males averaged 27.20 ($n = 10$, $SD = 4.24$) and females averaged 23.29 ($n = 7$, $SD = 3.20$). As for composite scores, males averaged 59.7 ($n = 10$, $SD = 6.58$), while females averaged 49.6 ($n = 7$, $SD = 5.56$). No significant differences were found between tonal subtest scores for males and females ($p = .064$).
Relationships were determined using Pearson’s $r$ and linear regressions. Pearson’s $r$ revealed statistically significant relationships among subtests and composite scores. Table 3.2 provides a description of zero-order correlations and Table 3.3 provides correlations among all variables. Positive, significant relationships were found between scores on the PAT-2 rhyming subtest and IMMA tonal subtest ($r = .549, p = .022$); PAT-2 rhyming subtest and IMMA composite ($r = .524, p = .031$); PAT-2 deletion subtest and IMMA tonal subtest ($r = .588, p = .013$); and PAT-2 composite and IMMA tonal subtest ($r = .485, p = .048$). Given that sex was associated with IMMA rhythm and composite scores, partial correlations were run controlling for sex; a description is provided in Table 3.4. After controlling for sex, positive, significant relationships were revealed between scores on the PAT-2 composite and IMMA composite ($r_{\text{partial}} = .499, p = .049, df = 14$); as well as PAT-2 blending subtest and IMMA tonal subtest ($r_{\text{partial}} = .579, p = .019, df = 14$). Additionally, the correlation between scores on the PAT-2 deletion subtest and IMMA tonal subtest was stronger when controlling for sex ($r_{\text{partial}} = .650, p = .006, df = 14$). Finally, a linear regression indicated IMMA tonal subtest scores predicted PAT-2 composite scores ($R^2 = .236, F(1,15) = 4.624, p = .048, SE = 6.560$).
Table 3.2

*Correlations Among PAT-2 and IMMA Scores*

<table>
<thead>
<tr>
<th>PAT-2 Scores</th>
<th>IMMA Scores</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tonal</td>
<td>Rhythm</td>
<td>Composite</td>
<td></td>
</tr>
<tr>
<td>Rhyming</td>
<td>.549*</td>
<td>.228</td>
<td>.524*</td>
<td></td>
</tr>
<tr>
<td>Segmentation</td>
<td>-.080</td>
<td>-.170</td>
<td>-.142</td>
<td></td>
</tr>
<tr>
<td>Isolation</td>
<td>.414</td>
<td>.207</td>
<td>.399</td>
<td></td>
</tr>
<tr>
<td>Deletion</td>
<td>.588*</td>
<td>.067</td>
<td>.325</td>
<td></td>
</tr>
<tr>
<td>Substitution</td>
<td>.106</td>
<td>.180</td>
<td>.236</td>
<td></td>
</tr>
<tr>
<td>Blending</td>
<td>.355</td>
<td>-.045</td>
<td>.125</td>
<td></td>
</tr>
<tr>
<td>Composite</td>
<td>.485*</td>
<td>.195</td>
<td>.461</td>
<td></td>
</tr>
</tbody>
</table>

*Notes.* IMMA tonal and rhythm subtests were not statistically significantly correlated, indicating the two tests are operating independently of one another and measuring two different constructs. *p < .05.*
Table 3.3

*Correlation is significant at the .05 level, two-tailed.
**Correlation is significant at the .01 level, two-tailed.

| Variable                  | #   | Sex | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   |
|---------------------------|-----|-----|------|------|------|------|------|------|------|------|------|------|------|
| Teacher                   | -.118 | -.214 | .302 | -.128 | .211 | .363 | -.054 | .144 | -.081 | .413 | .193 | .332 |
| Age (Months) (#)          | .384 | -.336 | .013 | -.279 | -.190 | -.254 | .451 | -.090 | -.095 | -.090 | -.155 |
| Sex                       | -.297 | .337 | -.131 | -.002 | -.025 | .324 | -.132 | -.431 | -.514* | -.651** |
| 1. PAT-2 Rhyming          | ~    | .098 | .641** | .570* | .200 | .314 | .607** | .549* | .228 | .524* |
| 2. PAT-2 Segmentation      | ~    | .483* | .373 | .323 | .187 | .441 | -.080 | -.170 | -.142 |
| 3. PAT-2 Isolation        | ~    | .643** | .739** | .187 | .674** | .414 | .207 | .399 |
| 4. PAT-2 Deletion         | ~    | .305 | .559* | .649** | .588* | .067 | .325 |
| 5. PAT-2 Substitution      | ~    | -.095 | .572* | .106 | .180 | .236 |
| 6. PAT-2 Blending         | ~    | .417 | .355 | -.045 | .125 |
| 7. PAT-2 Composite        | ~    | .485* | .195 | .461 |
| 8. IMMA Tonal             | ~    | .422 | .778** |
| 9. IMMA Rhythm            | ~    | .850** |
| 10. IMMA Composite        | ~    | ~    | ~    | ~    | ~    | ~    | ~    | ~    | ~    | ~    | ~    | ~    | ~    |
Table 3.4

Partial Correlations Among PAT-2 and IMMA Scores, Controlling for Sex

<table>
<thead>
<tr>
<th>PAT-2 Scores</th>
<th>Tonal $r_{partial}$</th>
<th>Rhythm $r_{partial}$</th>
<th>Composite $r_{partial}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhyming</td>
<td>.489</td>
<td>.092</td>
<td>.456</td>
</tr>
<tr>
<td>Segmentation</td>
<td>.077</td>
<td>.003</td>
<td>.108</td>
</tr>
<tr>
<td>Isolation</td>
<td>.399</td>
<td>.165</td>
<td>.417</td>
</tr>
<tr>
<td>Deletion</td>
<td>.650*</td>
<td>.076</td>
<td>.425</td>
</tr>
<tr>
<td>Substitution</td>
<td>.105</td>
<td>.195</td>
<td>.289</td>
</tr>
<tr>
<td>Blending</td>
<td>.579*</td>
<td>.150</td>
<td>.467</td>
</tr>
<tr>
<td>Composite</td>
<td>.479</td>
<td>.149</td>
<td>.499*</td>
</tr>
</tbody>
</table>

Notes. IMMA tonal and rhythm subtests were not statistically significantly correlated after controlling for sex, indicating the two tests are operating independently of one another. *$p < .05$. 

Limitations

The limitations of the study are similar to limitations found in other studies utilizing small samples investigating relationships between phonological and musical domains (e.g., Bolduc & Montésinos-Gelet, 2005, $N = 13$; Lamb & Gregory, 1993, $N = 18$). The relatively small sample, which was similar across several demographic variables, does not lend strongly to generalizability to the larger population. Additionally, administering both the tonal and rhythm subtests of the IMMA on the same day could have affected scores on the rhythm measure, as it was administered second.

Discussion

Results of this investigation into the relationship between phonological awareness and music aptitude in second-grade students extend previous research. The positive, predictive relationship between tonal music aptitude scores and phonological awareness indicate the relationship between the constructs may exist past first grade for typically developing children.
(Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Rubinson, 2010). Further, the IMMA can help predict this relationship before age 10 (Forgeard et al., 2008).

Differences in music aptitude scores between sexes in the small sample may indicate that participants are not representative of the larger population, which is to be expected in small-sample studies. The IMMA test materials do not indicate sexes should be expected to score differently on the assessments and Rubinson (2010) did not indicate a difference between sexes when measured at baselines (p. 91). However, drawing conclusions about the exceptionality of this finding is difficult because previous researchers did not consistently report whether differences were found between sexes (Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008). Yet, the effect of sex in the current sample attenuates the correlations, which could have been different and/or stronger in a sample where males and females performed similarly on all measures.

Findings from this study align with those from Bolduc and Montésinos-Gelet (2005), who found a relationship between phonological awareness and only the tonal domain of music aptitude. Like Bolduc and Montésinos-Gelet (2005), the present study did not find a relationship between the rhythm domain and phonological awareness. Further, results align with previous studies reporting a relationship between phonological awareness and the tonal domain, independent of the rhythm domain (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Lathroum, 2011; Rubinson, 2010). A relationship between composite scores was found using partial correlations, when controlling for sex, which speaks to the findings of previous research studies, (Anvari et al., 2002; Lathroum, 201132; Peynirciog˘lu et al., 2002; Rubinson, 2010) although sex was not controlled for in those studies. This study did

32 Also included a melodic measure.
not support the findings of research studies that found relationships between phonological awareness and the rhythm domain of music aptitude (Anvari et al., 2002; Forgeard et al., 2008; Lathroum, 2011; Moritz, 2007; Rubinson, 2010). Overall, findings support the claim that phonological awareness may be more closely associated with the tonal domain, rather than the rhythmic (Anvari et al., 2002; Forgeard et al., 2008). Further, findings support the assertion that music aptitude as measured by Gordon’s IMMA is related to phonological awareness, particularly tonal aptitude (Forgeard et al., 2008). Studies that utilized Gordon’s measures did not consistently report relationships between phonological awareness composite (Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008) or rhythm scores (Bolduc & Montésinos-Gelet, 2005). However, all previous investigations examined reported relationships between tonal aptitude and phonological awareness (Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Rubinson, 2010).

**Phonological Skills**

Findings of the current study align with previous research correlating Gordon’s measures of music aptitude with phonological rhyming and deletion skills. Forgeard et al. (2008) also reported a positive relationship between phonemic deletion skills and tonal music aptitude. The relationship between tonal music aptitude and rhyming was also found among kindergarten children (Bolduc, 2008). The present study supports and extends these previous findings by contributing evidence that composite (tonal and rhythm) music aptitude scores correlate with rhyming. Further, the presence of this relationship in the current sample suggests the relationship persists over a period of years. Current findings do not align with Rubinson (2010), who reported a relationship between music aptitude and segmentation skills among kindergarteners. The level of segmentation skill measured could explain this discrepancy. Rubinson (2010) measured
segmentation at one level (phoneme) only, where the present study measured three levels
(phoneme, syllable, and sentence). Hence, segmentation scores in the present study represent
more complex tasks and may not be directly comparable to Rubinson’s (2010) previous findings.

Predictions

Predictions reported in the present study support and extend those reported by Forgeard
et al. (2008), who found IMMA tonal and rhythm scores separately predicted phonemic
awareness in participants approximately 10 years of age diagnosed with dyslexia. Current
findings differ from those of Forgeard et al. (2008) because a predictive relationship was not
found between phonological awareness and rhythm aptitude. This could be explained because
the significance threshold was more stringent in the current study ($p < .05$) than that of Forgeard
et al. (2008) ($p \leq .1$). For this reason, findings of the present study also extend Forgeard et al.’s
(2008) previous research by creating a prediction model using IMMA tonal subtest scores with a
higher significance threshold. Finally, the current study illuminates the presence of a predictive
relationship between IMMA tonal scores and phonological awareness in typical children,
younger than those previously investigated.

Implications for Music Teaching and Learning

The relationships found between music aptitude and phonological awareness in the
present study have implications for music teaching and learning. Results of this study could help
support music teachers in allotting time for music aptitude testing. First, understanding a
student’s developmental music aptitude can help music teachers tailor instruction (Gordon, 2012;
Stevens, 1987) to help the student better achieve more appropriate musical goals and ultimately
reach a higher stabilized music aptitude (Gordon, 1986, 2012). Higher levels of music aptitude
can lead to greater musical achievement over the course of the student’s life. Second, the
The correlational nature of the relationship between the constructs indicates that a measure of tonal music aptitude could be useful when assessing phonological awareness abilities. Because students with low music aptitude may also have low phonological awareness, a tonal music aptitude score may serve as early identification of those who may benefit most from additional musical and phonological assistance. In this way, the music teacher could gather valuable data to aid instruction in multiple areas.

Although previous researchers have indicated that music instruction naturally bolsters phonological awareness in young children (Degé & Schwarzer, 2011; Gromko, 2005; Moritz, 2007; Moritz et al., 2013; Richards, 2011), music teachers should continue to consider the connections between the two constructs when planning for instruction. Reading skills are best aided by music experiences when phonological instruction is added to pre-existing music curriculum (Standley, 2008). Music teachers should also inform reading specialists, speech-language pathologists, music therapists and other professionals who may remediate literacy skills about the positive effects of music experiences on phonological awareness development when added to phonological skill building programs (Bolduc, 2009; Bolduc & Lefebvre, 2012; Colwell, 1988; Herrera et al., 2011; Walton, 2014), because music added to other areas of a students’ education can serve to improve their musical skills overall.

Implications for Future Research

Given the relationship identified in the present investigation, the need for future research is evident. Correlational studies investigating the relationship between music aptitude and phonological awareness establish links between the constructs, but do not establish a causal relationship. Although evidence exists supporting the benefits of music instruction on phonological awareness, most research has been conducted with students below second grade.
Therefore, experimental research designs should be used to examine how this relationship could serve to bolster phonological skills in naturalist music environments for students this age and older.

Finally, this investigation has illuminated the need for the relationship between phonological awareness and music aptitude to be investigated in students with speech and language disabilities, particularly those students with phonological processing deficits. Previous research has revealed the relationship between music aptitude and phonological awareness in students with dyslexia (Forgeard et al., 2008), a learning disability that has been connected to deficits in phonological processing (Shaywitz & Shaywitz, 2005). Hence, future investigations should examine the relationship between music aptitude and phonological awareness in students with phonological processing deficits.

Conclusions

Phonological awareness is considered a building block of reading and one of the best predictors of future reading success (Ehri et al., 2001). Even though reading proficiency is the most fundamental skill for academic success (Lyon, Shaywitz, Shaywitz, & Chhabra, 2005, p. 209), deficits may go unnoticed until after first grade. When remediation is needed, elementary students may be removed from typical classroom to receive additional support (Elbaum et al., 2000; Hurt, 2012). Previous researchers have demonstrated the relationship between music aptitude and phonological awareness in Kindergarten children (Bolduc & Montésinos-Gelet, 2005; Rubinson, 2010); and the phonological benefits that can be realized by participating in musical activities for that age group (Gromko, 2005; Moritz et al., 2013; Richards, 2011). The relationships between music aptitude and phonological awareness found in the current study with second-grade students, when combined with previous evidence, provide support for students
beyond Kindergarten to participate in music classes, as both musical and language skills may be enhanced.

This study supports the notion that tonal music aptitude is a reliable predictor of phonological awareness abilities in second-grade students. Given previous findings supporting the efficacy of music in phonological training programs for students below second grade (Bolduc & Lefebvre, 2012; Herrera, Lorenzo, Defior, Fernandez-Smith, & Costa-Giomí, 2011; Richards, 2011; Walton, 2014), the relationships found in the present study between tonal music aptitude and phonological rhyming and deletion skills has implications. Using pitched activities during instruction targeting these phonological skills could increase efficacy for students in second grade. Experimental research is needed to examine whether enhancing tonal music aptitude could help naturally improve second-grade students’ abilities to execute these phonological skills.

Due to the shared variance between phonological awareness and music aptitude, as well as previous research supporting the addition of music to preliteracy or phonological training programs, music teachers and reading specialists should consider the connections between the two constructs when planning for instruction. It may not be advantageous for students to be removed from music classrooms to work on phonological awareness skills. Music teachers may be able to build students’ musical skills in natural ways that bolster music aptitude, without adding specialized phonological training to help improve students’ phonological awareness. Reading teachers and specialists are encouraged to include music in their instruction because music may also assist phonological awareness development in those settings.
References


Morris, R. D., Stuebing, K. K., Fletcher, J. M., Shaywitz, S. E., Lyon, G. R., Shankweiler, D. P.,


Appendix A-3

Demographic Information Form

Demographic Information:

Student Name: ___________________________ Date: ______

1. Sex: (select one)
   Male: ______   Female: ______

2. Current Age: Example - 7 years, 2 months
   Years: _______   Months: _______

3. Ethnicity: (select one)
   ____ Hispanic or Latino: An indication that the person traces his or her origin or descent to Mexico, Puerto Rico, Cuba, Central and South America, and other Spanish cultures, regardless of race.
   ____ Not Hispanic or Latino

4. Race: (select all appropriate)
   ____ American Indian or Alaska Native: A person having origins in any of the original peoples of North and South America (including Central America), and who maintains cultural identification through tribal affiliation or community attachment.
   ____ Asian: A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent. This area includes, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
   ____ Black or African American: A person having origins in any of the black racial groups of Africa.
   ____ Native Hawaiian or Other Pacific Islander: A person having origins in any of the original peoples of Hawai‘i, Guam, Samoa, or other Pacific Islands.
   ____ White: A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

5. Languages spoken by the child: (list all, check “No Second Language” if child does not speak a second language)
   Primary Language: ____________________________________________________________
   Other(s): _________________________________________________________ No Second Language: ______

6. Identified Disabilities: (please indicate disabilities which have been identified by a medical professional or school district and for which the student receives educational services)
   This information will not be shared with persons not associated with the study.
   This information will not be used to exclude students for the study.
   This information will be used to interpret test scores only.

   Because this study is interested in phonological awareness, an important aspect of reading development, it is important to know if the student has any impairment that could hinder his/her reading skills so results can be interpreted most appropriately.
   ____ Student has no Identified Disabilities
   ____ Autism
   ____ Deaf-blindness
   ____ Deafness
   ____ Developmental delay
   ____ Emotional disturbance
   ____ Hearing impairment
   ____ Intellectual disability
   ____ Multiple disabilities
   ____ Orthopedic impairment
   ____ Other health impairment
   ____ Specific learning disability
   ____ Speech or language impairment
   ____ Traumatic brain injury
   ____ Visual impairment, including blindness
Chapter 4: Study Two

A Longitudinal Investigation of the Relationship Between Phonological Awareness and Music Aptitude
Abstract

The purpose of this study was to investigate the relationship between phonological awareness and music aptitude over time. In grades 2 and 3 ($n = 7$), participants from a rural charter in Pennsylvania were tested using standardized measures of music aptitude (The Intermediate Measure of Music Audiation [IMMA]) and phonological awareness (The Phonological Awareness Test 2 [PAT-2]). Speech-language specialists administered a hearing screening and the PAT-2 16 months after initial testing period. The primary researcher administered and scored the IMMA 12 months after the initial testing period. Findings indicate that music aptitude measured in second grade could predict phonological awareness ability in third grade.

Keywords: phonological awareness, music aptitude, general music, special needs, speech impairment
A Longitudinal Investigation of the Relationship Between Phonological Awareness and Music Aptitude

Introduction

Strong reading skills are important for academic success (Lyon, Shaywitz, Shaywitz, & Chhabra, 2005, p. 209), but reading deficits that manifest early in life can continue into adolescence if left unchecked (Watson, Watson, & Fredd, 1982). Several factors contribute to reading development, including phonological awareness. Phonological awareness is strongly associated with reading acquisition and skills (Ehri et al., 2001; Kleeck, Gillam, & McFadden, 1998; Torgesen et al., 2001; Wagner & Torgesen, 1987; Yeh & Connell, 2008; Yopp & Yopp, 2000). Therefore, deficits in phonological awareness can lead to problems with reading that could continue throughout the lifetime (Shaywitz & Shaywitz, 2005, p. 1302; Torgesen, Wagner, & Rashotte, 1994).

In order to address phonological awareness deficits, students are sometimes removed from typical classroom settings, including “specials” such as music and art, to receive individual assistance (Elbaum, Vaughn, Hughes, & Moody, 2000). In addition, middle and high school students who need to take additional coursework in English or language arts may not have room in their schedules to add an elective in music (Elpus & Abril, 2011; Hoffman, 2013). Yet, denying students access to a music education is not appropriate. Kvet (1985) reported no significant differences in the reading or language scores of sixth-grade students removed from regular classroom instruction for instrumental music. Therefore, students should be able to receive music instruction in order to continue to build both musical and literacy skills.

Previous research points to connections between phonological awareness and musical aptitude among early elementary students (Forgeard et al., 2008; Moritz, Yampolsky, Papadelis,
Thomson, & Wolf, 2013; Rubinson, 2010) Musical discrimination skills have predicted phonological skills in typically developing children and children with dyslexia (Forgeard et al., 2008); music training during kindergarten has positively impacted phonological awareness skills (Moritz et al., 2013); and musical participation during preschool has significantly enhanced phonological awareness (Degé & Schwarzer, 2011). Yet, researchers have primarily investigated phonological awareness and musical ability among children whose phonemic inventories are still developing. Little is known about the nature of phonological awareness achievement and music aptitude among children whose phonemic inventories are nearly complete and whose music aptitude is still developing. Because deficits in phonological awareness can persist and relationships between music aptitude and phonological awareness have been previously demonstrated, examining the relationship between phonological awareness and music aptitude over time among children with more complete phonemic inventories is warranted and the focus of this study.

**Rationale**

Particularly, little is known about the relationship between music aptitude and phonological awareness among third-grade students, whose music aptitude is still developing but whose phonemic inventory is essentially complete. Previous researchers have indicated a need for longitudinal investigations that examine music aptitude and language-related processes (Yang, Ma, Gong, Hu, & Yao, 2014). Due to the stability of individual differences in phonological processing, new research should address cognitive variables that could continue to positively influence a student’s phonological development (Blachman, 1994). Hence, understanding how the two constructs relate could help improve remediation by helping
researchers understand the nature of a cognitive variable (i.e., music aptitude) that relates to a student’s phonological development.

