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Individual Differences In Music Discrimination And Their Relation To Reading And Reading-Related Skills In Children

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INDIVIDUAL DIFFERENCES IN MUSIC DISCRIMINATION AND THEIR RELATION TO READING AND READING-RELATED SKILLS IN CHILDREN

by

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ABSTRACT

Research suggests that there may be a relationship between music and reading. Some researchers have found that musical rhythm is related to reading in children, while others have found that it is musical pitch and not rhythm that correlates with reading. Prosody is the melodic element of language that encompasses both pitch and rhythm. In the past, these have been studied separately. In the present study, we analyzed pitch and rhythm discrimination skills, phonological awareness, prosody and reading in thirty-nine seven and eight year old children. We predicted that music and reading skills would be related, and that prosody would make unique contributions to reading. We found that when controlling for phonological awareness, it is rhythm and not pitch that predicts reading. Further, prosody explains additional variance in reading beyond that accounted for by rhythm and thus makes a unique contribution to reading.

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LIST OF SYMBOLS

*	The correlation is significant at the .05 level (2-tailed)
**	The correlation is significant at the .01 level (2-tailed)

LIST OF ABBREVIATIONS

NWR ..... Non-Word Reading

PA ..... Phonological Awareness

RC ..... Word Reading Composite

RS ..... Raw Score

SS ..... Scaled Score

WR ..... Word Reading

CHAPTER 1

INTRODUCTION

Language is inherently melodic with predictable patterns of intonation, rhythm and stress, and some of these patterns are described as prosodic stress, pitch and rhythm. While these patterns are most often observed in oral language, they are also accessible when reading written language. Reading is a fundamental skill with significant long-term implications on academic achievement, and children begin learning underlying reading skills at a very early age. Many children are also exposed to various music skills throughout their development, and children that acquire these music skills are often also skilled readers. Previous research has shown that both phonological and prosodic awareness are important skills related to children's reading abilities, and it is possible that music might be important for reading as well. Researchers have explored this perspective and have gathered that there is a relationship between phonological awareness and music, and that prosodic awareness may also make unique contributions to the relationship between music and reading. Specifically, the components of music that are possibly important for reading are pitch and rhythm. While researchers have amassed data regarding the role of pitch in reading, the role of rhythm is much less clear. The prevalence of conflicting findings regarding the significance of pitch and rhythm discrimination skills provides ample support for future researchers to continue refining the relationship between individual differences in music discrimination and reading and reading-related skills.

The purpose of this study is to examine the relationship between individual differences in music discrimination and reading and reading-related skills in children ages seven and eight. In concurrence with previous studies, we measured music sensitivity by assessing pitch and rhythm discrimination skills. We expected that children's performance in these areas would provide insight in to their relationship to reading, phonological awareness and prosodic awareness. Consistent with previous research studies, it was our prediction that there would be a significant relationship among pitch and rhythm discrimination skills, phonological awareness, prosodic awareness and reading. Additionally, we predicted that prosody would make a unique contribution to reading over and above the contributions made by musical pitch and rhythm.

Phonological and Prosodic Awareness

A subsystem of phonology that is of central merit in this study is prosody, or the melodic nature of language as organized by the rhythm, tempo and stress of words. Prosodic awareness enhances and informs other linguistic subsystems, such as syntax and semantics, by providing information regarding lexical representations and word boundaries (Whalley & Hansen, 2006). Since prosody is inherently melodic, it may function through similar underlying systems of music, which includes pitch and rhythm. In order to study this further, Whalley & Hansen (2006) analyzed the relationship between phonological and prosodic awareness, rhythm sensitivity and reading skills. Their findings suggest that after controlling for phonological awareness and rhythm sensitivity there is a positive relationship between the prosodic awareness and the reading abilities of children ranging from 8.8 to 10.5 years of age. Likewise, researchers have

observed interconnection between phonological awareness, reading skills and music perception skills in early readers without formal music training (Anvari, Trainor, Woodside & Levy, 2002).