Previous longitudinal investigations have employed measures lacking in dimensionality. Forgeard et al. (2008) examined both the tonal and rhythmic subdomains of music aptitude, but used only deletion tasks to measure phonemic awareness. Moritz et al. (2013) measured multiple phonological awareness subskills, but did not assess the tonal subdomain of music aptitude. Therefore, a longitudinal study with older students examining music aptitude and phonological domains awareness using evidence representing multiple dimensions is needed.

Understanding the relationship between music aptitude and phonological awareness over time could have important educational implications. A positive relationship between the constructs among this age group could benefit all children. First, students in this age group could be encouraged to participate in more musical experiences throughout life. Such experiences would help improve their music aptitude, ability, and achievement over their lifetimes. Second, such a finding would indicate that musical experiences could help to improve phonological awareness for this age group. Typically developing students would benefit from the ways in which music reinforces developing skills; students with phonological deficits could spend more time in naturalistic environments, such as music classes. Rather than being pulled out of classrooms for individual assistance, students could participate in group musical experiences to improve phonological awareness and musical aptitude simultaneously. Conversely, literacy instruction could be improved in elementary classrooms by adding musical elements, which, in turn, could lead to higher musical aptitudes. Therefore, the nature of the relationship between phonological awareness and music aptitude, as well as whether potential to achieve in music can predict phonological awareness achievement over time should be examined.
Phonological Awareness

Phonological awareness, a feature of phonological processing, is a general term for a person’s ability to analyze and manipulate language (American Speech-Language-Hearing Association [ASHA], 2017). As an over-arching concept, phonological awareness encompasses all sizes of sound units (e.g., words, syllables, phonemes). Phonemes represent the smallest units of sounds within a language. Phonemes establish word meanings and distinguish between words when combined with other units. For example, *bit* and *fit* differ by only the initial phoneme and have different meanings. Referring only to the phoneme level, phonemic awareness is a feature of phonological awareness. Phonological awareness allows individuals to break down words into smaller units and can be described in terms of phoneme awareness, syllable awareness, and onset-rime awareness (Moats & Tolman, 2015).

The phonemic inventory begins developing before birth and is mostly in place by age 7 (Bauman-Waengler, 2012, p. 139). However, certain phonological awareness skills could develop as late as age 9 (Moats & Tolman, 2015). Phonological awareness skills can include activities in which different sound units (e.g., phoneme, syllable, word) are manipulated through skills such as blending, substituting, matching, isolation, rhyming, segmenting, and deletion (Robertson & Salter, 2007; Moats & Tolman, 2015). Development for each skill typically follows a predictable progression, which is often understood in terms of a child’s chronological age (Moats & Tolman, 2015). Yet, as children age, they may experience less phonological awareness growth from year to year due to their current levels of achievement. Kantor (2010) reported initial levels of phonological awareness were negatively related to growth rates. In this way, children with higher initial levels of phonological awareness may experience less growth than children with lower initial levels during the same period of time.
Although phonological skills follow a positive trajectory, phonological awareness skills may remain relatively stable throughout the elementary years in relation to peers (Blachman, 1994; Torgesen et al., 1994). In a longitudinal examination of phonological processing skills in students from kindergarten to second grade researchers indicated that individual differences in phonological awareness skills were stable in the early elementary grades (Torgesen et al., 1994). Researchers concluded that “phonological processing skills should be considered to be important human abilities in their own right, similar to the intellectual abilities assessed on measures of general intelligence” (Torgesen et al., 1994, p. 282).

Additionally, “phonological processing disabilities are the cause of a substantial proportion of reading disabilities in young children, adolescents, and adults” (Torgesen et al., 1994, p. 284). Hence, a number of children with phonological processing deficits may also have reading disabilities. Yet, children who have the most difficulty making sense of oral language (e.g., the largest deficits in phonological processing) may be most resistant to phonemic awareness training alone to help remediate these deficits. They may respond better to remediation that is more complex (Blachman, 1994; Torgesen et al., 1994).

Researchers should examine variables that could positively influence phonological development among children over time (Torgesen et al., 1994, p. 284). Phonological awareness skills have demonstrated stability during the early years of life. While growth may be realized, it may not be enough to overcome deficits without additional assistance. Deficits in phonological awareness could lead to reading disabilities that can persist throughout an individual’s life (Torgesen et al., 1994, p. 284). Yet, children with deficits in phonological processing may be more resistant to phonological training alone (Torgesen et al., 1994) and older children may be more likely to experience less growth over time. The phonemic inventory stabilizes around age 7
(Bauman-Waengler, 2012, p. 139) and children with higher levels of phonological awareness (e.g., older children) may experience less growth as compared to children with low levels of phonological awareness (Kantor, 2010). For these reasons, there is a need for research addressing cognitive variables that could influence a student’s response to phonological remediation (Blachman, 1994), such as music aptitude.

**Music and Phonological Awareness**

Researchers have investigated the connections between music and phonological awareness. Relationships between music aptitude/ability and phonological skills have received attention over the years. Additionally, relationships between music training and phonological awareness have also been examined. Musical *training* often refers to a quantifiable amount of training (measured in minutes, weeks, years, etc.); or to a type of musical training (e.g., instrumental, tonal, Kodaly, etc.). In these ways, musical training may be used to delineate groups to compare performance on variables of interest or used as a treatment in an experimental study. Although, musical training as a variable is rather easily distinguished; the terms ability and aptitude are often used in, seemingly, interchangeable fashions, even though the terms are not necessarily synonymous (Müller, 2011; Nardo & Reiterer, 2009).

**Music Aptitude vs. Music Ability**

Disentangling music aptitude from music ability can be quite challenging due to similarities between the terms. Music ability may refer to person’s capabilities in music; whereas music aptitude refers to one’s ability to intuitively learn music (Gordon, 2012). While ability and aptitude are similar, the distinction seems to reside in the understanding of *aptitude* as innate, inborn, intuitive, or natural (Gordon, 1986, 2012; Müller, 2011; Nardo & Reiterer, 2009; Nichols, 1999; Stevens, 1987), whereas ability could refer to something innate or something
acquired (Merriam-Webster, Incorporated, 2017; Nardo & Reiterer, 2009). While some draw distinctions between aptitude and ability (Nardo & Reiterer, 2009), an essential purpose of a test of aptitude or ability is often to predict future behavior (Gordon, 1986; Kaplan & Saccuzzo, 2005; National Research Council, 1982; Stevens, 1987; Wigdor, 1982;). For these reasons, studies wherein musical aptitude and/or musical ability were investigated are included under the heading of music aptitude in this manuscript.

Differing approaches exist to the measurement and understanding of music aptitude (see Culp (in press) for a detailed review). In this discussion, I use Gordon’s (2012) definition of musical aptitude: “one’s potential to learn music” (p. 44). Every person is born with a certain potential to achieve in music, which is “ever changing, moving up and down as it develops” (Gordon, 2012, p. 46). It is influenced by outside factors until approximately age 9. During this period of time, music aptitude is considered developmental and stabilizes thereafter. To measure music aptitude, Gordon (1986) designed measures of audiation (a person’s ability to assign meaning to musical events). It is not possible to completely separate the measurement of music aptitude from music achievement (Gordon, 1986). However, a test’s emphasis on the construct (e.g., music aptitude or music achievement) will determine what it measures (Gordon, 1986). Therefore, tests designed to measure music aptitude must be used to measure the construct of music aptitude.

**Music Aptitude and Phonological Awareness**

Researchers investigating the relationships between musical aptitude/ability and phonological awareness abilities have reported positive relationships between the constructs ($p’s < .05$) (Anvari, Trainor, Woodside, & Levy, 2002; Bolduc & Montésinos-Gelet, 2005; Culp, in press; Lamb & Gregory, 1993; Lathroum, 2011; Loui, Kroog, Zuk, Winner, & Schlaug, 2011;
Peynircioğlu, Durgunoğlu, & O’ney-Küsefoglu, 2002; Moritz et al., 2013). Forgeard et al. (2008) also reported a correlation between music discrimination abilities and phonemic awareness in children with dyslexia and above average intelligence \( (p \leq .1) \). Relationships noted between music and phonological awareness have remained present even after controlling for factors of age, SES, musical training/ability, and/or intelligence (Forgeard et al., 2008; Loui et al., 2011). Results of these correlational studies indicate pitched tasks have stronger relationships with phonological awareness than rhythmic tasks (Bolduc & Montésinos-Gelet, 2005; Culp, in press; Forgeard et al., 2008).

In addition to correlational studies wherein music aptitude and phonological awareness were measured a single time, researchers have examined also the relationships between music ability and phonological awareness over time (Forgeard et al., 2008; Moritz et al., 2013). Moritz et al. (2013) studied the relationship between kindergarten rhythm skills and second-grade reading skills. Participants \( (n = 12; \text{mean age} = 8;1^{33}) \) completed rhythmic skill assessments in kindergarten and phonological assessments in second grade. After controlling for cognitive ability measured in kindergarten, rhythm skills (discrimination and production) positively correlated with phonological skills (blending nonwords and nonword repetition) \( (r_{partial}'s = .62 - .72^{34}, p's < .05) \). Forgeard et al. (2008) reported that phonemic awareness, as measured by deletion tasks, correlated with both the tonal and rhythm subtest of Gordon’s *Primary Measures*

\footnote{Years;months.}
\footnote{Polarity changed for reporting, as authors indicated negative correlations were signs of positive correlational agreement to the way in which some rhythmic skills were measured: low score = high performance.}
of Music Audiation (PMMA) among participants (mean age = 6;6) with instrumental music training \((n = 32)\) and without \((n = 12)\). After 31 months, improvement from baseline in phonemic awareness was not predicted by the PMMA rhythm subtest, but was predicted by improvement on the PMMA tonal subtest (partial \(r^2 = .09, p = .06\)). Phonemic awareness improvement was also predicted by the researcher-designed melodic discrimination tasks for the music group \((r = .54, \text{partial } r^2 = .18, p = .04, n = 27)\), but not controls \((r = -.24, \text{partial } r^2 = .02, p = .76, n = 10)\). Results of these investigations indicate the relationship between phonological awareness and musical abilities lasts over time and is stronger among children who receive musical training (Forgeard et al., 2008).

The Effects of Music Training on Phonological Awareness

Researchers have also indicated the benefits of musical participation for phonological awareness for children from around the world. General music activities have been beneficial for phonological awareness skills among preschool children (Degé & Schwarzer, 2011) and kindergarteners (Gromko, 2005; Moritz et al., 2013; Richards, 2011). Although general music participation has been beneficial for phonological awareness, training on a musical instrument may not bolster phonological awareness skills beyond typical development (Forgeard et al., 2008). When added to preliteracy or phonological training programs, music has been beneficial for children in preschool (Herrera, Lorenzo, Defior, Fernandez-Smith, & Costa-Giomi, 2011) and kindergarten (Bolduc, 2009; Bolduc & Lefebvre, 2012; Walton, 2014). In fact, adding general musical activities to phonological training may be more beneficial for phonological awareness development than using language-based activities alone (Bolduc & Lefebvre, 2012). Participating in musical activities has also demonstrated phonological benefits for children who speak more than one language (e.g., Fisher, 2001; Herrera et al., 2011). Although music
treatment conditions vary in frequency (number of total sessions), length (minutes in each session, weeks of treatment), and intensity (type of treatment), music has been associated with gains in phonological awareness skills in as little as 4 weeks\textsuperscript{35} (Moreno, Friesen, & Bialystok, 2011), 10 minutes per day\textsuperscript{36} (Degé & Schwarzer, 2011), or 10 sessions\textsuperscript{37} (Bolduc & Lefebvre, 2012). Results of these investigations indicate that musical participation positively influences phonological awareness development, particularly when vocalization is incorporated, and benefits from musical participation may be realized rather quickly.

**Purpose**

Findings from a previous investigation (Culp, in press) with children in second grade ($N = 17$), indicated a positive relationship between standardized scores obtained from *The Phonological Awareness Test 2* (PAT-2) (Robertson & Salter, 2007) and raw scores obtained from the *Intermediate Measures of Music Audiation* (IMMA) (Gordon, 1986). In Culp’s (in press) examination, IMMA Tonal subtest scores positively correlated with PAT-2 Composite scores ($r = .485$, $p = .048$). Tonal subtest scores were also reasonable predictors of PAT-2 standardized composite scores ($R^2 = .236$, $F(1,15) = 4.624$, $p = .048$, $SE = 6.560$). After controlling for sex, composite scores between the two measures also correlated ($r_{\text{partial}} = .499$, $p = .049$).

\textsuperscript{35} 120 minutes in each session, 20 sessions total (every day over 4 weeks), 2400 minutes total.

\textsuperscript{36} 10 minutes in each session, 100 sessions total (every day over 20 weeks), 1000 minutes total.

\textsuperscript{37} 40 minutes in each session, 10 sessions total (once per week over 10 weeks), 400 minutes total.
The purpose of this study is to investigate the relationship between phonological awareness and music aptitude over time. The study also examined whether musical aptitude can predict phonological awareness in elementary students over time, over and beyond what can already be anticipated by known demographic predictors and after controlling for possible hearing loss. Evidence was obtained from PAT-2 and IMMA and participants were tested in grades 2 and 3. Scores obtained from IMMA were expected to demonstrate a moderate, positive relationship with PAT-2 scores, given previous examples connecting phonological awareness to music aptitude over time (Forgeard et al., 2008; Moritz et al., 2013) and results reported by Culp (in press). The following questions guided the study:

1. What is the nature of the relationship between phonological awareness and music aptitude over time?

2. Can potential to achieve in music predict phonological awareness achievement over time?

Method

Design

The study utilized a correlational design. Evidence was obtained from standardized measures of music aptitude and phonological awareness: IMMA and PAT-2. Additional demographic variables were included to determine variance contributed and to further define the sample.

Participants

The sample was comprised of third-grade students enrolled in an elementary charter school in rural Pennsylvania. All students who completed all measures in Culp (in press) as second-grade students were invited to participate in the current study \( n = 17 \). Of that pool, 3
students moved from the district, leaving a potential 14 students to be sampled from two classrooms. In total, 8 students returned permission slips to participate in the study, but 1 was removed for failing the hearing screening. Remaining participants ($N = 7$) were between 8;5–9;1 years of age ($M = 8;9$) at the time of phonological awareness testing. Three males and four females from two different classrooms (Class A or Class B) participated in the study.

Demographic information reported from guardians indicated all participants spoke English as their primary language and no additional languages, all were Caucasian, and self-identified disabilities included a speech or language impairment and an other health impairment. Participants did not participate in summer music enrichments, but 2 subjects participated in summer reading programs.

**Instruments**

Hearing, phonological awareness, and music aptitude measures for this study were also used in Culp (in press). All instruments were chosen to ensure consistency in measurement, provide valid and reliable assessments, and allow for comparison with national norms and previous research as appropriate.

**Hearing screening.** A Rapid Hearing Screening was administered by speech-language specialists in line with Department of Health (2001) guidelines and the research site’s parameters. The hearing loss dial was set at 30DB and the frequency dial at 500, 1000, 2000, and 4000. The right, then left ears were tested individually. Lack of participant response at any frequency in either ear constituted a failure. Because hearing acuity is important for reliably assessing abilities relying on the auditory domain (i.e., phonological awareness and music aptitude), failing the hearing screening was grounds for removal from the study.
**Phonological awareness.** The PAT-2 was used to measure phonological awareness. Developed for students in grades ages 5–9 (grades K-4), versions of this test have been used in previous similar investigations (Culp, in press; Moritz et al., 2013). The phonological awareness portion takes about 30 minutes to complete. In total, the test contains 130 items, distributed among six subtests (i.e., Rhyming, Segmentation, Isolation, Deletion, Substitution, and Blending), which contain 10–30 items (see Table 4.1). In addition to scores on the subtests, a composite score is also produced. Graduate students in speech-language pathology, overseen by a licensed speech-language pathologist, administered and scored the PAT-2. A demonstration item was given for each subtest and responses were scored as a 1 (correct) or 0 (incorrect). Age-based standardized scores were used in the present analysis.
Music aptitude. The IMMA was used to measure developmental musical aptitude. This measure is appropriate for children in grades 1–4 and was used in previous similar research (Culp, in press; Forgeard et al., 2008). Hence, it was selected for this study to more easily allow for comparison. The Tonal and Rhythm subtests each contain 40 items, wherein participants must indicate whether groups of tones are the same or different by circling same or different faces on an answer sheet. In its entirety, the test takes about 40 minutes to complete. Gordon (1986) recommended subtests be administered on separate days, beginning with the Tonal. The test yields three scores: tonal, rhythm, and composite (combined score of Tonal and Rhythm subtests). As a standardized measure of music aptitude, percentile scores are provided. However,
raw scores were used in the analysis based on analysis from previous studies (e.g., Culp, in press; Rubinson, 2010) and recommendations in the test manuals.

**Demographic information.** Demographic information was very similar to that collected by Culp (in press) (e.g., sex, age, ethnicity, race, languages spoken, identified disabilities, and classroom teacher). This information was collected to establish the diversity of the sample and allow for factors that have exerted an influence on phonological awareness and/or music aptitude to be examined. Classroom teacher was examined because instruction can affect student achievement and relationships between sex and IMMA scores were found previously (Culp, in press). Two additional questions were added regarding summer enrichments (reading or music) (see Appendix A-4). These questions were added because this study sought to understand how a previously-established relationship could change over time. Since developmental music aptitude is impacted by outside musical experiences and reading enrichments could influence phonological awareness, both were included. Additional demographic information regarding SES, intelligence, and previous musical training was not collected because relationships between music and phonological awareness remained statistically significant after controlling for such factors (Forgeard et al., 2008; Loui et al., 2011).

**Procedure**

Procedures were very similar to those used by Culp (in press). The speech-language pathologist (SLP) involved in the study distributed and collected consent forms, which were sent home in three rounds. The IMMA was administered to each intact classroom. Due to time constraints and the schedule of the research site, both subtests were administered on the same day by the primary researcher (a music specialist). As in previous studies (e.g., Culp, in press), subjects participated in a short movement call-and-response activity, that lasted approximately 3
minutes, after the Tonal subtest and before the Rhythm subtest. Class A was tested on the same day as Class B. Absent students \((n = 3)\) were tested on a make-up day 2 weeks later.

Phonological testing and hearing screenings were completed approximately 4 months after music testing due to the SLP’s schedule. Speech-language specialists administered the hearing screening and PAT-2 in accordance with standard administration procedures. Data from 1 participant was not included in the final analysis because that participant failed the hearing screening. The last participant was completed PAT-2 subtests approximately 1 month after the first participant.

**Data Analysis**

Speech-language specialists scored hearing screenings (pass/fail) and PAT-2 subtests. Standardized scores on the subtests as well as a composite score were determined for each participant. The primary researcher scored the IMMA, yielding raw scores for each subtest and a composite score for each participant. The notation used in this report is as follows:

A. \(t_1\) = time/measurement 1  
B. \(t_2\) = time/measurement 2  
C. \(X_{t1}\) = scores from time/measurement 1 (e.g., IMMA Tonal \(t_1\))  
D. \(X_{t2}\) = scores from time/measurement 2 (e.g., PAT-2 Blending \(t_2\))

Due to the small sample size, nonparametric measures were used. Mann-Whitney U tests for independent samples examined mean differences between independent groups (i.e., sex, classroom, disability, music enrichment, and reading enrichment) on measures of phonological awareness and music aptitude. Wilcoxon signed-ranks tests were used to determine differences in music aptitude and phonological awareness scores from \(t_1\) to \(t_2\).
New regression formulas for predicting PAT-2 scores were not computed in this analysis. However, the regression model developed by Culp (in press) using IMMA tonal scores from $t_1$ was used to predict phonological awareness scores for $t_2$. First, IMMA tonal scores from $t_1$ were used in the model to predict phonological awareness at $t_2$. Then, IMMA tonal scores from $t_2$ were used in the model to predict phonological awareness at $t_2$.

Because Pearson product-moment correlations control for sample size, Pearson’s $r$ was used to examine relationships among variables of interest. Relationships were determined under the following conditions:

A. Correlations among variables $t_1$
B. Correlations among variables $t_2$
C. Correlations among variables $t_1$, $t_2$
D. Correlations between PAT-2 Composite observed scores and predicted scores using IMMA Tonal$_{t_1}$ and IMMA Tonal$_{t_2}$

Results

The mean, standard deviation, and range for scores from $t_1$ and $t_2$ are reported in Table 4.2. All scores for PAT-2 in $t_1$ were within normal ranges (85-115), however some $t_2$ scores fell below normal ranges, in that scores were more than 2 $SD$ below the mean (i.e., lower than 70). As in $t_1$, IMMA scores for $t_2$ were rather low compared to percentiles provided in test materials.
Table 4.2

Means, Standard Deviations, and Ranges

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Max. Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$t_1$</td>
<td>$t_2$</td>
<td>$t_1$</td>
<td>$t_2$</td>
</tr>
<tr>
<td>*PAT-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>103</td>
<td>91</td>
<td>11.0</td>
<td>19.8</td>
</tr>
<tr>
<td>Segmentation</td>
<td>98</td>
<td>86</td>
<td>9.1</td>
<td>16.7</td>
</tr>
<tr>
<td>Isolation</td>
<td>100</td>
<td>89</td>
<td>11.5</td>
<td>24.0</td>
</tr>
<tr>
<td>Deletion</td>
<td>106</td>
<td>98</td>
<td>7.9</td>
<td>13.6</td>
</tr>
<tr>
<td>Substitution</td>
<td>99</td>
<td>96</td>
<td>13.9</td>
<td>15.7</td>
</tr>
<tr>
<td>Blending</td>
<td>107</td>
<td>106</td>
<td>2.9</td>
<td>6.8</td>
</tr>
<tr>
<td>Composite</td>
<td>100</td>
<td>91</td>
<td>8.8</td>
<td>17.1</td>
</tr>
<tr>
<td><strong>IMMA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tonal Subtest</td>
<td>28.1</td>
<td>28.3</td>
<td>4.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Rhythm Subtest</td>
<td>23.6</td>
<td>26.1</td>
<td>5.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Composite</td>
<td>51.7</td>
<td>54.4</td>
<td>8.2</td>
<td>8.6</td>
</tr>
</tbody>
</table>

Note. PAT-2 standardized \( M = 100, \ SD = 15 \).

*\( t_2 \) occurred 16 months after \( t_1 \).

**\( t_2 \) occurred 12 months after \( t_1 \).

Mean differences between groups were compared using Mann-Whitney U and Wilcoxon signed-ranks tests. Mann-Whitney U tests revealed no statistically significant differences among independent variables (i.e., sex, classroom) for PAT-2 or IMMA tests in time 1. In examining group performance in time 2, Mann-Whitney U tests revealed no statistically significant differences among any demographic variable (i.e., sex, classroom, disability, music enrichment, and reading enrichment) for PAT-2 or IMMA tests. In examining individual participant performance from time 1 to time 2, the Wilcoxon signed-ranks test did not reveal differences between individual participant scores from \( t_1 \) to \( t_2 \) for PAT-2 or IMMA tests (\( p' \)s > .05).

Correlations

Pearson product-moment correlations were performed to examine relationships. First, relationships among variables in time 1 (\( t_1 \)) and time 2 (\( t_2 \)) were examined. Next, existing relationships between \( t_1 \) and \( t_2 \) were investigated. Finally, relationships between observed PAT-2
scores in time 2 (PAT-2\textsubscript{t2}) were compared to predicted PAT-2 scores that were projected based on IMMA scores from time 1 (IMMA\textsubscript{t1}) or time 2 (IMMA\textsubscript{t2}).

**Time 1 (t1).** Statistically significant relationships among variables measured in time 1 were revealed. A summary of correlation coefficients among PAT-2 and IMMA scores in \( t_1 \) is provided in Table 4.3. Age, classroom teacher, and sex were examined to determine any relationships with the constructs. Disability status was not examined as no disabilities were reported among participants during the first measurement period. No statistically significant correlations were found among age or classroom teacher with PAT-2 or IMMA scores. However, sex was found to have a statistically significant relationship with IMMA Tonal (\( r = -.867, p = .011 \)) and Composite scores (\( r = -.865, p = .012 \)), favoring males. Among this sample (\( N = 7 \)), IMMA Rhythm scores demonstrated strong statistically significant negative relationships with PAT-2 Segmentation scores (\( r = -.761, p = .047 \)). Two subtests of the PAT-2 were statistically significantly correlated; a significant correlation was not found between the subtests of the IMMA. See Table 4.4 for a more complete description of correlations among variables.
Table 4.3

*Correlation Coefficients Among PAT-2$t_1$ and IMMA$t_1$ Scores*

<table>
<thead>
<tr>
<th>PAT-2$t_1$</th>
<th>IMMA Scores$t_1$</th>
<th>Tonal</th>
<th></th>
<th>Rhythm</th>
<th></th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhyme</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.686</td>
<td>.089</td>
<td>.049</td>
<td>.917</td>
<td>.437</td>
<td>.327</td>
<td></td>
</tr>
<tr>
<td>Segmentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-.458</td>
<td>.302</td>
<td>-.761*</td>
<td>.047</td>
<td>-.747</td>
<td>.054</td>
<td></td>
</tr>
<tr>
<td>Isolation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.557</td>
<td>.194</td>
<td>-.014</td>
<td>.976</td>
<td>.321</td>
<td>.483</td>
<td></td>
</tr>
<tr>
<td>Deletion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.642</td>
<td>.120</td>
<td>-.327</td>
<td>.474</td>
<td>.175</td>
<td>.707</td>
<td></td>
</tr>
<tr>
<td>Substitution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.338</td>
<td>.459</td>
<td>.007</td>
<td>.988</td>
<td>.204</td>
<td>.660</td>
<td></td>
</tr>
<tr>
<td>Blending</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.351</td>
<td>.440</td>
<td>-.098</td>
<td>.835</td>
<td>.147</td>
<td>.754</td>
<td></td>
</tr>
<tr>
<td>Composite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.635</td>
<td>.125</td>
<td>-.134</td>
<td>.774</td>
<td>.292</td>
<td>.525</td>
<td></td>
</tr>
</tbody>
</table>

*Notes. IMMA tonal and rhythm subtests were not statistically significantly correlated.*

*p < .05, two-tailed.*

Table 4.4

*Correlation Coefficients Among Variables in t1*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sex</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAT-2 Rhyme$t_1$</td>
<td>-.376</td>
<td>~</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAT-2 Segmentation$t_1$</td>
<td>.740</td>
<td>-.078</td>
<td>~</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAT-2 Isolation$t_1$</td>
<td>-.248</td>
<td>.773*</td>
<td>.251</td>
<td>~</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAT-2 Deletion$t_1$</td>
<td>-.429</td>
<td>.617</td>
<td>.245</td>
<td>.731</td>
<td>~</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAT-2 Substitution$t_1$</td>
<td>-.109</td>
<td>.231</td>
<td>.213</td>
<td>.678</td>
<td>.340</td>
<td>~</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAT-2 Blending$t_1$</td>
<td>-.294</td>
<td>.306</td>
<td>.223</td>
<td>.328</td>
<td>.682</td>
<td>-.234</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>PAT-2 Composite$t_1$</td>
<td>-.307</td>
<td>.460</td>
<td>.273</td>
<td>.771*</td>
<td>.714</td>
<td>.830*</td>
<td>.240</td>
<td>~</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMMA Tonal$t_1$</td>
<td>-.867*</td>
<td>.686</td>
<td>-.458</td>
<td>.557</td>
<td>.642</td>
<td>.338</td>
<td>.351</td>
<td>.635</td>
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<td></td>
</tr>
<tr>
<td>IMMA Rhythm$t_1$</td>
<td>-.561</td>
<td>.049</td>
<td>-.761*</td>
<td>-.014</td>
<td>-.327</td>
<td>.007</td>
<td>-.098</td>
<td>-.134</td>
<td>.347</td>
<td>~</td>
</tr>
<tr>
<td>IMMA Composite$t_1$</td>
<td>-.865*</td>
<td>.437</td>
<td>-.747</td>
<td>.321</td>
<td>.175</td>
<td>.204</td>
<td>.147</td>
<td>.292</td>
<td>.809*</td>
<td>.832*</td>
</tr>
</tbody>
</table>

*p < .05, two-tailed.*

**Time 2 (t2).** Relationships among variables measured in time 2 were examined. Age, classroom teacher, reading enrichment, disability status, and sex were examined to determine any relationships with the constructs. See Table 4.5 for a summary of the correlation coefficients among tests; see Table 4.6 for a summary of correlation coefficients among all variables
measured in time 2. Age was found to correlate only with PAT-2 Blending scores \( (r = -0.756, p = 0.049) \), indicating that as age increased, scores decreased relative to national norms. Sex correlated with IMMA Tonal subtest scores \( (r = -0.899, p = 0.006) \) and IMMA Composite scores \( (r = -0.827, p = 0.022) \), favoring males. The only significant correlation found between phonological awareness and music aptitude was between IMMA Tonal and PAT-2 Isolation scores \( (r = 0.849, p = 0.016) \). Pearson’s \( r \) revealed statistically significant correlations among some subtests of the PAT-2. Again, IMMA subtests were not significantly correlated.

Table 4.5

*Correlation Coefficients Among PAT-2\(_{2}\) and IMMA\(_{2}\) Scores*

<table>
<thead>
<tr>
<th>PAT-2 Scores(_{2})</th>
<th>Tonal</th>
<th>Rhythm</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( r )</td>
<td>( p )</td>
<td>( r )</td>
</tr>
<tr>
<td>Rhyming</td>
<td>0.362</td>
<td>0.425</td>
<td>-0.122</td>
</tr>
<tr>
<td>Segmentation</td>
<td>0.460</td>
<td>0.299</td>
<td>0.640</td>
</tr>
<tr>
<td>Isolation</td>
<td>0.849*</td>
<td>0.016</td>
<td>0.244</td>
</tr>
<tr>
<td>Deletion</td>
<td>0.478</td>
<td>0.277</td>
<td>-0.068</td>
</tr>
<tr>
<td>Substitution</td>
<td>0.528</td>
<td>0.224</td>
<td>0.496</td>
</tr>
<tr>
<td>Blending</td>
<td>-0.342</td>
<td>0.452</td>
<td>0.020</td>
</tr>
<tr>
<td>Composite</td>
<td>0.649</td>
<td>0.115</td>
<td>0.298</td>
</tr>
</tbody>
</table>

*Notes.* IMMA tonal and rhythm subtests were not statistically significantly correlated.  
\(^*p < .05,\) two-tailed.
Table 4.6

*Correlation Coefficients Among Variables in t2*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sex</th>
<th>Age</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>.091</td>
<td>-.329</td>
<td>.300</td>
<td>.300</td>
<td>-.002</td>
<td>-.140</td>
<td>-.297</td>
<td>-.283</td>
<td>-.251</td>
<td>-.072</td>
<td>-.240</td>
<td>-.288</td>
<td>-.283</td>
<td>-.325</td>
</tr>
<tr>
<td>Sex</td>
<td>~</td>
<td>-.068</td>
<td>-.548</td>
<td>.091</td>
<td>-.231</td>
<td>-.716</td>
<td>-.666</td>
<td>-.468</td>
<td>-.691</td>
<td>.450</td>
<td>-.657</td>
<td>-.899**</td>
<td>-.526</td>
<td>-.827*</td>
</tr>
<tr>
<td>Age (Months)</td>
<td>~</td>
<td>-.120</td>
<td>-.120</td>
<td>-.477</td>
<td>-.364</td>
<td>-.085</td>
<td>-.374</td>
<td>-.472</td>
<td>-.756*</td>
<td>-.488</td>
<td>.177</td>
<td>-.119</td>
<td>.046</td>
<td></td>
</tr>
<tr>
<td>1. Reading Enrichment</td>
<td>~</td>
<td>.300</td>
<td>-.106</td>
<td>.658</td>
<td>-.183</td>
<td>-.032</td>
<td>.530</td>
<td>-.472</td>
<td>.180</td>
<td>.232</td>
<td>.478</td>
<td>.393</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Disability Status</td>
<td>~</td>
<td>-.502</td>
<td>.331</td>
<td>-.524</td>
<td>-.158</td>
<td>.074</td>
<td>-.072</td>
<td>-.22</td>
<td>-.483</td>
<td>-.283</td>
<td>-.445</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PAT-2 Segmentation</td>
<td>~</td>
<td>.281</td>
<td>.391</td>
<td>.887**</td>
<td>-.006</td>
<td>.628</td>
<td>.460</td>
<td>.640</td>
<td>.618</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. PAT-2 Isolation</td>
<td>~</td>
<td>.726</td>
<td>.479</td>
<td>.064</td>
<td>.787*</td>
<td>.849*</td>
<td>.244</td>
<td>.648</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. PAT-2 Deletion</td>
<td>~</td>
<td>.725</td>
<td>.189</td>
<td>.920**</td>
<td>.478</td>
<td>-.068</td>
<td>.258</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. PAT-2 Substitution</td>
<td>~</td>
<td>.094</td>
<td>.877**</td>
<td>.528</td>
<td>.496</td>
<td>.584</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. PAT-2 Blending</td>
<td>~</td>
<td>.219</td>
<td>-.342</td>
<td>.020</td>
<td>-.199</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. PAT-2 Composite</td>
<td>~</td>
<td>.649</td>
<td>.298</td>
<td>.554</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. IMMA Tonal</td>
<td>~</td>
<td>.543</td>
<td>.898**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. IMMA Rhythm</td>
<td>~</td>
<td>.857*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. IMMA Composite</td>
<td>~</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05, two-tailed.

**p < .01, two-tailed.
**Time1 (t₁) and Time 2 (t₂).** Correlations among variables from t₁ and t₂ were determined within-tests (e.g., PAT-2₁ with PAT-2₂) and between-tests (e.g., PAT-2₁ and IMMA₂) (see Table 4.7). From time 1 to time 2, PAT-2 Rhyming \((r = .860, p = .013)\) and Isolation scores \((r = .795, p = .033)\) were positively correlated. Significant strong positive correlations were also found between all IMMA subtests from time 1 to time 2: Tonal \((r = .805, p = .029)\), Rhythm \((r = .780, p = .038)\), and Composite \((r = .888, p = .008)\).

Table 4.7

<table>
<thead>
<tr>
<th></th>
<th>(M_{t₁})</th>
<th>(M_{t₂})</th>
<th>(r)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PAT-2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyming</td>
<td>103</td>
<td>91</td>
<td>.860*</td>
<td>.013</td>
</tr>
<tr>
<td>Segmentation</td>
<td>98</td>
<td>86</td>
<td>-.588</td>
<td>.165</td>
</tr>
<tr>
<td>Isolation</td>
<td>100</td>
<td>89</td>
<td>.795*</td>
<td>.033</td>
</tr>
<tr>
<td>Deletion</td>
<td>106</td>
<td>98</td>
<td>.445</td>
<td>.317</td>
</tr>
<tr>
<td>Substitution</td>
<td>99</td>
<td>96</td>
<td>.482</td>
<td>.274</td>
</tr>
<tr>
<td>Blending</td>
<td>107</td>
<td>106</td>
<td>-.533</td>
<td>.218</td>
</tr>
<tr>
<td>Composite</td>
<td>100</td>
<td>91</td>
<td>.528</td>
<td>.223</td>
</tr>
<tr>
<td><strong>IMMA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tonal</td>
<td>28.1</td>
<td>28.3</td>
<td>.805*</td>
<td>.029</td>
</tr>
<tr>
<td>Rhythm</td>
<td>23.6</td>
<td>26.1</td>
<td>.780*</td>
<td>.038</td>
</tr>
<tr>
<td>Composite</td>
<td>51.7</td>
<td>54.4</td>
<td>.888*</td>
<td>.008</td>
</tr>
</tbody>
</table>

Notes. \(N = 7\). Paired-sample.

* \(p < .05\)

Statistically significant correlations were also found among IMMA Tonal₁ and PAT-2₂ subtests. IMMA Tonal₁ scores correlated with PAT-2 Isolation₂ \((r = .817, p = .025)\), Deletion₂ \((r = .808, p = .028)\), Substitution₂ \((r = .773, p = .041)\) and PAT-2 Composite₂ \((r = .862, p = .013)\) scores, as summarized in Table 4.8. Statistically significant relationships were not found among PAT-2₁ subtests and IMMA₂ subtests \((p's > .05)\).
Table 4.8

Correlation Coefficients Among PAT-2 and IMMA Scores in t1 and t2

<table>
<thead>
<tr>
<th></th>
<th>PAT-2t1</th>
<th>IMMAt1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rhyme</td>
<td>Segmentation</td>
</tr>
<tr>
<td>RHyme</td>
<td>.860*</td>
<td>- .290</td>
</tr>
<tr>
<td>Segmentation</td>
<td>.089</td>
<td>- .588</td>
</tr>
<tr>
<td>Isolation</td>
<td>.881*</td>
<td>- .293</td>
</tr>
<tr>
<td>Deletion</td>
<td>.854*</td>
<td>- .240</td>
</tr>
<tr>
<td>Substitution</td>
<td>.409</td>
<td>- .635</td>
</tr>
<tr>
<td>Blending</td>
<td>.294</td>
<td>.406</td>
</tr>
<tr>
<td>Composite</td>
<td>.795*</td>
<td>- .488</td>
</tr>
<tr>
<td>Tonal</td>
<td>.538</td>
<td>- .643</td>
</tr>
<tr>
<td>Rhythm</td>
<td>-.120</td>
<td>- .656</td>
</tr>
<tr>
<td>Composite</td>
<td>.267</td>
<td>- .738</td>
</tr>
</tbody>
</table>

Note. N = 7.
*p < .05, two-tailed.
**p < .01, two-tailed.
Predictions

The predictive potential of music aptitude for phonological awareness achievement in time 2 (PAT-2 Composite\textsubscript{t2}) was examined using tonal music aptitude measured in \textit{t1} and \textit{t2} (Tonal\textsubscript{t1} and Tonal\textsubscript{t2}). A linear regression was used to determine that IMMA Tonal\textsubscript{t1} scores were statistically significant predictors for PAT-2 Composite\textsubscript{t2} scores ($R^2 = .743$, $F(1, 5) = 14.459$, $p = .013$, $SE = 9.48$); Tonal\textsubscript{t2} scores were not statistically significant predictors for PAT-2 Composite\textsubscript{t2} scores ($R^2 = .421$, $F(1, 5) = 3.632$, $p = .115$, $SE = 14.24$).

The formula\textsuperscript{38} developed from all scores gathered in time 1 to predict PAT-2 scores was used in the present analysis. Scores from IMMA Tonal\textsubscript{t2}, then IMMA Tonal\textsubscript{t1} were inputted into the equation to generate predictions for PAT-2 Composite\textsubscript{t2} achievement. A statistically significant relationship was found between observed PAT-2 Composite\textsubscript{t2} scores and prediction scores generated using IMMA Tonal\textsubscript{t1} scores ($r = .862$, $p = .013$); a statistically significant relationship was not found between PAT-2 Composite\textsubscript{t2} scores and predicted scores generated using IMMA Tonal\textsubscript{t2} scores ($r = .649$, $p = .115$).

Limitations

Small samples ($N$'s < 20) are not uncommon among studies investigating music and phonological awareness (e.g., Bolduc & Montésinos-Gelet, 2005; Culp, in press;Forgeard et al., 2008; Lamb & Gregory, 1993). However, limitations are similar to those utilizing small samples, such that results do not lend strongly to generalizability to the larger population. Additionally, scores on the IMMA Rhythm subtest could have been affected since both the Tonal and Rhythm subtests were administered on the same day. Finally, phonological awareness testing took place

\textsuperscript{38} Formula: \textit{84.362 + .635 * (IMMA Tonal Score)} = PAT-2 Composite Score
approximately 4 months after music aptitude testing, which is a longer span of time than in \( t_1 \), where all measures were completed within 1 month.

Due to the small sample \((N = 7)\), results should be taken with caution and as preliminary. This investigation will need to be replicated with a larger, more diverse sample before further conclusions can be drawn. However, findings of statically significant relationships among constructs that have been related in previous research studies utilizing larger samples are worth noting.

**Discussion**

Insights regarding the phonological and musical systems of these participants can be gained from this investigation. These findings may provide more evidence for the stabilization of these systems among the current sample. Conversely, appropriate experiences may not have been provided to allow participants to achieve significant growth from time 1 to time 2.

Disability status and reading enrichments did not influence music aptitude or phonological awareness scores among this sample. In time 2, two participants identified as having a disability in (i.e., other health impairment or speech or language impairment) and two participated in summer reading programs. Perhaps these variables did not influence either construct because the constructs had stabilized; or enough influence was not exerted so as to be observable in the current investigation.

In time 1 and time 2, sex correlated with measures of music aptitude, favoring males. A similar finding was reported by Culp (in press), who found males significantly outperformed females on measures of rhythmic and composite music aptitude. In the current investigation, although males tended to score higher than females on measures of tonal and composite music aptitude, as seen in time 1 and time 2, differences between groups were not significant. Hence,
musical systems of males and females were not operating in significantly different ways in the current investigation. Still, given the small sample size, the relationships found with gender are worth noting.

Although age did not correlate with any measure in time 1, age negatively correlated with PAT-2 Blending scores in time 2. This finding indicates that as these subjects aged, phonological blending skills decreased in relation to the standardization sample. This finding also speaks to the relatively lower scores measured in time 2 than in time 1.