Pitch & Rhythm Sensitivity and Reading

There is conflicting evidence regarding the roles of pitch and rhythm in reading. Douglas & Willats (1994) observed that rhythm discrimination skills correlated with reading abilities in seven and eight year olds. To further investigate the relationship among music sensitivity and reading, Anvari, Trainor, Woodside & Levy (2002) dichotomized music sensitivity to include the relationship among pitch and rhythm, and thus were able to measure these skills as well as early reading abilities in four and five year old children. These researchers found that there is a correlation among pitch perception skills, phonological awareness and early reading skills. Specifically, pitch perception skills were noted to be a reliable predictor of early reading skills such as letter identification and reading a few words. Interestingly, Anvari et al. (2002) also found that pitch sensitivity remains a predictor of these early reading abilities even when controlling for phonological awareness. This finding indicates that while the role of the auditory mechanisms in pitch perception skills and in early reading abilities is similar, this relationship extends beyond the processing of phonological awareness.

When considering both pitch and rhythm sensitivity, Anvari et al. (2002) were perplexed to find that although pitch sensitivity consistently related to phonemic awareness and reading, rhythm sensitivity did not. While they noted rhythm production and rhythm discrimination tasks correlated with pitch sensitivity and reading in four year

olds, neither relationship was observed in five year olds. This vast discrepancy provides little indication of the role of rhythm sensitivity in reading-related skills. We assert that the likely reasoning for the inconsistency of these results is that average performance on the primary measure of reading in this study only required participants to name letters. While this task was used appropriately due to the age of the participants and their limited reading abilities, it was ultimately an insensitive measure of reading.

To further assess how reading skills apply to music skills, researchers Tsang & Conrad (2011) examined how music training impacts reading performance in a broad range of participants ranging between five and nine years of age. These researchers discovered a relationship among pitch sensitivity and phonological awareness. They also noted that pitch sensitivity is only a predictor of reading abilities in non-music trained children, which indicates that the relationship between music and reading skills is impacted by music training. While these findings corroborate the previous assertion that music sensitivity impacts reading ability as a function of shared underlying language skills, they also found no association between rhythm discrimination skills and reading skills, which contradicts previous findings that recognize the influences of rhythm sensitivity. This discrepancy provides cause for further examination as to why these findings were unique to non-music participants. Because music sensitivity may vary based on the length of music instruction and reading and reading-related skills develop across age levels, it is possible that these findings are inconsistent with previous studies due to the wide age-range of their participants.

In contrast, Gordon, Shivers, Wieland, Kotz, Yoger and McAnuley (2014) conducted a study on six-year-old children that were slightly older than the children

tested by Anvari et al. (2002) and studied only rhythm discrimination skills. In their study, they found that rhythm discrimination skills did account for individual differences in phonological awareness, but only prior to controlling for the IQ of participants. Once Gordon et al. (2014) controlled for IQ, they found that rhythm accounted for differences in expressive language skills (such as morpho-syntax) but not phonological awareness. These findings indicate that there is likely an overlap of neurocognitive resources used for the processing of musical rhythm and language, and that rhythm is not uniquely attributed to increased phonological awareness.

A longitudinal study by David, Wade-Woolley, Kirby and Smithrim (2007) that observed children from first through fifth grade provides more insight into the underlying neurocognitive processes that link rhythm discrimination skills and language. These researchers notably linked rhythm production skills with reading real words and non-words, and observed that children's rhythm production abilities correlate with their phonological awareness and naming speed. Additionally, children's rhythm abilities are a significant predictor of variance in reading ability at every grade level observed in their study. These findings are in line with the conclusion of Huss, Verney, Fosker, Mead & Goswami (2011) that rhythm functions as a means of organizing music into patterns and forms, and that those patterns and forms mirror the organizational structure of language phonology through speech prosody. Based on these studies, we find evidence to support the assertion that rhythm and pitch likely have language-based analogies and involvement in speech and reading, which is recognized as prosody.

A study by Gordon, Jacobs, Schuele and McAuley (2015) further elaborated upon these findings by analyzing previous research and perspectives regarding the link

between rhythm, grammar and language development. As part of their analysis, they referenced the behavioral and brain data of children and adults, and noted that prosody and components of the timing of sentences have an impact on morpho-syntactic processing in real time. They also provided evidence that children who have language impairment also present with rhythm discrimination and grammatical deficits. Inversely, Gordon et al., (2015) also noted that in typically developing six and seven year old children, there is a strong, positive correlation between rhythm discrimination skills and expressive grammar skills. Each of these components provide support for the assertion that rhythm discrimination skills are associated with performance on grammatical skills, including complex syntax, and that due to the underlying hierarchal and rule-based nature of rhythm and grammar, each process benefits from prosodic cues.