Scores were generally lower on measures of phonological awareness and higher on measures of music aptitude—though differences between mean scores in $t_1$ and $t_2$ were not statistically significant on any measure ($p's > .05$). The lack of statistically significant differences from year to year indicates that, as a group, phonological awareness achievement remained constant from time 1 to time 2, relative to national norms for achievement by age. Further, music aptitude remained constant in relation to group performance.

While not statistically significant, the general decrease in phonological awareness scores while music aptitude scores rose slightly has implications for the current sample. Regarding phonological awareness, this finding may speak to the stabilization of the phonemic inventory among this sample, which aligns with theories of stabilization after age 7 (Bauman-Waengler, 2012, p. 139). Because phonological awareness did not improve, there was an observed decrease in scores when compared against national norms. Contrarily, music aptitude scores increased slightly, even though they remained low when compared to norms provided in test materials, which aligns with the assertion that older students achieve higher scores on the IMMA (Gordon, 1986).
The nature of phonological awareness and musical systems of these participants has been partly revealed during the course of this investigation. Because outside factors (i.e., age, sex, disability status, reading enrichments, and time) did not significantly affect scores on most phonological or musical assessments, the musical and phonological systems among this sample may be stabilized or approaching stabilization. This finding may also illustrate the need to provide musical and/or language experiences that will significantly influence growth after age 7. Still, relationships may not have been detected due to the small sample size.

Correlations

Although the sample was small, relationships noted in this preliminary investigation align with previous research and offer insights into the nature of the musical and phonological systems of this group. Sex remained correlated with music aptitude scores from time 1 to time 2, favoring males on the Tonal and Composite subtests. Similar findings are echoed in previous research, where the rhythmic and composite scores of males were higher than females (Culp, in press).

Time 1 ($t_1$). When participants were assessed in second grade, rhythmic music aptitude, as measured by discrimination skills, was negatively correlated with phonological segmentation skill ($r = -.761, p = .047$). This finding has not been noted in previous research utilizing kindergarten children (Moritz et al., 2013; Rubinson, 2010) or children in second grade (Culp, in press). Previous researchers have not found a significant relationship between rhythmic music aptitude, as measured by discrimination skills, and phonological segmentation skills at baselines (Culp, in press; Moritz et al., 2013; Rubinson, 2010). Hence, previous research does not support a negative relationship between phonological segmentation and rhythmic discrimination abilities, which likely implies this relationship is unique to this sample.
Time 2 ($t_2$). Tonal music aptitude had a positive significant strong correlation with phonological isolation ($r = .849, p = .016$), a finding that is both supported and refuted in previous research utilizing kindergarten children (Rubinson, 2010) and children in grade 2. Rubinson (2010) reported a relationship between tonal music aptitude and initial sound fluency skills. Contrarily, Culp (in press) did not report a relationship among phonological isolation skills and tonal musical aptitude. Given the measurement tools used presently were the same as Culp (in press), it would be expected for the findings of these two investigations to more closely align. However, relationships found in the present study could have been influenced by the larger testing window than used by Culp (in press). During the first measurement (i.e., Culp, in press), all assessments were completed within one month; assessments were completed within four months in the present study due to the SLP’s availability. Thus, results are attenuated and this relationship may be unique to this sample.

Time1 ($t_1$) and Time 2 ($t_2$). Still, of greatest interest in the present investigation were the relationships noted between music aptitude measured in time 1 and phonological awareness measured in time 2 among this sample. Tonal music aptitude measured in second grade was closely related to phonological awareness achievement in third grade in the areas of phonological isolation, substitution, deletion, and composite skills. Unfortunately, the uniqueness of this finding is difficult to surmise, as sparse information could be located speaking to the nature of the relationship between music aptitude and phonological awareness over time. Though Moritz et al. (2013) reported positive correlations between musical abilities and phonological abilities measured in kindergarten to second grade, only rhythmic skills (i.e., rhythmic production, rhythmic perception, and tempo production) were examined. Current findings align most closely with those of Forgeard et al. (2008), who reported tonal music discrimination improvement was
related to phonemic awareness improvement 31 months after initial measurements. Thus, this finding lends support to the notion that the tonal subdomain is more closely related to phonological awareness than the rhythmic subdomain (Anvari et al., 2002; Culp, in press; Forgeard et al., 2008; Rubinson, 2010). Further, tonal music abilities measured at an earlier point may be related to phonological skills measured over one year later.

**Predictions**

Participant scores obtained during second grade on the PMMA Tonal subtest were statistically significant predictors for composite scores obtained during third grade on the PAT-2. Previous researchers indicated that music abilities measured earlier in life were related to reading-related abilities later in life (Butler, Marsh, Sheppard, & Sheppard, 1985; David, Wade-Woolley, Kirby, & Smithrim, 2007; Forgeard et al., 2008; Moritz et al., 2013). Because some researchers seem to have examined only the rhythmic subdomain (e.g., Butler et al., 1985; David et al., 2007; Moritz et al. 2013), Forgeard et al.’s (2008) findings best support current findings. Forgeard et al. (2008) reported phonemic awareness improvement was predicted by improvement in PMMA Tonal scores \( \text{partial } r^2 = .09, p = .06 \) after 31 months \( \text{mean age} = 6;6 \). Similar to the present study, phonemic awareness improvement was not predicted by improvement in rhythmic discrimination (Forgeard et al., 2008). Although thresholds of significance were higher than the present study \( (p’s \leq .1) \), Forgeard et al.’s (2008) findings support the potential predictive potential of tonal music aptitude measured early in life for phonological skills measured later found in the present study.

**Implications for Music Teaching and Learning**

Relationships noted in the present study have implications for music teaching and learning. Music aptitude measured in second grade may predict phonological awareness in third
grade. Additionally, the plateau of skills noted in this sample speaks both to the stability of the phonemic inventory after age 7 and to the developmental nature of music aptitude prior to age 9. Given the stability of the phonemic inventory, and the pliability of music aptitude, improving music aptitude may help to improve certain phonological abilities, which may be more difficult to improve after age 7. Music teachers should spend time developing music aptitude and incorporate strategies that bolster phonological awareness. Many of these strategies can also be employed by reading specialists.

**Implications for Future Research**

Due to the small sample size, the need for further research with a larger, more diverse sample to more fully probe the relationships between phonological awareness and music aptitude is warranted. Such investigations could assist in the development of remediation tools for phonological skills that have connections with music aptitude. This investigation has also revealed a need for more empirical knowledge regarding the nature of the relationship between music aptitude and phonological awareness over time, without a treatment effect. While researchers have demonstrated the benefits of music training on the phonological awareness skills of young children, particularly in preschool (Degé & Schwarzer, 2011; Herrera et al., 2011) and kindergarten (Gromko, 2005; Moritz et al., 2013; Richards, 2011), little could be located about the nature of the relationship without the influence of additional music instruction (e.g., Forgeard et al., 2008; Moritz et al., 2013). Without understanding the unadulterated nature of the relationship of music aptitude and phonological awareness over time, one cannot be completely certain how music training may, indeed, influence such a relationship. While training has been beneficial for phonological awareness skill development, researchers should consider reporting levels of phonological awareness and music aptitude at baselines and after treatment,
as in Peynircioğlu et al. (2002). Such information, which seems largely absent from the literature, would add valuable insight into how music training influences musical aptitude, phonological awareness, and the relationship between the two. Such information may also assist in evenly distributing musical and phonological abilities between control and experimental groups, which would lend to validity. Additionally, because regression formula developed using 17 participants reliably predicted phonological awareness achievement among this subset, questions are raised regarding the influence of the peer group regarding phonological or musical development. Hence, future investigations could seek to understand the relationship between phonological awareness and music aptitude over time by utilizing larger samples; omitting a musical treatment; reporting levels of music aptitude before and after musical treatments; and examining peer influence on musical and phonological achievements.

**Conclusions**

Although findings of this investigation should be interpreted cautiously, as preliminary evidence of any existing relationships, this investigation lends valuable insights regarding this particular sample. Tonal aptitude measured in second grade predicted phonological awareness measured in grade 3. In fact, the strongest and most significant relationships noted among measures were not found within each measurement, but rather from time 1 to time 2. Although both constructs remained relatively stable within themselves, findings indicate that the nature of music aptitude and phonological awareness may change over time. Music aptitude measured at one point in life may not relate to a phonological skill measured near or around the same time. However, the initial level of music aptitude may have predictive potential for later phonological awareness achievement. Still, the measurements taken in this study speak to the stabilization of the phonemic inventory around age 7 and the developmental nature of music aptitude until age 9.
Music teachers and reading teachers may want to consider the nature of these two constructs, and the possible influence of peers, when planning for instruction. Students should remain in music classrooms among their peers to bolster musical aptitude early in life, as their initial levels of musical aptitude may predict future phonological awareness achievement.
References


Appendix A-4

Demographic Information Form

Demographic Information:

Student Name:______________________________________ Date:_____

1. Sex: (select one) Male:_____ Female:_____

2. Current Age: Years: ________ Months:_____

   Date of Birth: (Month, Day, Year) _________________________________________________

3. Ethnicity: (select one)

   ____ Hispanic or Latino: An indication that the person traces his or her origin or descent to Mexico, Puerto Rico, Cuba, Central and South America, and other Spanish cultures, regardless of race.

   ____ Not Hispanic or Latino

4. Race: (select all appropriate)

   ____ American Indian or Alaska Native: A person having origins in any of the original peoples of North and South America (including Central America), and who maintains cultural identification through tribal affiliation or community attachment.

   ____ Asian: A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent. This area includes, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.

   ____ Black or African American: A person having origins in any of the black racial groups of Africa.

   ____ Native Hawaiian or Other Pacific Islander: A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.

   ____ White: A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

5. Languages spoken by the child: (list all, check “No Second Language” if child does not speak a second language)

   Primary Language:________________________________________________________

   Other(s):_______________________________________________________ No Second Language: ______

6. Identified Disabilities: (please indicate disabilities which have been identified by a medical professional or school district and for which the student receives educational services)

   This information will not be shared with persons not associated with the study.

   This information will not be used to exclude students for the study.

   This information will be used to interpret test scores only.

   Because this study is interested in phonological awareness, an important aspect of reading development, it is important to know if the student has any impairment that could hinder his/her reading skills so results can be interpreted most appropriately.

   ____ Student has no Identified Disabilities

   ____Autism

   ____Deaf-blindness

   ____Deafness

   ____Developmental delay

   ____Emotional disturbance

   ____Hearing impairment

   ____Intellectual disability

   ____Multiple disabilities

   ____Orthopedic impairment

   ____Other health impairment

   ____Specific learning disability

   ____Speech or language impairment

   ____Traumatic brain injury

   ____Visual impairment, including blindness

7. Child participated in a summer reading program or enrichment: (select one) Yes:_____ No:_____

8. Child participated in a summer music program or enrichment: (select one) Yes:_____ No:_____

Chapter 5: Study Three

The Relationship Between Phonological Awareness and Music Aptitude in Elementary Students

with Speech Sound Disorders
Abstract

The purpose of this study was to determine the nature of the relationship between phonological awareness and music aptitude in elementary students with speech sound disorders. This study also sought to examine whether music aptitude can predict phonological awareness in students with speech sound disorders. To examine this relationship, The Phonological Awareness Test 2 (PAT-2) and the Primary Measures of Music Audiation (PMMA) were administered to children in grades K-3 identified with phonological disorders or delays (N = 12). Demographic information and data from measures of intelligence and vocabulary were gathered. Results indicate a moderately strong positive correlation between phonological awareness and music aptitude among elementary students with speech sound disorders. Music aptitude predicted phonological awareness as an individual predictor, but did not remain a significant predictor when added to a model that also considered vocabulary and intelligence. Still, the combination of music aptitude, intelligence, and vocabulary explained more variance in phonological awareness than any variable alone.

Keywords: phonological awareness, music aptitude, special needs, speech sound disorder, phonological process
The Relationship Between Phonological Awareness and Music Aptitude in Elementary Students with Speech Sound Disorders

Introduction

Both language and music are vital to human development and are essential parts of the human experience. Phonological awareness is an important and foundational feature of language development, wherein a person analyzes and manipulates the sounds of language (Degé & Schwarzer, 2011). Children who struggle with verbal language skills may be removed from typical classroom settings, such as music classrooms, to receive specialized assistance from speech-language pathologists (SLPs) (American Speech-Language-Hearing Association [ASHA], 2014a). However, removing children from music classrooms for individual assistance with speech and language skills may not be the most appropriate option.

Music participation has been linked to enhanced language development (Fisher, 2001; Lorenzo, Herrera, Hernández-Candelas, & Badea, 2014; Yang, Ma, Gong, Hu, & Yao, 2014). For this reason, music has been recommended for use in speech-language therapy (Bauman-Waengler, 2012; Zoller, 1991) because it may help children work toward therapy goals (Mogharbel, Sommer, Deutsch, Wenglorz, & Laufs, 2006; Kilcoyne, Carrington, Walker-Smith, Morris, & Condon, 2014). At the Society for Music Perception and Cognition’s Biennial meeting, ASHA leadership advocated for more research investigating the connections between language and music as well as music’s therapeutic applications (Rogers, 2015). Particularly, ASHA called for future studies to investigate the personal factors of the people for whom music is recommended for use (Rogers, 2015, p. 40).

Therefore, research is needed to examine variables that could influence a child’s response to phonological remediation (Blachman, 1994). Understanding the relationship between
perceiving the sounds of language and music could lead to the development of remediation strategies that would benefit students both linguistically and musically—possibly leading to earlier dismissal from therapy and enhanced musical skills. Therefore, this study seeks to understand the relationship between music aptitude and phonological awareness among children with speech sound disorders (SSDs), who are at an increased risk for phonological delays.

**Speech Sound Disorders**

*Speech sound disorders* (SSDs) are characterized by “a significant delay in the acquisition of articulate speech sounds” (Lewis et al., 2006, p. 1294). Although specific incidence rates are difficult to quantify, SLPs treat children with such deficits frequently (ASHA, 2014a, 2015). Speech sound disorders are believed to be more prevalent among males (ASHA, 2017) and elementary students (Baker & McLeod, 2011; Bauman-Waengler, 2012; Mullen & Schooling, 2010). Children with SSDs may have more difficulties developing communication skills (Call, 1980), developing academically and socio-emotionally (Baker & McLeod, 2011), and learning to read (Anthony et al., 2011; Bird, Bishop, & Freeman, 1995; Carroll & Snowling, 2004; Larivee & Catts, 1999; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004). They also may have deficits in their phonological awareness (Anthony et al., 2011; Bird et al., 1995; Carroll & Snowling, 2004; Kleeck, Gillam, & McFadden, 1998; Larivee & Catts, 1999; Raitano et al., 2004; Rvachew & Grawburg, 2006). *Speech sound disorder* is an umbrella term, but is commonly associated with articulation errors (characterized by errors in individual sounds) and phonological process disorders (characterized by errors in patterns of sounds) (Bauman-Waengler, 2012).
Articulation Disorders

A type of speech disorder, an *articulation disorder* impairs an individual’s expression of speech sounds, the realization of phonemes. Articulation disorders are characterized by “difficulties with the motor production aspects of speech, or an inability to produce certain speech sounds” (Bauman-Waengler, 2012, p. 8). Because articulation development follows a predictable developmental trajectory, errors are often classified relative to a student’s numerical age. Given the age of the student, s/he may receive services for as little as one articulation error, such as realizing /r/ as a [w] at age 8. Summarizing the research examining deficits in literacy and phonological awareness among children who were deficient in speech, Kleeck et al. (1998) indicated “findings for children with speech impairments are inconclusive” (p. 66). Hence, children with deficits in speech production may not be at an increased risk for phonological awareness or literacy problems. This assertion may be explained if speech deficits were primarily characterized by motor production difficulties, rather than deficits in the underlying phonological system.

Phonological Process Disorders

*Phonological disorders*, “impaired comprehension of the sound system of a language and the rules that govern the sound combinations” (Bauman-Waengler, 2012, p. 8), affect groups of sounds. For example, a student may substitute a single sound for many other sounds, such as /t/ for /d/, /k/, and /g/; thereby, impairing the distinction between the sounds. Because a phonological disorder pertains to a group of sounds, it is considered a language disorder that impairs an individual’s understanding of language at the phoneme\(^{39}\), or theoretical, level.

\(^{39}\)Phonemes are considered the smallest units of sound in a language.
A phonological process is “[a] mental operation that applies in speech to substitute for a class of sounds or sound sequences presenting a common difficulty to the speech capacity of the individual” (Stampe, 1979, p. 1, as cited in Bauman-Waengler, 2012, p. 417). Known phonological processes are commonly used by young children to simplify adult speech and may be considered acceptable up to certain chronological ages. In this way, phonological processes often follow typical patterns (e.g., stopping fricatives or final consonant deletion), but can also be idiosyncratic in nature. When these processes continue beyond the ages at which they are supposed to be suppressed, students can be identified with a phonological process disorder (Bauman-Waengler, 2012). Although phonological process disorders are classified as speech disorders (ASHA, 2014b), the presence of multiple sound errors could indicate an impaired underlying phonological system. When the underlying phonological system is compromised, deficits in expressive and/or receptive language, as well as reading and phonological awareness can occur (Bauman-Waengler, 2012; Bird et al., 1995; Carroll & Snowling, 2004; Rvachew & Grawburg, 2006).

**Phonological Awareness**

Phonological awareness, a feature of phonological processing, is a person’s ability to analyze and manipulate language, including individual sound units within a word and/or an entire word. Phonological awareness uses relies exclusively on the auditory modality (Bauman-Waengler, 2012, p. 146) and represents an individual’s awareness of the sound structure of spoken words, in contrast to written words. As a general, over-arching term, phonological

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40 Example: child substitutes /p/ for /f/ and /t/ for /s/.

41 Example: child consistently fails to pronounce final consonants in words.
awareness encompasses all sizes of sound units, such as phonemes, syllables, onset-rimes (e.g., b-at vs. c-at), and words. Often described in terms of phoneme awareness, syllable awareness, or onset-rime awareness, phonological awareness is a multilevel skill in which individuals break down words into smaller units.

Phonemes are the smallest units of sound in a language and represent a single sound (e.g., /b/ or /p/). When combined with other units of language (e.g., syllable or rime), phonemes establish word meanings and distinguish between words, such as bat vs. pat or cab vs. cap. As can be seen in the example, phonemes occur in different positions within words (e.g., beginning/initial, middle/medial, or end/final). Phonemic awareness is a feature of phonological awareness, but refers only to the phoneme, or single sound, level (Bauman-Waengler, 2012). A person’s phonemic inventory begins developing before birth and is typically in place by age 7, although some data may indicate age 9 (Bauman-Waengler, 2012, p. 139). Phonemes manifested as speech sounds develop in a predictable order in most children. For example, labial phonemes such as /m/ typically develop sooner than fricative sounds like /v/. Students can receive services for a single sound error; ages of onset derived from normative data often determine when students may receive services.

Although phonological skills can be remediated with success, children with phonological processing deficits may not benefit significantly from standard phonological awareness training programs alone (Torgesen et al., 1994, p. 285). Such children may respond better to more complex treatments (Blachman, 1994). In fact, Blachman (1994) intimated that future research should examine factors that increase the efficacy of training to improve phonological awareness skills (p. 288). For these reasons, this study examined the relationship between phonological
awareness and a cognitive variable has assisted in phonological awareness development in such settings (e.g., Bolduc, 2009; Bolduc & Lefebvre, 2012): music aptitude.

**Music and Phonological Awareness**

Researchers have pointed to connections between phonological awareness and musical skills. Statistically significant relationships (p’s < .05) between phonological awareness and musical subdomains have been reported (Anvari, Trainor, Woodside, & Levy, 2002; Bolduc & Montésinos-Gelet, 2005; Culp, in press; Lamb & Gregory, 1993; Lathroum, 2011; Loui, Kroog, Zuk, Winner, & Schlaug, 2011; Moritz, Yampolsky, Papadelis, Thomson, & Wolf, 2013; Peynircioğlu, Durgunoglu, & O’ney-Küsefoglu, 2002), indicating stronger relationships between tonal, rather than rhythmic, musical subdomains and phonological awareness. Relationships between music and phonological awareness persisted after controlling for factors of age, SES, musical training/ability, and/or intelligence (Forgeard et al., 2008; Lamb & Gregory, 1993; Loui et al., 2011; Moritz et al., 2013).

**Music Aptitude**

Music aptitude is “one’s potential to learn music” (Gordon, 2012, p. 44). Understandings of music aptitude and how it should be measured have been put forth previously (e.g., Gordon, 1986; Stevens, 1987). In this study, I utilized Gordon’s (2012) construct, in which a person’s music aptitude “is based on how well a person can draw generalizations from specific information and experience” (Gordon, 2012, p. 46) in regards to musical events. According to Gordon’s (1986, 2012) understanding of music aptitude, every person is born with a certain level of potential to achieve in music, which can be influenced by outside factors until approximately age 9. While music aptitude is developing, it may fluctuate, moving up and down.

Previous researchers have used measures of music aptitude to examine the relationship
between tonal (and/or melodic) and rhythmic (and/or tempo) subdomains of music and phonological skills. When tonal and rhythmic subdomains were combined into a unitary music construct, the combined construct correlated with phonological awareness skills (Culp, in press, Lathroum, 2011; Peynirciog’lu et al., 2002; Rubinson, 2010). Other researchers found phonological awareness correlated with both music subdomains (tonal and rhythm) when the subdomains were measured separately (Lathroum, 2011; Rubinson, 2010). Still, researchers have found relationships only with the tonal (Bolduc & Montésinos-Gelet, 2005) or rhythmic subdomain (Moritz et al., 2013). Overall, stronger relationships were noted between the tonal subdomain and phonological awareness when both the tonal and rhythmic subdomains were measured (Culp, in press; Forgeard et al., 2008; Rubinson, 2010). Hence, results of these studies seem to indicate that the tonal subdomain of music has a more pronounced relationship with the mental processes that govern phonological awareness skills (Culp, in press; Forgeard et al., 2008; Rubinson, 2010).

More specifically, researchers who utilized Gordon’s measures of music aptitude (i.e., Primary Measures of Music Audiation (PMMA) or Intermediate Measures of Music Audiation (IMMA) have reported relationships similar to those previously noted. Because the PMMA was used in the present investigations, studies utilizing Gordon’s measures are summarized here to allow for more direct and relevant comparisons later. In a study involving kindergarten children (N = 62; mean age = 5;5), Rubinson (2010) reported phonological awareness scores (i.e., initial

\[\text{42 Also included a melodic measure.}\]

\[\text{43 Age converted from the reported 5.42 years within the original manuscript to a years;months format to allow consistent age reporting within the current manuscript.}\]
sound fluency and phoneme segmentation) positively correlated with PMMA Composite scores ($r = .39, p = .002; r = .323, p = .009$, respectively); as well as Tonal ($r = .37, p = .003; r = .32, p = .010$, respectively) and Rhythm (initial sound fluency $r = .31, p = .014$) subtest scores separately. Bolduc and Montésinos-Gelet (2005) found a relationship between phonological awareness and PMMA Tonal subtest scores among kindergarten children ($N = 13; mean age = 5;6, r = .975, p < .001$), but a statistically significant relationship was not found with Rhythm subtest scores ($r = -.072, p = .815$); comparisons with PMMA Composite scores were not reported. Relationships with music aptitude were most pronounced among syllabic and rhyme identification tasks (Bolduc, 2008). Results of Forgeard et al.’s (2008) longitudinal investigation with typically developing children ($N = 44; mean age = 6;6^{44}$) indicated relationships between phonological awareness and the PMMA subtests separately subtests ($r$’s not reported, $p$’s < .01), but over time and controlling for age, verbal IQ, and SES, only improvement on the Tonal subtest predicted phonemic awareness improvement (partial $r^2 = .09, p = .06$) measured by deletion tasks. In an additional investigation with children diagnosed with dyslexia ($N = 31; mean age = 10;1$), Forgeard et al. (2008) determined both IMMA subtests predicted phonemic awareness (Tonal subtest $p = .07$, partial $r^2 = .12$; Rhythm subtest $p = .10$, partial $r^2 = .10$) after partialing out SES and age. Finally, Culp (in press) found tonal music aptitude correlated with phonological rhyming ($r = .549, p = .022$), deletion ($r = .588, p = .013$), and composite phonological awareness ($r = .485, p = .048$) among children in grade 2 ($N = 17$). After controlling for gender, IMMA composite scores were statistically significantly correlated with phonological awareness composite scores ($r_{partial} = .499, p = .049, df = 14$) (Culp, in press).

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44 Age converted from the reported 6.52 years within the original manuscript.
Although positive relationships with rhythmic music aptitude (Forgeard et al., 2008; Rubinson, 2010) and the combination of both the tonal and rhythmic subdomains (Culp, in press; Rubinson, 2010), have been reported, results of these investigations demonstrate consistent relationships between phonological awareness skills and tonal music aptitude when Gordon’s (1986) measures were utilized (e.g., Bolduc & Montésinos-Gelet, 2005; Culp, in press; Forgeard et al., 2008; Rubinson, 2010).

**Music Training and Participation**

Music training and participation have also been associated with *better* performance on phonological awareness tasks (Moritz et al., 2013; Overy, 2003). Kindergarten students who received more general music made greater gains in phonological awareness at the end of the school year as compared to peers who received less (Moritz et al., 2013). Phonological awareness improved among children who participated in musical activities (Degé & Schwarzer, 2011; Gromko, 2005; Moritz et al., 2013; Richards, 2011). Music also helped to improve phonological awareness when added to literacy/phonological programs (Bolduc, 2009; Bolduc & Lefebvre, 2012; Herrera et al., 2011). Further, Moreno et al. (2009) reported music training enhanced children’s neural responses for both speech and music, suggesting musical training may improve the phonological representations of speech sounds.

Music may also be effective for helping improve phonological awareness for those with the greatest deficits. Overy (2003) reported that a specially-designed music program had a significant positive effect on phonological ability for participants diagnosed with dyslexia (n = 9; *mean age* = 8;10). Further, kindergarteners with low phonological awareness, who received tonal music training, demonstrated significant gains in phonological awareness skills from pre to posttest (Richards, 2011). Results of these investigations indicate the utility of music for helping
improve phonological awareness among a variety of populations and across varied circumstances, indicating a possible connection between the two constructs.

**Purpose**

Although musical skills have been connected to phonological skills among typically developing children and those with dyslexia, little is known about such a relationship among children with SSDs, who also struggle with phonological awareness. Therefore, the purpose of this study was to determine the nature of the relationship between phonological awareness and music aptitude in elementary students with speech sound disorders. Results of this investigation could help demonstrate that musical skills and phonological skills are related in students with SSDs. Understanding this relationship could support the development of musical remediation methods that SLPs can use. Results could also encourage schools to allow students with SSDs to remain in music classrooms to further develop musical skills. Additional emphasis on the student’s musical development in these ways could help students improve communication and cultivate musical ways of expression simultaneously.

This study also examined whether musical aptitude can predict phonological awareness in students with SSDs. Two outcomes were expected: music aptitude scores would demonstrate a moderate-strong, positive relationship with phonological awareness scores and also predict phonological awareness scores. The questions that guided this study were:

1. What is the nature of the relationship between phonological awareness and music aptitude among elementary students with speech sound disorders?
2. What role does potential to achieve in music play in predicting phonological awareness among elementary students with speech sound disorders?
Method

Design

The study utilized a correlational design. Evidence for music aptitude and phonological awareness were obtained from standardized measures: *Primary Measures of Music Audiation* (PMMA) (Gordon, 1986) and *The Phonological Awareness Test 2* (PAT-2) (Robertson & Salter, 2007). Data were also obtained from two standardized measures for vocabulary and intelligence: *Peabody Picture Vocabulary Test* (PPVT-4) (Dunn & Dunn, 2007) and *Kaufman Brief Intelligence Test* (KBIT-2) (Kaufman & Kaufman, 2004).

Participants

The sample was comprised of students in grades K-3 enrolled in elementary schools in Pennsylvania. Thirteen consent forms were returned and one participant was withdrawn from the study by the parent. Remaining participants were between 5;7-9;2 years of age ($N = 12$; *mean age* = 6;8; males = 9, females = 3), with the majority in first grade (K $n = 2$, first grade $n = 8$, second grade $n = 1$, third grade $n = 1$). All participants primarily spoke English and no other languages were spoken in homes. One participant did not disclose racial or ethnic information, remaining participants identified as Caucasian/White and not Hispanic, except one participant who identified as Hispanic or Latino. The median household income for participants, as determined by the school’s zip code, ranged from $43,731-$85,285. Speech-language pathologists referred children to whom they provided services for a phonological disorder or delay. For referral, children met the following criteria: (1) normal hearing, (2) normal oral-motor function, and (3) have no additional impairments that could negatively affect their performance on assessments (e.g., Down syndrome, cerebral palsy, autism). Speech-language pathologists typically have this information and conduct such screenings (e.g., hearing and oral-motor) as a
part of their scope of practice. Examples of the participant recruitment letter and consent form are included in Appendices A-5 and B-5, respectively.

**Instruments**

All measures were chosen based on previous literature reviewed as well as recommendations from SLPs and experts in children’s musical development. Standardized measures were preferred in order to provide valid and reliable assessments of student performance and to allow for comparison against national norms as well as previous research. Utilizing a speech perception measure was also considered due to the reported relationship between speech perception and phonological awareness in students with SSDs (Rvachew & Grawburg, 2006). However, a standardized measure suitable for use with students in grades K-3 could not be located.

**Phonological awareness.** As in previous investigations (e.g., Culp, in press; Moritz et al., 2013), the PAT was used to measure phonological awareness. The most current version–PAT-2– was used in this study, as in Culp (in press). Developed for children ages 5–9 (grades K-4), standardization was completed using 1,582 subjects representing national census for race, gender, age, and educational placement (Standardized Range 55–145, \( M = 100, SD = 15 \)). The phonological awareness portion is comprised of 6 subtests (i.e., rhyming, segmentation, isolation, deletion, substitution, and blending) containing 10–30 items each and takes approximately 30 minutes to complete. Speech-language professionals, who administered the PAT-2, provided a demonstration item for each subtest and scored all responses as 1 (correct) or 0 (incorrect). Age-based standardized scores were used in the current investigation.

**Music aptitude.** The PMMA, a standardized measure of developmental music aptitude for K-3 students, was selected as the music aptitude measure for this study. The PMMA was
selected due to its prevalence in previous literature (e.g., Forgeard et al., 2008; Rubinson, 2010) and to provide a measure that would not unnecessarily challenge children who are at risk for phonological awareness deficits (i.e., Forgeard et al., 2008). The PMMA yields three scores: Tonal, Rhythm, and Composite (combined total of the rhythm and composite tests) and takes approximately 40 minutes to complete. Subtests should be administered on separate days, beginning with the tonal, and no more than two weeks apart. Each subtest contains 40 items organized in a question-answer format, where a musical question is followed by a musical answer. Participants circle faces on an answer sheet to indicate whether or not the answer is the same as or different from the question. Reliable test administration requires a music specialist administer the test to participants individually or in groups. As a standardized measure of music aptitude, percentile scores are provided. However, raw scores were used in the analysis several reasons. First, there is a precedent for such an analysis based on previous investigations utilizing the PMMA (e.g., Culp, in press; Rubinson, 2010). Second, test materials recommend developing local norms to provide more meaningful interpretations (p. 86). Third, although the standardization sample was carefully selected, the sample was relatively small and comprised of children from schools in a single city (p. 85).

**Intelligence.** The KBIT-2, appropriate for use with students aged 4–90, was used as a basic measure of intelligence because IQ has been connected to phonological awareness in previous research (McBride-Chang, Manis, & Wagner 1996). The test was chosen because it yields standard scores for Verbal (crystallized) and Nonverbal (fluid) and IQ composite as well as percentile ranks by age, thereby taking nonverbal intelligence into account, which is important for students with communication disabilities. The national standardization sample was selected to represent the U.S. Census data (Standardized Range 40–160, $M = 100$, $SD = 15$). The verbal
(crystallized) scale consists of two parts (verbal knowledge and riddles). Verbal knowledge measures receptive vocabulary and a range of general information about the world. For each item, the examinee sees an array of six full-color illustrations presented on an easel. The examiner says a word or asks a general-information question, and the examinee points to the picture that shows the meaning of the word or the answer to the question. The riddles subtest measures verbal comprehension, reasoning, and vocabulary knowledge. The examiner says a verbal riddle and, depending on the item number, the examinee points to a picture or says the word that answers the riddle. The nonverbal knowledge (matrices) section requires understanding of relationships among stimuli and all items use a multiple-choice format. The examiner identifies a relationship or rule in a set of pictures or patterns and the examinee identifies the correct response by pointing to it or saying its letter. All answers to subtests are scored 0 or 1 and the total test takes approximately 15 minutes to complete with children aged 4–9. Speech-language pathologists administered and scored the measure; age-based standardized scores were used.

**Receptive vocabulary.** The PPVT-4 (Form A) served as a measure of English receptive vocabulary because receptive vocabulary has been connected to phonological awareness in previous research (Rvachew & Grawburg, 2006) for children with SSDs. For each item, the examiner says a word and the examinee selects the picture that best illustrates the word’s meaning. The test takes 10–15 minutes to complete and answers are scored 0 or 1. The test was standardized using a national sample that represents the U.S. Census for gender, race/ethnicity, region, SES, and clinical diagnosis or special education placement (Standardized Range 20–160, $M = 100, SD = 15$). Speech-language pathologists administered and scored the measure. Raw scores were converted to age-based standardized scores for analysis.
Procedure

Speech-language pathologists distributed consent forms to children in grades K-3 for whom they provided services for phonological disorders at the research sites on a rolling basis. The primary researcher collected consent letters from SLPs. Guardians were contacted via phone or email by the primary researcher to confirm the music testing schedule. At this time, the primary researcher also confirmed details from the consent forms and filled in missing information based on parental response as needed. Procedures for guardians to obtain student results were also discussed with guardians at this time.

Participants completed all assessments on an individual, rolling basis as consent forms were returned. All measures were completed within one month and no more than two complete measures (e.g., both PMMA subtests) were given on the same day. The PAT-2, KBIT-2 and PPVT-4 were administered and scored by SLPs at research sites. The Tonal and Rhythm subtests of the PMMA were administered on the same day with a break in-between to reduce cognitive fatigue. The break lasted at least one hour, during which participants resumed typical school activities. When possible, the Tonal subtest was administered in the morning and the Rhythm subtest was administered in the afternoon.

Data Analysis

The analysis utilized standardized scores from the PAT-2, PPVT-4, and KBIT-2 and raw scores from the PMMA. A paired-samples t-test examined differences between PMMA Tonal and Rhythm aptitude scores. A Shapiro-Wilk test for normality was used to check assumptions for normality among the data. Pearson product-moment correlation coefficients were used to determine relationships among composite and subtest scores, as well as certain demographic variables (e.g., age). Kendall’s tau b was used as a nonparametric measure of correlational
agreement among ordinal or categorical level data (e.g., SES, sex) with test scores. Finally, a linear regression was performed to develop a mathematical model for predicting PAT-2 scores. Due to the small sample, comparisons among groups (e.g., sex, SLP) were not made.

**Results**

Means, standard deviations, and ranges were computed for all measures and are reported in Table 5.1. All scores from KBIT-2, PPVT-4, and PAT-2 tests fell within normal ranges (70-130), except the PAT-2 composite score for one participant who fell just below 2 SD of the mean. A paired-samples t-test indicated no differences between scores of PMMA Tonal or Rhythmic music aptitude ($t(11) = .676, p = .513, r = .487$). A Shapiro-Wilk test for normality determined data from all measures (PPVT-4, KBIT-2, PAT-2, PMMA) met assumptions for normality ($p’s > .05$).
Table 5.1

**Means, Standard Deviations, and Ranges**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Max. Possible</th>
</tr>
</thead>
<tbody>
<tr>
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<td>113</td>
<td>13.2</td>
<td>83-128</td>
<td>160</td>
</tr>
<tr>
<td>KBIT-2</td>
<td></td>
<td></td>
<td></td>
<td>160</td>
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<tr>
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<td>88-124</td>
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<td>PAT-2</td>
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<tr>
<td>Rhyme</td>
<td>100</td>
<td>11.0</td>
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<td>15.2</td>
<td>72-122</td>
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<td>Isolation</td>
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<td>72-124</td>
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<td>Substitution</td>
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<td>14.9</td>
<td>77-125</td>
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<td>Blending</td>
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<td>Composite</td>
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<td>14.5</td>
<td>68-119</td>
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<tr>
<td>Tonal Subtest</td>
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<tr>
<td>Rhythm Subtest</td>
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<td>Composite</td>
<td>55.3</td>
<td>10.1</td>
<td>35-75</td>
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</table>

*Notes.* PPVT-4, KBIT-2, and PAT-2 standardized $M = 100$, $SD = 15$.

Pearson-product moment correlations were used to determine relationships among phonological awareness and music aptitude, as measured by PAT-2 and PMMA respectively.

The initial analysis revealed relationships among PAT-2 scores and PMMA scores (see Table 5.2). Analyses also revealed statistically significant relationships among independent and dependent variables (see Table 5.3).
Table 5.2

*Correlation Coefficients Among PAT-2 and PMMA Scores*

<table>
<thead>
<tr>
<th>PAT-2 Scores</th>
<th>Tonal</th>
<th>Rhythm</th>
<th>Composite</th>
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<tbody>
<tr>
<td>Rhyme</td>
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<td>Segmentation</td>
<td>.377</td>
<td>.114</td>
<td>.375</td>
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<tr>
<td>Isolation</td>
<td>.473</td>
<td>.060</td>
<td>.479</td>
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<td>Deletion</td>
<td>.439</td>
<td>.077</td>
<td>.592*</td>
</tr>
<tr>
<td>Substitution</td>
<td>.091</td>
<td>.389</td>
<td>.146</td>
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<tr>
<td>Blending</td>
<td>.361</td>
<td>.125</td>
<td>.461</td>
</tr>
<tr>
<td>Composite</td>
<td>.576*</td>
<td>.025</td>
<td>.661**</td>
</tr>
</tbody>
</table>

*Notes.* PMMA subtests were not statistically significantly correlated \( r = .487, p = .054 \).

* \( *p < .05 \), one-tailed.

** \( **p \leq .01 \), one-tailed.
Table 5.3

Correlation Coefficients Among all Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>SES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td></td>
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<td>(r_b)</td>
<td>(r_b)</td>
<td>(r)</td>
<td>(r)</td>
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<td>(r)</td>
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<td>(r)</td>
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</tr>
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<td>2. Sex</td>
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<td>~</td>
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<td>3. Age in Months</td>
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<td>4. PPVT-4 Composite</td>
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<td>-.349</td>
<td>.265</td>
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<td></td>
</tr>
<tr>
<td>5. KBIT-2 Verbal</td>
<td>-.127</td>
<td>-.020</td>
<td>.048</td>
<td>-.181</td>
<td>.718**</td>
<td>~</td>
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<td>6. KBIT-2 Nonverbal</td>
<td>-.434*</td>
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<td>-.072</td>
<td>-.469</td>
<td>.469</td>
<td>.066</td>
<td>~</td>
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</tr>
<tr>
<td>7. KBIT-2 Composite</td>
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<td>-.164</td>
<td>-.072</td>
<td>-.391</td>
<td>.828**</td>
<td>.861**</td>
<td>.564*</td>
<td>~</td>
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<tr>
<td>8. PAT-2 Rhyme</td>
<td>-.352</td>
<td>-.084</td>
<td>.147</td>
<td>-.118</td>
<td>.683**</td>
<td>.579*</td>
<td>.198</td>
<td>.572*</td>
<td>~</td>
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</tr>
<tr>
<td>9. PAT-2 Segmentation</td>
<td>-.344</td>
<td>.041</td>
<td>-.358</td>
<td>-.054</td>
<td>.373</td>
<td>-.007</td>
<td>.607*</td>
<td>.308</td>
<td>.182</td>
<td>~</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10. PAT-2 Isolation</td>
<td>.074</td>
<td>-.041</td>
<td>-.024</td>
<td>-.224</td>
<td>.616*</td>
<td>.364</td>
<td>.378</td>
<td>.489</td>
<td>.454</td>
<td>.552*</td>
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<td>11. PAT-2 Deletion</td>
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<td>-.073</td>
<td>-.490</td>
<td>.767**</td>
<td>.661**</td>
<td>.602*</td>
<td>.852**</td>
<td>.565*</td>
<td>.548*</td>
<td>.722**</td>
<td>~</td>
<td></td>
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<tr>
<td>12. PAT-2 Substitution</td>
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<td>-.412</td>
<td>-.424</td>
<td>.309</td>
<td>.294</td>
<td>.387</td>
<td>.438</td>
<td>.098</td>
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<td>.660**</td>
<td>.633*</td>
<td>~</td>
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<td></td>
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<tr>
<td>13. PAT-2 Blending</td>
<td>-.037</td>
<td>.000</td>
<td>-.170</td>
<td>-.210</td>
<td>.304</td>
<td>.225</td>
<td>.352</td>
<td>.356</td>
<td>.575*</td>
<td>.328</td>
<td>.558*</td>
<td>.665**</td>
<td>.564*</td>
<td>~</td>
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<td></td>
<td></td>
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<tr>
<td>14. PAT-2 Composite</td>
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<td>-.118</td>
<td>-.370</td>
<td>.667**</td>
<td>.454</td>
<td>.525*</td>
<td>.641*</td>
<td>.542*</td>
<td>.722**</td>
<td>.876**</td>
<td>.909**</td>
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<td>.708**</td>
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<tr>
<td>15. PMMA Tonal</td>
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<td>0.000</td>
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<td>-.099</td>
<td>.417</td>
<td>.419</td>
<td>-.027</td>
<td>.338</td>
<td>.656*</td>
<td>.377</td>
<td>.473</td>
<td>.439</td>
<td>.091</td>
<td>.361</td>
<td>.576*</td>
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<td>17. PMMA Composite</td>
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<td>.450</td>
<td>.114</td>
<td>.433</td>
<td>.639*</td>
<td>.375</td>
<td>.479</td>
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<td>.146</td>
<td>.461</td>
<td>.661**</td>
<td>.887**</td>
<td>.835**</td>
</tr>
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</table>

Note. PMMA subtests were not statistically significantly correlated \((r = .487, p = .054)\).