Music Sensitivity and Academic Outcomes

Academic achievement is measured in a myriad of ways. Due to the inherent value of reading skills in activities of daily living, an individual's reading abilities are likely to have a substantial impact on success in a variety of contexts, and are thus an appropriate measure of academic achievement. In an effort to better understand why some children have increased academic achievement compared to their peers, Butzlaff (2000) conducted a meta-analysis of twenty-nine studies and observed that there is a strong, positive association between music instruction and children's performance on standardized tests of reading (Butzlaff, 2000), and other researchers have found this increase in academic performance to extend to mathematic skills as well (Tucker, 1981). As music is considered an artistic discipline, these findings that support achievement that exceeds disciplinary boundaries are particularly interesting. To that end, there is likely a

wide array of benefits of training in a variety of artistic disciplines, such as visual arts. However, research has shown that increased performance on measures of preliteracy skills such as visual-auditory learning (i.e. the child's ability to map visual symbols to words within their oral vocabulary) are uniquely observed in children that receive music training as opposed to visual arts training (Moreno, Friesen & Bialystok, 2011). Thus, research suggests that the academic contributions of music training extend beyond general enrichment through training in an artistic discipline.

While most children receive some level of formal or informal music training, not all receive the same enhanced academic outcomes. In order to better understand if the length of music training had near transfer or far transfer effects on these academic skills, Corrigall and Trainor (2011) conducted a study with six and nine year old children and evaluated how lower-level reading skills like word decoding (which would suggest near transfer) and higher-level reading skills like reading comprehension (which would suggest far transfer) differed as a function of the number of hours of music training. Their data revealed that the number of hours in which a child participates in music training is associated with their reading comprehension skills, but not their word decoding skills. These findings suggest that if near transfer occurs, it occurs mostly in beginning readers or those that are struggling with reading. This also indicates that music training has far transfer effects that impact the skills and knowledge that can be applied in various functional situations, such as understanding new reading material. Therefore, although the number of hours in which a child participates in music training can lead to increased reading comprehension skills, basic reading skills do not inherently vary as a function of the number of hours of music training.

Current Study

The purpose of this study was to investigate how both musical rhythm and pitch are related to reading and the reading-related skills of phonological and prosodic awareness in children ages seven and eight. While many studies have made the connection between music and language, no study has tested musical pitch, rhythm, prosody and phonological awareness simultaneously as contributors to reading. Therefore, we have two research questions in the current work. First, we seek to determine how pitch and rhythm are related to reading and reading-related skills. Second, we test whether prosodic awareness explains variance in reading outcomes beyond what is already accounted for by music skills and phonological awareness. We predict that musical pitch and rhythm would have a significant relationship with reading and reading-related skills, and that prosody, as a language-based process, would make a unique contribution to reading over that made by music variables.

CHAPTER 2

METHOD

Participants

The participants in this study consisted of thirty-nine typically developing seven and eight year old males (N=16) and females (N=23) with an average age of 97.11 months (SD=6.075). Recruitment procedures were cleared by the University of South Carolina IRB and are as follows: participants were to be recruited from local public and charter elementary school after-school programs in the Columbia, South Carolina area. The parents of each participant were given written notice that children that participated in the school's after-school program were being asked to participate in a research study, and a voluntary opt-out form was provided. The parents of each participant also completed a questionnaire detailing their child's hearing status, speech and language impairment status, neurological impairment status, maternal education level, and level and frequency of participation in music activities inside and outside of school. In accordance with IRB stipulations, no written consent was required for participation in this study and participants provided verbal assent and participated on a voluntary basis. There was no monetary compensation for participation.

Procedure

Following parental notification that a research study was to be conducted, seven and eight year old participants were presented with the opportunity to participate in the

study. Graduate and undergraduate research assistants that had completed onboarding procedures and research battery instruction conducted the experiment. The experiment itself took place individually in a quiet room located in the after-school care location. It took approximately one hour to complete each music and reading-related tasks. Each participant completed the tasks in the prescribed order, and in the event that the child was unable to complete the test battery in one session, their progress was noted and completed from that point at the next available session. All measures that required a verbal response were audio-recorded for offline scoring. After successful completion of all study tasks, the participant was debriefed and returned to their after-school activities.

Materials

This experiment consisted of a battery of tests measuring pitch and rhythm discrimination skills, phonological awareness, prosodic awareness and word and non-word reading and fluency. Excluding the prosodic awareness task, each assessment was norm-referenced for the appropriate age range and had acceptable levels of reliability and validity. Due to the lack of standardized prosodic awareness assessments, the prosodic awareness task was generated for this study in accordance with prosodic awareness tasks utilized in previous studies. Each participant was tested individually.

Pitch and Rhythm Discrimination. Each participant completed the tonal and rhythm task as part of Gordon's Primary Measures of Music Audiation (1979). The tonal task assessed their pitch discrimination skills, while the rhythm task assessed their rhythm discrimination skills. Each assessment required participants to listen to two short musical recordings (tonal during the tonal assessment, and rhythmic beats during the

rhythm task) and then to decide if the two songs sounded the same or different. Each participant completed two to three practice items verbally with the research assistant. In the event that an incorrect answer was given during the practice items, the songs were replayed and the correct answer was provided. Once the practice items had been administered, the assessment began. For each melody pairing, participants were presented with two pairs of cartoon faces. One pair showed identical faces; the other pair showed different faces. Each participant listened to the melody pairing and circled the identical cartoon pair if the two melodies were the same, or circled the different cartoon pair if the melodies were different. Each test consisted of thirty items and took approximately 10 minutes to complete.

Phonological Awareness. Participants completed Wagner, Torgesen, Rashotte and Pearson's (2013) Comprehensive Test of Phonological Processing (CTOPP-2) to assess phonological awareness via participants' ability to manipulate words by removing phonological segments from words that were presented verbally to form other words. The research assistant sat next to the participant and read the instructions for each item. This test was comprised of twenty items and each item was attempted until the participant produces three consecutive incorrect responses. For example: say 'baseball'. Now say 'baseball' without saying 'base'… 'Ball'.

Prosodic Awareness. Due to the lack of standardized prosodic awareness assessments, a Stress Assignment assessment was created that was similar to prosodic awareness measures used in previous research studies. A word was presented verbally and participants were instructed to listen for and identify the main beat in the word. For each item, participants viewed a set of open squares that corresponded to the number of

syllables in the word. For example, the word "history" had three open squares. Participants then used a marker to darken the square that corresponded with the main beat, or primary stress, in the word. Each item was repeated twice, and each participant completed 6 practice items with the research assistant. In the event that an incorrect answer was given during the practice phase, the word was repeated and the correct answer was provided. This assessment consisted of twenty items and was not timed.

Reading Achievement and Fluency. Each participant then completed two subtests of the Torgesen, Wagner and Rashotte's (2012) Test of Word Reading Efficiency (TOWRE-2) assessment. The first subtest evaluated their sight word efficiency. During this assessment, participants read as many words as possible in forty-five seconds. The second subtest evaluated their phonemic decoding efficiency, and they read as many non-words as possible in forty-five seconds. During this assessment, participants were timed while reading lists of non-words on a card presented to them. At the beginning of each assessment, participants were presented with a short list of practice items and asked to read the list as fast as they could. At any time, they could skip any items that they did not know. Once the practice list had been completed, they were presented with a longer list of words and given the same instructions. Participants were also asked to stop after forty-five seconds, and any words read after that point were not counted towards their score.

CHAPTER 3

RESULTS

Descriptive Statistics

Each of the 39 participants completed all portions of the experiment. All participants were judged to fall within the standard range based on their performance on the pitch discrimination, rhythm discrimination, phonological awareness, prosodic awareness, word reading and non-word reading tasks. Each variable was also analyzed and found to be free of floor and ceiling effects.

Measures of Reading

Two measures of reading skill were used in this study: sight word efficiency and phonemic decoding efficiency. As anticipated, the scores from the word reading and non-word reading tasks are highly correlated ($r=.864$, $p<.01$), and thus were converted into standardized z-scores and averaged into a composite measure of word reading. This word reading composite score is the dependent variable for the later analysis (Table 3.2).