*p < .05, one-tailed.

**p ≤ .01, one-tailed.
Because vocabulary, as measured by PPVT-4, had the strongest correlational agreement of any independent variable with PAT-2 scores, correlational agreement was re-examined. After controlling for vocabulary, correlations among independent and dependent variables changed. Statistically significant relationships remained among certain dependent variables (see Table 5.4) and were no longer found among dependent and independent variables (p’s > .05) (see Table 5.5).

Table 5.4

**Correlation Coefficients Among PAT-2 and PMMA Scores, Controlling for Vocabulary**

<table>
<thead>
<tr>
<th>PAT-2 Scores</th>
<th>Tonal</th>
<th></th>
<th>Rhythm</th>
<th></th>
<th>Composite</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>( r_{partial} )</td>
<td>( p )</td>
<td>( r_{partial} )</td>
<td>( p )</td>
<td>( r_{partial} )</td>
<td>( p )</td>
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<tr>
<td>Rhyme</td>
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<td>.037</td>
<td>.272</td>
<td>.209</td>
<td>.509</td>
<td>.055</td>
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<tr>
<td>Segmentation</td>
<td>.262</td>
<td>.218</td>
<td>.149</td>
<td>.331</td>
<td>.250</td>
<td>.229</td>
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<td>Isolation</td>
<td>.302</td>
<td>.184</td>
<td>.169</td>
<td>.309</td>
<td>.287</td>
<td>.196</td>
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<tr>
<td>Deletion</td>
<td>.203</td>
<td>.274</td>
<td>.544*</td>
<td>.042</td>
<td>.431</td>
<td>.093</td>
</tr>
<tr>
<td>Substitution</td>
<td>-.044</td>
<td>.449</td>
<td>.065</td>
<td>.424</td>
<td>.008</td>
<td>.491</td>
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<tr>
<td>Blending</td>
<td>.270</td>
<td>.211</td>
<td>.377</td>
<td>.127</td>
<td>.381</td>
<td>.124</td>
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<tr>
<td>Composite</td>
<td>.439</td>
<td>.088</td>
<td>.472</td>
<td>.071</td>
<td>.543*</td>
<td>.042</td>
</tr>
</tbody>
</table>

*Note.* PMMA subtests were not statistically significantly correlated (\( r_{partial} = .400, p = .112, df = 9 \)).

\*\( p < .05 \), one-tailed.

\**p < .01, one-tailed.**
Table 5.5

Correlation Coefficients Among SES, KBIT-2, PAT-2, and PMMA Scores, Controlling for Vocabulary

<table>
<thead>
<tr>
<th>Variables</th>
<th>SES 1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>r_{partial}</td>
<td>r_{partial}</td>
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<td>r_{partial}</td>
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<td>r_{partial}</td>
<td>r_{partial}</td>
<td>r_{partial}</td>
<td>r_{partial}</td>
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<tr>
<td>KBIT-2 Verbal</td>
<td>.235</td>
<td>~</td>
<td>.235</td>
<td>~</td>
<td>~</td>
<td>.235</td>
<td>~</td>
<td>.235</td>
<td>~</td>
<td>.235</td>
<td>~</td>
<td>.235</td>
</tr>
<tr>
<td>KBIT-2 Nonverbal</td>
<td>-.372</td>
<td>-.441</td>
<td>~</td>
<td>-.372</td>
<td>-.441</td>
<td>~</td>
<td>-.372</td>
<td>-.441</td>
<td>~</td>
<td>-.372</td>
<td>-.441</td>
<td>~</td>
</tr>
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<td>KBIT-2 Composite</td>
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<td>.683**</td>
<td>.354</td>
<td>~</td>
<td>.683**</td>
<td>.354</td>
<td>~</td>
<td>.683**</td>
<td>.354</td>
<td>~</td>
<td>.683**</td>
<td>.354</td>
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<tr>
<td>PAT-2 Rhyme</td>
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<td>-.188</td>
<td>.018</td>
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<td>-.222</td>
<td>.175</td>
<td>-.188</td>
<td>.018</td>
<td>~</td>
<td>-.222</td>
<td>.175</td>
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<td>PAT-2 Segmentation</td>
<td>-.353</td>
<td>-.425</td>
<td>.528*</td>
<td>-.001</td>
<td>-.107</td>
<td>~</td>
<td>-.353</td>
<td>-.425</td>
<td>.528*</td>
<td>-.001</td>
<td>-.107</td>
<td>~</td>
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<td>PAT-2 Isolation</td>
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<td>.441</td>
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<td>.435</td>
<td>-.143</td>
<td>.128</td>
<td>-.049</td>
<td>.057</td>
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<td>.050</td>
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<td>-.163</td>
<td>.312</td>
<td>.627*</td>
<td>.650</td>
<td>~</td>
<td>.475</td>
<td>.108</td>
<td>.288</td>
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<tr>
<td>PAT-2 Blending</td>
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<td>.010</td>
<td>.249</td>
<td>.196</td>
<td>.527*</td>
<td>.243</td>
<td>.494</td>
<td>.706</td>
<td>.519</td>
<td>~</td>
<td>.199</td>
<td>.010</td>
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<tr>
<td>PAT-2 Composite</td>
<td>.081</td>
<td>-.048</td>
<td>.322</td>
<td>.212</td>
<td>.158</td>
<td>.685**</td>
<td>.793**</td>
<td>.832**</td>
<td>.708**</td>
<td>.711**</td>
<td>~</td>
<td>.081</td>
</tr>
<tr>
<td>PMMA Tonal</td>
<td>-.277</td>
<td>.189</td>
<td>-.277</td>
<td>-.014</td>
<td>.559*</td>
<td>.262</td>
<td>.302</td>
<td>.203</td>
<td>-.044</td>
<td>.270</td>
<td>.439</td>
<td>~</td>
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<td>.236</td>
<td>.272</td>
<td>.149</td>
<td>.169</td>
<td>.544*</td>
<td>.065</td>
<td>.377</td>
<td>.472</td>
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<td>-.123</td>
<td>.122</td>
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<td>.250</td>
<td>.287</td>
<td>.431</td>
<td>.008</td>
<td>.381</td>
<td>.543*</td>
<td>.862**</td>
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</table>

*p < .05, one-tailed.

**p ≤ .01, one-tailed.
Finally, linear regressions were performed to examine predictive relationships among variables. Given that statistically significant relationships among PAT-2 Composite and PMMA subtest scores were not found when controlling for vocabulary, predictive relationships for PAT-2 scores PMMA subtest scores were not examined. A summary of the regression models can be found in Table 5.6. A linear regression indicated PMMA Composite scores predicted PAT-2 Composite scores ($R^2 = .437$, $F(1,10) = 7.766$, $p = .019$, $SE = 11.380$). The regression formula for this model was $48.163 + .947 \times \text{(PMMA Composite Score)}$. The PPVT-4 predicted PAT-2 composite scores ($R^2 = .445$, $F(1,10) = 8.032$, $p = .018$, $SE = 11.296$) slightly better than PMMA Composite scores alone; whereas PMMA Composite scores were better predictors for PAT-2 scores than KBIT-2 scores ($R^2 = .411$, $F(1,10) = 6.982$, $p = .025$, $SE = 11.640$). For further analysis, PPVT-4 and KBIT-2 were combined into a single variable due to collinearity between them ($r = .828$, $p < .001$), representing the combination of vocabulary and intelligence (PPKB). A linear regression indicated PPKB predicted PAT-2 Composite scores ($R^2 = .470$, $F(1,10) = 8.867$, $p = .014$, $SE = 11.043$) slightly better than PMMA, KBIT or PPVT-4 scores alone. When SES, PPKB, and PMMA Composite scores were entered into the equation and sequentially removed, no variable emerged as a statistically significant predictor on its own. However, the combination of PPKB and PMMA Composite scores explained more variance in PAT-2 scores than any variable alone ($R^2 = .621$, $F(2,9) = 7.362$, $p = .013$, $SE = 9.848$).
Table 5.6

Summary of Regression Predicting PAT-2 Composite Scores

<table>
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<tr>
<th>Variable(s)</th>
<th>$R^2$</th>
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<th>SE(B)</th>
<th>$\beta$</th>
<th>$t$</th>
<th>Sig. ($p$)</th>
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<td>.458</td>
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<tr>
<td>SES</td>
<td>3.815</td>
<td>3.298</td>
<td>.286</td>
<td>1.157</td>
<td>.281</td>
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</tr>
<tr>
<td>PMMA Composite</td>
<td>.780</td>
<td>.351</td>
<td>.544</td>
<td>2.219</td>
<td>.057</td>
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</tr>
<tr>
<td>PPKB</td>
<td>.362</td>
<td>.152</td>
<td>.570</td>
<td>2.380</td>
<td>.045*</td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>.621</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Constant</td>
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<td>28.857</td>
<td>-.042</td>
<td>.968</td>
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</tr>
<tr>
<td>PMMA Composite</td>
<td>.627</td>
<td>.332</td>
<td>.438</td>
<td>1.891</td>
<td>.091</td>
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<tr>
<td>PPKB</td>
<td>.307</td>
<td>.147</td>
<td>.483</td>
<td>2.087</td>
<td>.067</td>
<td></td>
</tr>
</tbody>
</table>

Notes. PPKB represents the combined scores of PPVT-4 and KBIT-2. $N = 12$.

$p < .05$

Limitations

The primary limitation in this study was the small sample size, similar to other studies utilizing small samples examining relationships between phonological and musical abilities (e.g., Bolduc & Montésinos-Gelet, 2005, $N = 13$; Culp, in press, $N = 17$; Lamb & Gregory, 1993, $N = 18$). The small sample, which was similar across several demographic variables, does not lend to generalizability. Still, in reviewing studies involving children with speech sound disorders, Baker and McLeod (2011) reported 103 had small samples ($N$’s ≤ 20), accounting for 78% of the studies reviewed (pp. 106-107).

In addition, although there is precedent in previous research (Culp, in press), administering both PMMA subtests on the same day could have affected scores on the Rhythm subtest, as it was administered second. In research studies, it is often more practical to administer the music subtests on the same day to respect school schedules and avoid excluding participants due to absence on separate testing days. The hour break participants received between subtests
may have minimized this limitation.

**Discussion**

The most notable results from this investigation are the relationships uncovered between the constructs of composite music aptitude and composite phonological awareness among students with SSDs. Previous researchers have also reported a relationship between phonological awareness and the tonal subdomain of music aptitude, independent of the rhythm subdomain (Bolduc & Montésinos-Gelet, 2005; Culp, in press; Forgeard et al., 2008; Lathroum, 2011; Rubinson, 2010). However, unlike Bolduc and Montésinos-Gelet (2005) and Culp (in press), a relationship between the rhythm subdomain and phonological deletion was found. Others have also reported relationships between phonological awareness and the rhythmic subdomain of music aptitude (Forgeard et al., 2008; Moritz et al., 2013; Rubinson, 2010). A relationship between composite scores for both phonological awareness and music aptitude was found before and after controlling for vocabulary, which is also evidenced in previous research (Culp, in press; Lathroum, 201145; Peynirciog˘lu et al., 2002; Rubinson, 2010). Because the relationship between phonological rhyming with tonal music aptitude was slightly stronger than relationships noted between other subdomains, these findings lend moderate support to the claim that certain phonological awareness skills may be more closely associated with the tonal subdomain, rather than the rhythmic (e.g., Culp, in press; Forgeard et al., 2008; Rubinson, 2010). Further, findings support the assertion that music aptitude as understood by Gordon (1986) is related to phonological awareness (Bolduc & Montésinos-Gelet, 2005; Culp, in press; Forgeard et al., 2008; Rubinson, 2010).

Although vocabulary was not significantly correlated with music aptitude, relationships

45 Also included a measure of melody
between music aptitude and phonological awareness were influenced by vocabulary. While the strength of the relationship between composite music aptitude and composite phonological awareness decreased after controlling for vocabulary, the relationship remained statistically significant. However, without the influence of vocabulary, the positive relationships between composite phonological awareness with the musical subdomains ceased to be significant. Because music aptitude did not correlate with vocabulary, results suggest vocabulary was acting a moderator variable among music aptitude relationships with phonological awareness and music aptitude. In contrast, Rvachew and Grawburg (2006) reported receptive vocabulary mediated the indirect effects of speech perception on phonological awareness among children with SSDs (p. 83). Hence, rather than explaining relationships between music aptitude and phonological awareness, vocabulary may affect the strength of the relationship between the two. For example, the relation between tonal or rhythmic music aptitude and phonological awareness may be stronger among children with strong vocabulary skills and less strong or nonexistent among children with low vocabulary skills. In this way, music aptitude may have a unique relationship with phonological awareness that is not explained by outside factors, accounting for a unique portion of the variance within the construct of phonological awareness.

Further, vocabulary and intelligence were highly correlated among this sample, such that the measure of intelligence nearly acted as a measure of vocabulary and vice versa. This strong relationship explains why the relationship between phonological awareness and intelligence was no longer statistically significant when the effects of vocabulary were controlled. In this way, results of the current investigation are echoed among previous studies wherein the effects of intelligence were controlled (Forgeard et al., 2008; Lamb & Gregory, 1993; Loui et al., 2011; Moritz et al., 2013), but results differ. Findings of the current investigation indicate that both the
tonal and rhythmic subdomains of music aptitude when combined correlate with phonological awareness achievement. This finding may indicate that the relationship between music aptitude and phonological awareness manifests differently among children with compromised phonological systems; both the rhythmic and tonal music subdomains may contribute comparably to analyzing and manipulating language (e.g., Forgeard et al., 2008), whereas tonal music ability may assist with these processes among typically developing learners. Yet, the small sample size makes such assertions difficult to conclude certainly. Consequently, although tonal music aptitude has demonstrated stronger relationships with phonological awareness among typically developing children (Bolduc & Montésinos-Gelet, 2005; Culp, in press), composite music aptitude may have a stronger relationship with phonological awareness among children with SSDs that is moderated by vocabulary.

Although this study did not aim to describe the nature of music aptitude among children with SSDs, findings indicate music aptitude may be rather evenly distributed and not influenced by vocabulary or intelligence within this sample. Neither vocabulary nor intelligence was significantly related to music aptitude in the present study, though Anvari et al. (2002) had reported a significant relationship between vocabulary and music ability with younger children. This difference could be explained by the musical measurement tasks in the current study (discrimination) as opposed to Anvari et al.’s (2002) investigation (perception, discrimination, and production), as well as the age of the participants. Perhaps intelligence and vocabulary are not related to musical discrimination tasks in the same way as other musical tasks or as students age, as students in the current study were older. Given the evenly distributed music aptitude scores, findings do not seem to align with previous research indicating children at risk for phonological deficits scored lower on measures of music aptitude (Forgeard et al., 2008). This
difference may be explained because the PMMA was used in the present study, where the IMMA was used in the former; PMMA is a less difficult measure of developmental music aptitude. Further, music aptitude subdomains were not significantly related and no differences were found between PMMA Tonal and Rhythm subtest scores. Hence, results indicate vocabulary and intelligence are not independently related to music aptitude among children with SSDs and that these children performed equivalently on tonal and rhythmic music aptitude measures, without noted deficits in or significant relationships between either musical subdomain. In these ways, the music aptitudes of children with SSDs closely resemble Gordon’s (1986, 2012) understandings of music aptitude.

**Phonological Skills**

Although findings must be interpreted cautiously due to the small sample size, relationships noted between music aptitude and phonological rhyming and deletion tasks align with previous research. As in the present study, Forgeard et al. (2008) also reported a positive relationship between phonemic deletion and rhythmic music aptitude among both typically developing children and children with dyslexia. In contrast, Culp (in press) did not report a significant relationship between phonological deletion and rhythmic music aptitude among typically developing second-grade students. The relationship between tonal music aptitude and rhyming was also found among kindergarten children (Bolduc, 2008) and second-grade students (Culp, in press). The detection of these relationships in the small sample speaks to the strength these relationships: Music aptitude subdomains consistently demonstrate relationships with phonological rhyming and deletion (Bolduc, 2008; Culp, in press; Forgeard et al., 2008).

**Predictions**

Whereas tonal music aptitude may have unique predictive potential for phonological
awareness skills among typically developing children (Culp, in press; Forgeard et al., 2008), composite music aptitude may be a more reliable predictor of phonological awareness skills among children at risk for phonological awareness deficits, such as children with SSDs. This assertion may also be supported by Forgeard et al.’s (2008) finding that scores on both the IMMA Tonal and Rhythmic subtests predicted phonemic awareness among children with dyslexia, a finding that Forgeard et al. (2008) did not find over time among typically developing children. Because both subtests demonstrated a predictive relationship with phonemic awareness in Forgeard et al.’s (2008) investigation, it is reasonable to assume that, if combined, they may also reliably predict phonemic awareness. The combined predictive potential of the music aptitude subdomains was evidenced in the current investigation, wherein neither PMMA subtest was a suitable independent predictor for PAT-2 composite scores. However, music aptitude was not a significant, independent predictor of phonological awareness when vocabulary and intelligence were also considered. Hence, composite music aptitude may explain a unique portion of the variance to the construct of phonological awareness over and beyond what can be understood by vocabulary or intelligence alone, but it is not necessarily a significant predictor when vocabulary and intelligence are considered. Still, results must be interpreted cautiously because different relationships could have been revealed among a larger sample (N > 18).

**Implications for Music Teaching and Learning**

The relationships found between music aptitude and phonological awareness in the present study have implications for music teaching and learning regarding students with communication disabilities—particularly, students with SSDs. Given that music aptitude explained a substantial and unique portion of the variance found in phonological awareness, results support allotting time for music aptitude testing among this population. Music aptitude
testing could serve as a possible early identification measure for children in need of additional phonological or musical assistance. Results would allow music teachers and other specialists to tailor instruction to improve outcomes in both settings. The positive relationship observed between the constructs indicates a measure of music aptitude that accounts for both the tonal and rhythmic subdomains could have utility in assessing overall phonological awareness. Because children with SSDs who have low music aptitude may also have low phonological awareness, a music aptitude score may serve to identify those who may benefit from additional musical and phonological assistance.

Additionally, understanding these students’ developmental music aptitude could provide useful information to tailor instruction (Gordon, 2012; Stevens, 1987) for enhancing both musical and communication outcomes. In music settings, music teachers would be able to help students better achieve more appropriate musical goals, resulting in higher stabilized music aptitudes (Gordon, 1986, 2012). Higher levels of music aptitude enhance musical understanding, allowing for more information to be derived from musical events, and leading to greater musical achievement throughout one’s life. In therapeutic settings, SLPs and reading specialists could incorporate activities that guide students toward goals in ways that engage musical subdomains, thereby capitalizing on this factor, which contributes a significant portion of unique variance to phonological awareness. To accomplish these outcomes, SLPs could collaborate with music educators to determine ways in which they could help students meet shared goals through the purposeful integration of music and language in both settings (Culp & Roberts, 2015).

Music utilized in other areas of a students’ education can serve to improve musical skills while enhancing other educational outcomes. Music teachers should inform school specialists regarding the benefits of music experiences on phonological awareness development that may be
found when added to phonological skill building programs (Bolduc, 2009; Bolduc & Lefebvre, 2012; Colwell, 1988; Herrera et al., 2011; Walton, 2014). Still, music experiences are most beneficial for reading skills when phonological instruction is added to a pre-existing music curriculum (Standley, 2008). Hence, music teachers, SLPs, reading specialists, and music therapists should consider the ways in which music instruction can naturally support development of musical and phonological awareness skills.

**Implications for Future Research**

Given the relationship between phonological awareness and music aptitude identified among children with SSDs in the present investigation, but considering the limitations of this study, further research is needed. Primarily, study procedures should be replicated with a larger sample. Still, the benefits of music instruction on phonological awareness skills (Degé & Schwarzer, 2011; Gromko, 2005; Overy, 2003) may be due to the relationships found between the two constructs (Culp, in press; Forgeard et al., 2008; Rubinson, 2010). Yet, correlational studies establish connections rather than causal relationships. Future experimental research is needed to investigate whether music instruction added to therapeutic sessions could improve phonological awareness among children with SSDs.

Given relationships noted between constructs dependent on the auditory domain found in this study among children with SSDs, future researchers should examine relationships among additional constructs with a dependence on the auditory domain. Present findings indicate the possibility of a shared underlying system for music and phonological processing. Researchers have suggested shared underlying system between speech perception and production as well (Chiappe, Chiappe, & Siegel, 2001; Mann & Foy, 2003; Snowling, 1981) and have demonstrated strong relationships between phonological awareness and speech perception (Rvachew &
Grawburg, 2006). Hence, such investigations could examine the relationships between musical and speech skills, as well as the effects of music instruction on such skills. It is recommended researchers include children with identified speech deficits as well as typically developing children, as more information is needed regarding these relationships among all learners.