Table 3.1 *Descriptive Statistics for Children's Measures to be Included in this Analysis (N= 39)*

Variable	Minimum	Maximum	M	SD
Age (in months)	85	106	97.11	6.075
Pitch Discrimination	22	39	32.69	3.981
Rhythm Discrimination	22	39	30.10	4.678
PA RS	13	32	24.56	5.798
PA SS	6	15	10.58	2.585
Prosody	5	16	11.26	3.447
Word Reading RS	30	84	60.46	12.814
Word Reading SS	79	134	107.87	13.362
Non-Word Reading RS	5	50	29.87	11.970
Non-Word Reading SS	70	129	104.39	13.922

Correlations

To determine which individual measures were most relevant to the current analyses and should be included throughout each tier of analysis, correlations between the dependent variable (reading) and the independent variables (music and reading-related skills) were conducted. Intercorrelations among all variables are presented in Table 3.1. The relationship among music and reading was examined via the correlation coefficients of rhythm discrimination, pitch discrimination, phonological awareness, prosody and reading. In this analysis, phonological awareness, rhythm discrimination, and prosody are each significantly correlated with reading. In addition to reading and

pitch, our data indicates that there is a relationship between phonological awareness and rhythm as well. Interestingly, rhythm correlates significantly with every other variable represented in our correlation analyses, excluding prosody. Phonological awareness, one of our most proximal measures of reading, also correlates with prosody, and prosody in turn is noted to correlate significantly with each variable, excluding both pitch and rhythm. Pitch discrimination was the only variable that did not reveal a significant relationship with reading, phonological awareness, or prosody. While our findings do indicate that there is a significant relationship between pitch discrimination skills and rhythm discrimination skills, these findings deny a direct relationship between pitch discrimination skills and reading and other reading-related skills. Because a relationship between pitch and other variables was not found, pitch was excluded from all further analyses.

Table 3.2 *Intercorrelations Among Rhythm Discrimination, Pitch Discrimination, Phonological Awareness, Prosody, and Reading (N=39)*

	1	2	3	4	5	6	7
1. Rhythm	-	.690**	.412**	.253	.351*	.542**	.462**
2. Pitch		-	.231	.234	.182	.239	.218
3. PA			-	.370*	.655**	.657**	.679**
4. Prosody				-	.417**	.341*	.393*
5. WR					-	.864**	.965**
6. NWR						-	.965**
7. RC							-

*p<.05
**p<.01

Question 1: What is the relationship between music and reading?

The purpose of this study was to explore the relationship between music and reading by analyzing how pitch and rhythm relate to reading and the reading-related skills of phonological awareness and prosody. Correlations between the dependent variable (reading) and individual independent variable measures were analyzed to determine which individual measures were relevant to the analysis. Because pitch discrimination was not found to correlate with reading or the reading-related skills of phonological and prosodic awareness, it was excluded from further analysis regarding this research question. Thus, prosodic awareness, phonological awareness and reading did not appear to improve the prediction of pitch discrimination skills. However, rhythm was correlated with all variables except for with the prosodic awareness measure, which only correlated with phonological awareness and reading measures. Therefore, only rhythm discrimination, prosody and phonological awareness variables were entered into the regression as previously determined.

In order to determine the specific contributions to reading accounted for through each variable, simple regression analyses were conducted with reading as the dependent variable (Table 3.3). The first analyses considered rhythm discrimination, and indicated that rhythm accounted for 21.4% of the variance in reading noted in our study. When prosody was added during the second step, our analysis indicated that prosody accounted for an additional 8.1% of the variance, and that rhythm and prosody combine to account for 29.5% of the variance in reading. The third step of the linear regression analysis included the addition of phonological awareness, which made the largest percentage contribution and accounted for another 22.3% of the variance. Thus, rhythm, prosody and

phonological awareness combine to explain 51.8% of the total variance in reading noted in this study.

These analyses indicate that rhythm, prosody and phonological awareness skills significantly predict reading performance, prosody accounts for additional variance over and above rhythm, phonological awareness accounts for all of the variance once it is considered, and that pitch does not contribute any variance to reading. The preliminary analyses for our first research question also indicated that while rhythm discrimination skills were a good predictor of pitch discrimination skills, neither prosody nor phonological awareness are good predictors of pitch discrimination skills.