Conclusions

Phonological awareness plays important roles in developing communication skills. Considered a building block of reading (Ehri et al., 2001), scholars have also posited phonological awareness is related to perceiving and producing speech sounds due to a shared underlying system (Chiappe et al., 2001; Mann & Foy, 2003; Snowling, 1981). When additional remediation is needed, students may be removed from typical classroom settings to receive additional support (ASHA, 2014a; Elbaum, Vaughn, Hughes, & Moody, 2000; Hurt, 2012). Yet, relationships noted between musical and phonological abilities (Moreno et al., 2009) suggest students should remain in typical classroom settings, such as music classrooms, to build musical and phonological skills concurrently. Current findings support a positive relationship between phonological awareness and music aptitude among children with SSDs, which indicates possible benefits from music participation for this population.

Further, this study provides preliminary evidence regarding the nature of music aptitude and its relationship to phonological awareness among children with SSDs, which may be beneficial when planning for instruction. Music aptitude scores were evenly distributed, suggesting children with SSDs may not necessarily have deficits in this area and may not attain significantly higher scores in a single area of music aptitude when compared to another (i.e., tonal vs. rhythm). The combination of tonal and rhythmic music aptitude predicted phonological awareness among children with SSDs alone, but did not emerge as a significant predictor when
vocabulary ability was considered. Still, when predicting phonological awareness achievement, music aptitude was nearly as robust as vocabulary and more robust than intelligence alone. Moreover, when added to a model that considers both intelligence and vocabulary, music aptitude may account for as much as 15% of the variance present in the construct of phonological awareness. Hence, children with SSDs should be provided the same opportunities to participate in musical experiences as their typically developing peers and may benefit from music instruction during phonological training or vice versa.

After all, children have the right to acquire the skills necessary to communicate with and understand their world—whether orally (speaking), visually (reading), or musically. Due to the significant portion of shared variance between phonological awareness and music aptitude, music teachers, SLPs, music therapists, and reading specialists should consider the connections between the two constructs when working with children with SSDs. By allowing children to remain in musical settings to work with music teachers, developmental musical aptitude could be enhanced while communication skills are naturally bolstered. Other specialists are encouraged to include music in therapeutic and educational settings, because musical practices can help students achieve shared musical and communication goals.
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doi:10.1177/8755123308322270


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doi:10.1038/srep05854

Appendix A-5

Participant Recruitment Letter Example

[Date]

Greetings Parents and Guardians,

You are receiving this letter because your child is being invited to participate in a research study conducted through Penn State. My name is Mara Culp and I am a Ph.D. candidate studying music education. I am very interested in the relationship between students’ potential to achieve in music (musical aptitude) and their ability to understand and manipulate speech sounds (phonological awareness).

Previous research, including my own, has connected music aptitude and ability to phonological awareness. Researchers have also identified that music may be a useful therapeutic and remediation tool for students with speech sound disorders. I hope my research will shed further light on the relationship between musical abilities and phonological abilities.

To understand this relationship, vocabulary, brief intelligence, music aptitude, and phonological awareness tests will be administered to students who receive services for a phonological process disorder or phonological delay. The procedures for this study have been approved by the school. [Speech-language therapist’s name], the speech-language therapist at your child’s school, will be involved in the project. She has identified your student as a potential participant and questions regarding study procedures can be directed to Mara Culp.

In addition to the potential benefits the results of this study could offer to other students, the information collected can also serve to improve instruction for your child. With your permission, information collected from this study can be provided to the speech-language therapist.

Please review the information included to determine if your student will be able to participate.

I look forward to working with you and your child,

Mara Culp
[contact information]
Appendix B-5

Consent Form Example

Human Subjects Approval has been granted by: The Pennsylvania State University [IRB#]

Title of Project: The relationship between music aptitude and phonological awareness in students with speech sound disorders

Principal Investigator: Mara Culp
[contact information]

1. Purpose of the Study: The purpose of this study is to determine the relationship between music aptitude and phonological awareness in elementary students with speech sound disorders.

2. Procedures to be followed:
Students will be removed from classes, stay after school or come to school early to complete tests. Parental and family preferences will be considered regarding before or after school tests, as well as school schedules and room availability. All testing will be completed in private areas of the school such as the music space or speech-language space. All times are approximate and all tests will be completed within one month.

A. Student Selection and Consent
1. Participants
a. A maximum of 37 students will be used in this study. Therefore, students will be recruited and tested on a rolling basis. The first 37 students to return consent forms will be included in the study. After the 37, students returning consent forms will be placed on a list and contacted should more participants be needed.

b. Speech-language pathologists (SLPs) will select students in K, 1st, 2nd or 3rd grade with phonological process disorders or phonological delays who:
i. have no additional relevant disabilities or impairments (e.g., Down syndrome, cerebral palsy)

ii. have normal hearing

iii. have normal oral-motor function

2. Consent form
a. Child’s speech-language pathologist (SLP) will distribute consent forms. Return consent forms as soon as possible, and no later than [Day, Month Date, Year].

B. Study Procedures:
1. Vocabulary test
a. The primary researcher or SLP will oversee administration to participants individually.

2. Brief intelligence test
a. The primary researcher or SLP will oversee administration to participants individually.

3. Music Aptitude
a. The primary researcher will oversee administration to participants individually or in groups.

4. Phonological Awareness
a. SLP will oversee administration to participants individually.
3. Duration/Time:
   1. Vocabulary Test (10 minutes)
   2. Brief Intelligence Test (15 minutes)
   3. Phonological Awareness Test (30 minutes)
   4. Music Aptitude Test (40 minutes)
      a. Tonal Music Aptitude (20 minutes)
      b. Rhythm Music Aptitude (20 minutes)

4. Statement of Confidentiality: The student’s participation in this research is confidential. Students will be assigned a number for research purposes. Parents and the child’s speech-language pathologist, if indicated by parents, will have access to student results through the primary researcher. However, parents and students will not be made aware of the student’s assigned number for research purposes. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

5. Right to Ask Questions: Please contact Mara Culp at [phone number] or [email] with questions or concerns about this study.

6. Voluntary Participation: The decision to participate in this research is voluntary. The student can stop participating in the study at any time. You must be the student’s legal guardian and at least 18 years of age or older to sign this form and consent for your student to participate in this research.

7. Your signature implies that you have read the information in this form and consent for your student to take part in the research and will provide demographic information to be used as part of the study. Please sign and date the form attached if you agree to these terms. The signature page must be returned to the student’s speech-language pathologist and will be kept by the primary researcher for five years. A copy of this form is also included for your records or future reference.

8. Obtaining student results: Student scores on test measures will be made available to parents through the primary researcher. After consent forms are returned, the primary researcher will contact you to schedule music testing times. At that time, arrangements will be made for supplying student scores. It is intended that scores will be made available upon each student’s completion of all measures.

9. The signed consent form should be placed in a sealed envelope and hand-delivered by your student to the speech-language therapist. Mara Culp (primary researcher) will collect them from the speech-language therapist.
Check one:

______ I grant permission for speech and language test results to be supplied to my child’s speech-language pathologist

______ I DO NOT grant permission for speech and language test results to be supplied to my child’s speech-language pathologist

________________________________________________________________________

Guardian Signed Name ____________________________ Date __________

________________________________________________________________________

Guardian Printed Name ____________________________ Date __________

Phone Number: ____________________________ Email: __________________________

________________________________________________________________________

Student Printed Name ____________________________ Date __________

Student Grade in School: __________________________

Student Birth Date (month, day, year): _________________

Student Sex: __________________________

Languages Spoken in the Home: (please list) __________________________

Languages Spoken by Student Fluently: (please list) __________________________

Ethnicity: (circle one) Not-Hispanic or Latino ; Hispanic or Latino

Race: (list all) ____________________________________________________________

________________________________________________________________________

Name of Elementary School ____________________________ Zip Code __________

________________________________________________________________________

Name of Speech-Language Pathologist (Return Letter to Speech-Language Pathologist)

________________________________________________________________________

Name of Classroom Teacher
Chapter 6: Discussion

Overview of Individual Studies

Conducting these three studies has been a journey of discovery that allowed for a deeper understanding of the relationship between music aptitude and phonological awareness. The purpose, method, research questions, and a brief summary of findings from each study are addressed in this section. Comparisons to previous literature and a general discussion follow, wherein findings from the three separate investigations are synthesized. Based on insights from 3 years of research, implications for music teaching and learning, implications for future research, and conclusions are presented thereafter.

Study 1

The purpose of this study was to investigate the relationship between phonological awareness and music aptitude. The study also sought to examine whether musical aptitude can predict phonological awareness in second-grade students after ensuring normal hearing acuity. Second-grade students between 6;9–8;046 years of age ($M = 7;5$) in a rural elementary school in Pennsylvania served as participants ($N = 17; 7$ female; $10$ male). All participants spoke English and no additional languages, were Caucasian not Hispanic, and had no identified disabilities. The study utilized a correlational design. Evidence was obtained from standardized measures of music aptitude and phonological awareness: Intermediate Measures of Music Audiation (IMMA) (Gordon, 1986) and The Phonological Awareness Test 2 (PAT-2) (Robertson & Salter, 2007). Demographic information was also gathered to determine variance contributed and further define the sample.

Guiding questions and answers were as follows:

46 Years;months.
1. What is the nature of the relationship between phonological awareness and music aptitude as measured by The Phonological Awareness Test 2 and the Intermediate Measures of Music Audiation? Findings indicated a moderate, positive relationship between standardized PAT-2 Composite scores and raw IMMA Tonal subtest scores ($r = .485$, $p = .048$). After controlling for sex, composite scores between the two measures also correlated ($r_{\text{partial}} = .499$, $p = .049$).

2. Can potential to achieve in music predict phonological awareness achievement using evidence obtained from The Phonological Awareness Test 2 and the Intermediate Measures of Music Audiation? A linear regression indicated IMMA raw tonal subtest scores predicted PAT-2 standardized composite scores ($F(1,15) = 4.624$, $p = .048$, $SE = 6.560$).

**Study 2**

The purpose of this study was to investigate the relationship between phonological awareness and music aptitude over time. The study also examined whether musical aptitude can predict phonological awareness in elementary students over time. The study utilized a correlational design. Participants ($N = 7$; 4 female, 3 male) from a rural charter school in Pennsylvania completed standardized measures of music aptitude (IMMA) and phonological awareness (PAT-2) in grades 2 and 3. Participants were between 8;5–9;1 years of age ($M = 8;9$) at the time of phonological testing, all spoke English as their primary language and no additional languages, were Caucasian, and self-identified disabilities included a speech or language impairment and an other health impairment. Speech-language specialists administered a hearing screening and the PAT-2 16 months after initial testing period. The primary researcher administered and scored the IMMA 12 months after the initial testing period.
Guiding questions and answers were as follows:

1. What is the nature of the relationship between phonological awareness and music aptitude over time? Results indicated that tonal music aptitude measured in second grade exhibited a strong, positive relationship with composite phonological awareness skills measured in third grade ($r = .862, p = .013$).

2. Can potential to achieve in music predict phonological awareness achievement over time? Findings indicated that tonal music aptitude measured in second grade could predict overall phonological awareness ability in third grade ($R^2 = .743, F(1, 5) = 14.459, p = .013, SE = 9.48$).

**Study 3**

The purpose of this study was to determine the nature of the relationship between phonological awareness and music aptitude in elementary students with speech sound disorders (SSDs). This study also sought to examine whether music aptitude can predict phonological awareness among this population. Students in grades K-3 receiving services for phonological disorders from SLPs in elementary schools in Pennsylvania served as participants ($N = 12; 3$ female, $9$ male). Participants were between 5;7–9;2 years of age ($M = 6;8$) and spoke English. Most participants identified as Caucasian/White and not Hispanic ($n = 10$) and median household incomes$^{47}$ ranged from $43,731-$85,285. For inclusion in the study, participants met the following criteria: (1) normal hearing, (2) normal oral-motor function, and (3) no additional impairments that could affect performance on assessments (e.g., Down syndrome, cerebral palsy, autism). The study utilized a correlational design; evidence was obtained from standardized

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$^{47}$ Determined by school zip code.
measures of music aptitude (*Primary Measures of Music Audiation* [PMMA] (Gordon, 1986)) and phonological awareness (PAT-2). Data were also obtained from standardized measures of vocabulary (*Peabody Picture Vocabulary Test* [PPVT-4] (Dunn & Dunn, 2007)) and intelligence (*Kaufman Brief Intelligence Test* [KBIT-2] (Kaufman & Kaufman, 2004)).

Guiding questions and answers were as follows:

1. What is the nature of the relationship between phonological awareness and music aptitude among elementary students with speech sound disorders? Results indicated a moderate positive correlation between phonological awareness and music aptitude among elementary children with SSDs after controlling for vocabulary ($r_{partial} = .543, p = .042, df = 9$).

2. What role does potential to achieve in music play in predicting phonological awareness among elementary students with speech sound disorders? Music aptitude composite scores were reliable predictors for phonological awareness achievement alone ($R^2 = .437, F(1,10) = 7.766, p = .019, SE = 11.380$), but did not remain reliable predictors when added to a model that considered vocabulary achievement. The combination of vocabulary and intelligence as a single variable with music aptitude more reliably predicted phonological awareness ($R^2 = .621, F(2,9) = 7.362, p = .013, SE = 9.848$) than music aptitude, vocabulary, or intelligence alone.

**Limitations**

Several limitations may have affected outcomes in these three investigations. Hence, limitations should be considered when interpreting results. These limitations are identified and discussed below prior to further discussion.
Participants

The current investigations utilized small samples ($N < 20$), and therefore some caution is warranted when generalizing to the larger populations. However, precedent for small samples exists within the literature. Investigations of phonological awareness and music abilities have used small sample sizes (e.g., Bolduc & Montésinos-Gelet, 2005, $N = 13$; Lamb & Gregory, 1993, $N = 18$; Moritz, Yampolsky, Papadelis, Thomson, & Wolf, 2013, $N = 12^{48}$) and among studies of children with SSDs, Baker and McLeod (2011) noted 103 investigations utilizing small samples ($N$’s ≤ 20). Although the distribution of males and females in each sample resembled demographics of each population, samples were largely homogenous in terms of race/ethnicity and males outperformed females on measures of music aptitude in the first investigation.

Small samples in these lines of research may be explained by the nature of the data collection procedures, as well as the availability of participants who meet inclusion criteria. Children with special needs represent a subset of the school population. This subset is further limited by grade restrictions as well as diagnoses. Although SSDs are common among elementary-aged children, other disorders may be present, narrowing the pool. In addition, children with special needs may be less likely to participate in studies requiring a great deal of testing. During investigations of phonological awareness and music aptitude, participants may spend over an hour in testing situations. These assessments may demand individual testing and a participant could spend 30 minutes completing a single assessment. Unfortunately, these children spend more time in testing situations during school hours than typically developing children because performance data is necessary to identify children for services and track progress.

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48 The second of two studies discussed in the same publication.
Hence, gathering data from multiple domains among a specialized population can substantially restrict who will be able and willing to participate.

**Testing and Scoring Procedures**

Testing and scoring procedures were carefully considered during each investigation, but certain elements require discussion as they may have contributed to results and subsequent interpretation. Despite recommendations in the test manual (Gordon, 1986), both subtests of the music aptitude measure were administered on the same day. To reduce testing fatigue, a break was provided after the tonal subtest (approximately 3 minutes in Studies 1 and 2; at least one hour in Study 3). This procedure also reduced the risk that participants would be removed from the study due to absence on testing days and minimized disruption to research sites for scheduling. While this is not recommended practice, it maintained a standard testing procedure across all three investigations. Still, the rhythmic assessment was administered second and testing fatigue could have impacted scores.

Speech-language specialists, some of whom were graduate students overseen by a licensed speech-language pathologist (SLP), administered the measures of phonological awareness. Although SLPs are trained in test administration, scoring for correct and incorrect answers on phonological awareness measures is ultimately determined by the test administrator. Each participant typically completed all assessments within one month, but days between testing were not uniform. In addition, I could not require that tests be administered in the same order. Every SLP had to work within unique scheduling and administration circumstances. In Studies 1 and 3, all testing was completed within one month. In Study 2, music aptitude and phonological awareness testing were separated by approximately 4 months due to the SLP’s availability to test participants. All music aptitude subtests were completed on the same day, but phonological
awareness subtests could have been completed on separate days. For scoring phonological awareness measures, norms provided in the test manual (2007) were used for Studies 1 and 2; revised norms (2014) were used in Study 3. This change resulted due to the researcher’s access to and understanding of the revised norms. Once the revised norms were discovered, their use was deemed appropriate in Study 3.

**Comparisons to Previous Literature**

In the current investigations, I examined relationships between music aptitude and phonological awareness at the atomistic and gestalt levels. As a result, patterns emerged that were relatively consistent throughout these studies at both levels. In this section, I discuss these patterns by comparing and contrasting results from my studies with those of related research. These comparisons are integral to synthesizing and interpreting relationships between phonological awareness and music aptitude revealed in the present investigations.

**Tonal Music Aptitude**

Results of the current investigations and previous research indicate that tonal music abilities have consistent relationships with phonological awareness skills. Relationships were found among tonal music aptitude and phonological skills in the current studies. Similar results have also been reported by others, specifically those relationships reported with deletion (Forgeard et al., 2008), isolation (Rubinson, 2010), rhyming (Bolduc, 2008), and composite phonological skills (Anvari, Trainor, Woodside, & Levy, 2002; Bolduc & Montésinos-Gelet, 2005; Loui, Kroog, Zuk, Winner, & Schlaug, 2011). A relationship with substitution was found in one current investigation (Study 2) utilizing a small sample ($N = 7$) and existing research was not available to support or refute this finding, which should be interpreted cautiously given the small sample size. Meaningful relationships were not found between tonal music aptitude and
phonological blending or segmentation in the current investigations. A relationship between tonal music abilities and blending has not been substantially supported in previous research (Lathroum, 2011); previous research assessing segmentation at the phoneme level refutes the findings of the current investigations wherein segmentation was measured at multiple levels (Rubinson, 2010).

**Rhythmic Music Aptitude**

Independent relationships between phonological awareness and the rhythm subdomain of music aptitude, as noted in Studies 2 and 3, also have been reported in previous research studies (e.g., Forgeard et al., 2008; Lathroum, 2011; Moritz et al., 2013; Rubinson, 2010). However, results from previous investigations seem to indicate rhythm production tasks, rather than discrimination tasks used in my studies, may be more closely related to phonological awareness skills (e.g., Moritz et al., 2013). Still, evidence exists supporting a relationship between rhythm discrimination and phonological abilities at baselines (Lathroum, 2011; Rubinson, 2010) and later in life (Moritz et al., 2013).

Overall, scant previous literature was found to support or refute definitively current findings regarding relationships between rhythmic music aptitude and phonological awareness skills examined in the investigations reported in this dissertation. Due to the small sample sizes in the present investigations and lack of supporting evidence, results should be interpreted cautiously. The non-significant relationships found with rhyming skills (Study 3) are supported by a previous investigation (Moritz et al., 2013). Significant relationships were not found with blending in the current investigations, although a positive relationship has been found in previous research wherein kindergarten rhythmic discrimination skills correlated with second-grade phonological blending skills (Moritz et al., 2013). However, this relationship was not
substantially supported in a separate investigation (Lathroum, 2011). The relationship found with deletion among children with SSDs (Study 3) is both supported by the work of Forgeard et al. (2008) and not evidenced in previous research with typically developing children (Moritz et al., 2013). A statistically significant relationship with isolation was not revealed in the present studies, which is supported by Moritz et al. (2013) and refuted by Rubinson (2010), who found a correlation when the initial sounds were measured; the current investigation examined multiple levels. Similarly, the non-significant relationships reported in the current investigations with segmentation are evidenced in Moritz et al.’s (2013) work and refuted by Rubinson (2010) who measured segmentation at the phoneme level only, where the current investigation examined multiple levels. A negative relationship was revealed with segmentation in only Study 2 ($N = 7$), which is not evidenced in previous research (Moritz et al., 2013; Rubinson, 2010). Finally, relationships were not found with composite phonological awareness after controlling for vocabulary (Study 3). This finding is both supported in previous research (Bolduc & Montésinos-Gelet, 2005) and not completely substantiated by previous research, wherein the combination of rhythmic production and discrimination scores correlated with composite phonological awareness scores (Anvari et al., 2002). Again, the small samples sizes must be considered when interpreting these results.

Given the current findings along with the discrepancies in the previous research, it seems rhythmic music aptitude, as measured by discrimination, has few indisputable significant or non-significant relationships with phonological awareness skills. The only consistent finding among the current research and previous research supported the notion that rhythmic discrimination skills are not related to phonological rhyming (Moritz et al., 2013). To wit, rhythm production skills seem to be more closely associated with phonological awareness skills than rhythmic
discrimination skills alone (e.g., Anvari et al., 2002; Moritz et al., 2013). When relationships between rhythmic musical abilities and phonological awareness skills were found, they were often relatively weak ($r$’s < .4) and not consistent among previous research. For these reasons, it appears relationships between rhythmic music aptitude and phonological awareness are weak or a meaningful relationship is sample specific. Consequently, significant relationships among phonological awareness skills and rhythmic music aptitude may not have been uncovered due to the small samples sizes in the present investigations.

**Composite Music Aptitude**

Results of the current investigations indicate that composite music aptitude, the combination of tonal and rhythmic music aptitude, may be related to composite phonological awareness but not necessarily to phonological subskills. Meaningful correlations among composite music aptitude and phonological subskills were not found in the present investigations. However, previous research indicates possible connections between composite music aptitude and phonological skills, such as deletion (Peynirciog˘lu, Durgunog˘lu, & O˘ney-Küsefog˘lu, 2002), segmentation (Rubinson, 2010), and isolation tasks (Rubinson, 2010). Composite music aptitude correlated with composite phonological awareness in Studies 1 and 3 ($N$’s > 11). A smaller sample size in Study 2 ($N = 7$) and gender effects related to composite music aptitude scores, favoring males, may explain why composite music aptitude was not revealed during that investigation. The relationships found between composite music ability and composite phonological awareness have also been found by others, wherein both constructs were comprised of multiple subdomains and presented as a single variable (Anvari et al., 2002; Lathroum, 2011). Unlike previous research (Lathroum, 2011), musical subdomains were not correlated in the present investigations. Overall, results support the notion that the combination
of tonal and rhythmic music aptitude, as measured by discrimination tasks, is related to a person’s overall phonological awareness ability.

**Summary of Relationships Among Musical Aptitude and Phonological Awareness**

Taken together, current findings suggest the tonal subdomain of music aptitude is more closely related to phonological awareness than the rhythmic subdomain (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Rubinson, 2010), particularly among typically developing children (Studies 1 & 2). Positive relationships found among the tonal subdomain and phonological awareness skills in the current investigations are supported by previous research (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Loui et al., 2011; Rubinson, 2010). Findings also align with previous research wherein relationships were found between composite music aptitude and composite phonological awareness (Anvari et al., 2002; Lathroum, 2011). Results do not concur with findings wherein composite music aptitude correlated with an individual phonological skill (Peynirciogˇlu et al., 2002; Rubinson, 2010). Present findings regarding rhythmic music aptitude, with which phonological awareness skills shared few significant relationships, are not supported or refuted indisputably by previous literature (e.g., Anvari et al., 2002; Forgeard et al., 2008; Lathroum, 2011; Moritz et al., 2013; Rubinson, 2010). Still, rhythmic music aptitude may be related to phonological awareness skills, particularly deletion, among children with SSDs (Study 3) who are at-risk for phonological awareness deficits (e.g., Forgeard et al., 2008). Hence, tonal music aptitude may be more closely related to phonological awareness than rhythmic music aptitude when music aptitude is measured by same-different discrimination tasks (Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Rubinson, 2010). Given findings of the current investigations and relationships noted in previous literature, tonal music aptitude may be a reliable predictor of
overall phonological awareness achievement among typically developing children (Studies 1 & 2); composite music aptitude may have more utility in predicting phonological awareness achievement among children with SSDs (Study3).

**General Discussion**

This line of research has addressed questions regarding music aptitude and phonological awareness among children age 7 and older, as well as those with SSDs. Although these studies did not seek to describe the nature of music aptitude among these samples, certain features of their music aptitudes are worth noting. This discussion begins with a conversation regarding the nature of the participants in each study and the unique insights gained from each sample to help interpret findings. Having compared my findings to the work of others, it is apparent that certain musical abilities are more or less strongly associated with certain phonological skills; or their combinations. In this section, I offer my interpretations of current findings in light of previous literature, as well as my personal experience and opinion.

**Nature of the Participants**

The three different populations in these studies were chosen for the unique perspective and insight they would provide to understanding the relationship between music aptitude and phonological awareness. Even though a tendency existed for males to score higher than females on certain measures of music aptitude among typically developing children, relationships emerged among affected measures after controlling for sex or differences between sexes were not statistically significant. Findings from these investigations utilizing older children (aged 7-9) with more complete phonemic inventories as well as children with SSDs have implications for music teaching learning as well as future research.
By examining three populations, the current investigations provide further evidence of the nature of developmental music aptitude. Among typically developing children, music aptitude scores were found to increase over time, while the scores themselves on particular measures were related from year to year. This finding aligns with Gordon’s (1986) understanding of developmental music aptitude, which may move up or down as it develops. Among children with SSDs, music aptitude scores were rather evenly distributed, suggesting children with SSDs may not have generally lower music aptitude than typically developing children. This also supports Gordon’s (1986) assertion that music aptitude is evenly distributed throughout the population. Further, one subdomain of music aptitude did not seem more or less developed than another (i.e., tonal vs. rhythm) (e.g., Forgeard et al., 2008) and the combination of both tonal and rhythmic music aptitude played an important role in its relationship to phonological awareness achievement. Although vocabulary was highly correlated with phonological awareness, as an individual predictor, music aptitude was nearly as robust as vocabulary and more robust than intelligence. It should also be noted that when added to a model that considers both intelligence and vocabulary, music aptitude contributed unique variance to the construct of phonological awareness. In this model, music aptitude and the combination of vocabulary and intelligence ceased to be significant individual predictors, indicating the strong influence of the constructs on phonological awareness scores.

Music Aptitude and Phonological Awareness

Tonal music aptitude was consistently related to phonological awareness throughout these investigations. However, it is not clear why the tonal subdomain tends to exhibit a stronger relationship with phonological awareness than the rhythmic subdomain (Anvari et al., 2002; Sun, Lu, Ho, & Thompson, 2017). Because phonological awareness is also related to speech skills, I
contend that the relationships noted in these investigations may imply a relationship between
tonal music aptitude and speech as well. A shared relationship between tonal music aptitude,
speech skills, and phonological awareness among speakers of English, may be explained by the
features of the language.

Hence, a potential rationalization for this relationship could be found in the composition
of the English phonemic inventory as well as its prosodic features. Most unvoiced phonemes
have voiced cognates, phonemes that only differ in terms of voicing (e.g., /s/ and /z/). When
nasal consonants (e.g., /m/), liquids (e.g., /l/) and vowels are included, the English language
contains a preponderance of phonemes with a voiced feature that can be assigned pitch and
sustained over time, such as in singing. These voicing features are further utilized in the prosodic
features of English, the patterns of intonation and stress. Spoken stress is characterized by
increases in volume, length, and pitch, which may be more easily exaggerated or made apparent
in voiced phonemes. A person’s intonation, or variation of spoken pitch, assists a variety of
communicative functions during speech such as word stress, focus, sentence type, regulating
conversational interaction, and conveying emotions and attitudes (Xu, 2005). Due to the
preponderance of voiced phonemes in the English phonemic inventory as well as the important
functions pitch serves in communication, it is evident that understanding pitched aspects of
language serves important—perhaps even primary—functions in understanding speech and
deriving meaning from language. From an evolutionary standpoint, whether the ability to derive
meaning from pitch first served music or language remains a point of debate (Brandt, Gebrian, &
Slevc, 2012; Mithen, 2006; Pinker, 1997; Sperber, 1996; Wilson, 2012). However, it is apparent
that the ability to discriminate pitch has utility in both domains.
Still, the combination of both tonal and rhythmic subdomains was related to composite phonological awareness, the combination of phonological awareness skills, in two current investigations (Studies 1 & 3; N’s > 11). This finding could be explained because tonal music aptitude was related to at least one phonological awareness skill in all current investigations. Because tonal music aptitude is a feature of composite music aptitude, correlations observed among composite music aptitude and phonological awareness were likely due in large part to the tonal domain (Studies 1 & 3). Yet, rhythmic music aptitude was also positively correlated with a phonological awareness skill in Study 3, indicating that it also exerted influence on relationships observed between composite music aptitude and phonological awareness. Hence, this finding could also be explained by the nature of melody, which is comprised of tonal and rhythmic features, in both music and speech (Xu, 2005). According to Xu (2005), both tonal (pitch) and rhythmic (duration) elements comprise a person’s speech melody, which “is used to convey a variety of communicative functions” (p. 246). During musical and spoken events, the mind organizes both tonal and rhythmic information simultaneously, creating distinctions for interpretation. These smaller units could represent a tone, cadence, measure, or phrase in music; or a speech sound, word, phrase, and sentence in spoken language.

Yet, the rhythmic and tonal elements of music and speech may be further intertwined. In speech, timing has a direct impact on intonation, or pitch variation (Xu, 2009). The speed of the syllable will directly influence the achievable intonation, therefore impacting the overall meaning (Xu, 2005). This intertwined relationship, wherein rhythmic elements influence tonal elements, may also be evidenced within the musical domain when scores on tests of tonal and rhythmic abilities have correlated (e.g., Lathroum, 2011; Sun et al., 2017). Although Gordon’s (1986) measures independently measure music aptitude subdomains, because speech consists of
intertwined tonal and rhythmic elements, akin to a musical melody, perhaps the combination of musical subdomains will provide useful insight into music’s relationship to speech among children.

Whether tonal or a combination of tonal and rhythmic subdomains, music aptitude explained a significant and unique portion of the variance found in phonological awareness in the present investigations. The stability of phonological processing skills among elementary children (Torgesen, Wagner, & Rashotte, 1994) may call for additional means of remediation (Blachman, 1994). Given the plasticity of music aptitude until age 9 and the settled nature of phonemic inventory around age 7, improving music aptitude during its developmental stages may help to improve phonological abilities after age 7.

Phonological awareness has demonstrated important relationships with a variety of communication skills. In addition to the important role it plays in reading development (Ehri et al., 2001), scholars have posited an underlying system may govern phonological awareness, speech perception (Chiappe, Chiappe, & Siegel, 2001), and speech production (Snowling, 1981). Previous researchers have demonstrated the benefits of musical training on speech perception (Moreno et al., 2009), suggesting that musical participation “improves the development of the phonological representations” (p. 719) necessary for speech. Music, particularly singing, has been recommended for use in sessions for students with SSDs (Bauman-Waengler, 2012) and motivates children to work toward therapy goals (Kilcoyne, Carrington, Walker-Smith, Morris, & Condon, 2014). Hence, musical participation and enhancing music aptitude could positively affect phonological awareness, speech perception, and speech production.

Finally, the relationships uncovered between music aptitude and phonological rhyming and deletion tasks, in particular, are noteworthy. Phonological deletion correlated with a music
aptitude subdomain in all three investigations. Phonological rhyming correlated with tonal music aptitude in Studies 1 and 3 ($N$'s > 11). Rhyming skills are predictive of reading skills (National Center for Family Literacy, 2008, p. 77) and deletion tasks have been associated with reading achievement (Wilde, Goerss, & Wesler, 2003; Yopp, 1988). Therefore, music instruction targeting these specific tasks could be advantageous for phonological development.

**Implications for Music Teaching and Learning**

Findings indicate that students with low music aptitude may also have low phonological awareness skills. Thus, results support allotting time for music aptitude testing because a music aptitude score may serve two functions. First, it could serve to identify phonological deficits early in a child’s educational experience. Second, music aptitude testing could provide avenues to tailor instruction in music, general classroom, and therapeutic settings. More appropriate music instruction would help children achieve more suitable musical goals, resulting in higher stabilized music aptitudes (Gordon, 1986, 2012). Reaching a higher stabilized music aptitude will enhance musical engagements throughout the course of a person’s life. In this way, a person derives more understanding from musical events, leading to greater musical achievement. In general classroom and therapeutic settings, music activities could be incorporated by teachers, reading specialists, SLPs, and music therapists to enhance student understanding of nonmusical concepts. Engaging the musical domain during classroom and therapeutic instruction in developmentally appropriate ways capitalizes on students’ musical intelligence, *drawing on* and *enhancing* developmental music aptitude while building other skills.

In fact, music has been advantageous for phonological awareness development when added to literacy/phonological programs (Bolduc, 2009; Bolduc & Lefebvre, 2012; Herrera, Lorenzo, Defior, Fernandez-Smith, & Costa-Giomi, 2011; Richards, 2011; Walton, 2014) and
general musical participation has also been beneficial (Gromko, 2005; Moritz et al., 2013; Richards, 2011). Therefore, musical activities during instruction targeting these phonological tasks or in general music classes could increase abilities for both typically developing children and those with SSDs. Tonal activities could naturally enhance rhyming skills for all learners (Studies 1 & 3). Additionally, tonal activities may improve deletion skills for typically developing children (Studies 1 & 2) and rhythmic activities may be useful for children with SSDs to improve deletion skills (Study 3). Hence, adding music to other areas of the curriculum can help children grow musically while improving phonological awareness.

In these ways, both musical and phonological skills could be improved naturally in multiple settings without superfluous demands on teachers, therapists, or students. Music instruction naturally enhances phonological awareness among young children (Degé & Schwarzer, 2011; Gromko, 2005; Moritz et al., 2013; Richards, 2011); music is more beneficial for reading skills when such instruction is added to pre-existing music curricula (Standley, 2008). Music teachers should inform school specialists, therapists, teachers, and administrators about the positive effects of music experiences on phonological awareness development. Reading specialists, classroom teachers, SLPs, and music therapists should also collaborate with music educators to set shared goals and utilize music to improve musical skills while enhancing other knowledge in developmentally appropriate ways. Together, professionals can consider the ways music instruction naturally supports musical and phonological awareness skills to develop activities that will allow students to meet shared goals. By purposefully incorporating music and language in multiple settings, student achievement could be amplified in numerous areas simultaneously.
Implications for Future Research

The relationships found in the present investigations reveal phenomena in need of future investigation, as well as methodological considerations for future work. These correlational studies with small samples (N’s < 20) establish preliminary links, rather than generalizable explanations. Future investigators should replicate these studies with larger samples (N’s > 30) to add more power and produce more generalizable findings that demonstrate relationships between music aptitude and phonological awareness among children in grade 2 and beyond, as well as children with SSDs.

Additional experimental research investigating the effects of music on phonological awareness with additional populations is also warranted. Although researchers have rather consistently reported the benefits of music instruction on phonological awareness, most studies have been with typically developing children below grade 2 (e.g., Degé & Schwarzer, 2011; Gromko, 2005; Herrera et al., 2011; Moritz et al., 2013; Richards, 2011). Standley (2008) reported that music has been more valuable for reading skill development among children with special needs (d = .81) and less beneficial in general as children age (Pre-K d = .62; elementary d = .25). Researchers could seek to understand which features of musical instruction are most effective in assisting phonological awareness development. Findings from such investigations may assist in developing musical strategies to better assist children who are older.

These investigations have also revealed the need to understand the relationship of music aptitude and phonological awareness over time. It is believed that phonological awareness follows a rather predictable positive developmental trajectory (Bauman-Waengler, 2012; Moats & Tolman, 2015). While musical skill development likely follows a positive growth trajectory, music aptitude has demonstrated fluidity and may move up and down as it develops (Gordon,
If music aptitude has the potential to move up or down before age 9, it is reasonable to assume its relationship to a variable that exhibits a consistently positive growth trajectory may not remain stable from year to year. To this point, researchers have often sought to understand the effect of music on phonological awareness development (Degé & Schwarzer, 2011; Fisher, 2001; Gromko, 2005; Herrera et al., 2011; Moritz et al., 2013; Richards, 2011). Therefore, little is known about the nature of the relationship between phonological awareness and music aptitude without the influence of additional music instruction beyond what may be provided in a typical school experience. Understanding the nature of this relationship over time, without the influence of music study beyond that provided in school, would offer more clarity regarding the influence of music training by providing a baseline for comparison.

Future investigators should also consider measuring additional constructs when investigating correlational relationships between music aptitude and phonological awareness. Vocabulary was strongly related to phonological awareness in a current investigation, influencing relationships noted between music aptitude subdomains and phonological awareness skills. Vocabulary, as well as speech perception, has been identified as an important factor in phonological awareness development (Metsala, 1999; Rvachew & Grawburg, 2006). Although music aptitude has significantly correlated with phonological awareness after controlling for intelligence (Forgeard et al., 2008; Lamb & Gregory, 1993; Loui et al., 2011; Moritz et al., 2013), its predictive potential for phonological awareness when added to a model that considers vocabulary or speech perception is largely unknown. Therefore, future researchers may consider incorporating vocabulary and speech perception measures to provide additional knowledge regarding the relationship between music aptitude and phonological awareness.
To add further validity to experimental research investigating the benefits of music on phonological skill development, researchers should report data pertaining to initial levels of phonological awareness and music aptitude, as in Peynirciog’lu et al. (2002). Understanding initial levels of both could play a vital role by helping to ensure even distribution of musical and phonological abilities between control and experimental groups. Experiments utilizing groups matched on both music aptitude and phonological awareness ability could lend valuable insight into how music training influences phonological awareness, musical aptitude, and the relationship between the two.

**Final Conclusions**

These investigations support the notion that music aptitude, a person’s ability to assign meaning to musical events (audiate) and measured by same-different discrimination tasks (Gordon, 1986), is related to phonological awareness (Bolduc & Montésinos-Gelet, 2005; Forgeard et al., 2008; Rubinson, 2010). Music aptitude is related to phonological awareness among children in grades 2 and 3, as well as children with SSDs. Among typically developing children, tonal music aptitude may be a reliable predictor for phonological awareness abilities measured in both second grade and third grade. However, the nature of the relationship between music aptitude and phonological awareness may be influenced by time: music aptitude measured at one point may not correlate with phonological awareness skills measured near or around the same time, but predict skills measured at a later point. For children with SSDs, the combination of both tonal and rhythmic music aptitude accounted for a unique portion of the variance in phonological awareness over and beyond what could be explained by vocabulary and intelligence alone. A substantial amount of the variance in phonological awareness was also accounted for by tonal music aptitude among typically developing children. Hence, the musical
and phonological systems of these populations may be functioning in different ways wherein rhythm music aptitude is more or less connected to phonological awareness.

Certain relationships among phonological skills and music aptitude subdomains have been brought to the fore during these investigations. Tonal music aptitude is related to phonological rhyming (Bolduc, 2008), a relationship found in two of three investigations (Studies 1 & 3). Rhythmic music aptitude is not significantly related to phonological rhyming (Moritz et al., 2013), as noted in all current investigations. Phonological deletion is related to tonal music aptitude (Forgeard et al., 2008) and possibly to rhythmic music aptitude, particularly among children for whom phonological skills may be compromised (e.g., Forgeard et al., 2008). Phonological substitution is not related to music aptitude, as a significant relationship was not evidenced in any current investigation and not found specifically in previous research. Finally, composite phonological awareness is related to composite music aptitude among all learners (Lathroum, 2011); tonal music aptitude is related to composite phonological awareness among typically developing children (Anvari et al., 2002; Bolduc & Montésinos-Gelet, 2005; Loui et al., 2011).

Of course, due to the small sample sizes ($N$’s < 20) in these studies, findings should be interpreted cautiously. More statistically significant relationships could have been found and effect sizes could have been higher had at least 18 individuals taken part in any single study. For these reasons, findings should be seen as preliminary evidence of existing relationships while supporting relationships evidenced throughout the scholarly literature.

Every child should be given opportunities to develop the necessary skills to communicate with and understand the world. Due to the significant portion of shared variance between music aptitude and phonological awareness, it may be advantageous for students to remain in music
classrooms rather than being pulled out to work on phonological skills. If students remain in music settings among peers they will have opportunities to build music aptitude early in life, and early levels of music aptitude may predict future phonological awareness achievement. Hence, music teachers, SLPs, music therapists, reading specialists, principals, and administrators should consider the connections between these two constructs when planning for instruction.
References


VITA

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Mara E. Culp earned a Bachelor’s of Music Education from Siena Heights University in 2007 and a Master’s Degree in Music Education from Penn State in 2013. She taught K-12 general, choral, and instrumental music in Hillsdale, MI for 5 years. Her experiences teaching students with communication impairments in elementary general music classes led to her interest in the connections between speech-language and musical development. She has presented original research and practical sessions across the country at state, national, and international conferences; presented as an invited lecturer in the speech-language field; and has published work related to improving speech sounds. She is an Assistant Professor of Music Education in the Eastman School of Music.

Publications:

Research Projects & Presentations:
1. Building Preservice Elementary Teachers’ Confidence to Integrate Music in their Future Classrooms
2. A Qualitative Investigation of Speech-Language Pathologists' and Music Educators’ Techniques
3. The Use of Musical Techniques to Improve Speech Sounds

Workshops, Presentations & Guest Lectures:
1. Selecting Repertoire for K-6 Choirs
2. Using Music to Improve Speech Sounds
3. Preparing Preservice Music Teachers to Teach Students with Special Needs
4. How School-Based Therapists Use Music to Treat Students with Special Needs
5. Crossing Boundaries: Creating Inter-Disciplinary Collaborative Relationships
6. Working with Individuals Diagnosed with Autism – Invited Panelist