Table 3.3 *Linear Regression Analyses of Individual Contributions to Reading Made by Pitch Discrimination, Rhythm Discrimination, Prosody and Phonological Awareness (N=39)*

		R	R^2	R^2 Change	F Change	df1	df2	Sig. F Change
1.	Rhythm	.462	.214	.214	10.065	1	37	.003
2.	Prosody	.543	.295	.081	4.145	1	36	.049
3.	PA	.720	.518	.223	16.222	1	35	.000

Question 2: Does prosodic awareness explain variance in reading outcomes beyond what is already accounted for by music skills and phonological awareness?

To determine which individual variables were relevant to this analysis and should be included, correlations were conducted between reading and the individual independent variables. Because rhythm, phonological awareness and prosody were significantly correlated with reading, these variables were included as relevant predictors of variance. To determine the strength of the contributions of each independent variable as they relate

to reading, hierarchical linear regression analyses were conducted with reading as the dependent variable. Rhythm discrimination was entered on step 1 of the analyses and accounted for 21.4% of the variance (Table 3.3). Beta values reveal that rhythm was a significant predictor of reading when considered independent of other reading-related skills. When prosody was entered on step 2 of the analysis, it accounted for an additional 8.1% of the variance in reading above and beyond that attributed to rhythm, and both rhythm and prosody remained significant predictors of reading. Lastly, phonological awareness was entered on step 3 of the analysis, and it contributed an additional 22.3% variance above and beyond that attributed to rhythm and to prosody. After all variables had been entered on the final step of the regression, our results indicated that phonological awareness was the only remaining significant predictor of reading in children.

The results of all previous analysis indicate that pitch does not appear to predict prosody, phonological awareness or reading. The results of this analysis indicate that together, rhythm, prosody and phonological awareness significantly predict reading, and that prosody accounts for variance above and beyond what is accounted for by rhythm. Lastly, these results indicate that phonological awareness accounts for additional variance in reading over and above all other variables in the regression when added as the last step. This suggests that children who display increased prosodic awareness tend to have increased reading performance, and that this increase extends above and beyond that attributable to rhythm discrimination skills. Further, children with increased phonological awareness skills will tend to exhibit increased reading performance above and beyond that attributable to rhythm discrimination skills and prosodic awareness skills.

Table 3.4 *Hierarchical Linear Regression Analysis for Variables Predicting Reading (N=39)*

		β	Std. Error	Std. β	*t*	*p*
1.	Rhythm	.191	.060	.462	3.173	.003
2.	Rhythm	.160	.060	.388	2.682	.011
	Prosody	.165	.081	.294	2.036	.049
3.	Rhythm	.084	.054	.203	1.565	.127
	Prosody	.078	.071	.140	1.099	.279
	PA	.181	.045	.544	4.028	.000

CHAPTER 4

DISCUSSION

Summary of Results

The primary purpose of this study was to investigate the relationship between music and reading and the role of pitch and rhythm discrimination skills as predictors of individual differences in reading. In the current study, reading was assessed using sight word efficiency and phonemic decoding. Due to the high correlation between these two aspects of reading, performance on these measures was calculated into composite reading scores. Regarding our first hypothesis, our findings indicate that it is rhythm and not pitch that correlates with both phonological awareness and reading. While pitch discrimination skills are correlated with rhythm discrimination skills, pitch is not correlated with phonological awareness or reading. Interestingly, neither pitch nor rhythm correlates with prosody. These results were contrary to our initial hypothesis, suggesting that both pitch and rhythm would be correlated with reading, and that they would correlate with the reading-related skills explored in this study, which included prosody. In agreement with our second hypothesis, prosody did explain unique variance to reading over and above that attributed to rhythm.

General Discussion

As previously indicated, the exact role of music in reading has been unclear. The primary objective of the present study was to examine the relationship between music skills, reading, and reading-related skills, and to determine whether pitch and rhythm are significantly correlated with reading and reading-related skills. We hypothesized that both pitch and rhythm would correlate with phonological awareness, prosody and reading, and that both pitch and rhythm skills would be significant predictors of reading. However, consistent with Douglas & Willats (1994) and David et al. (2007), our intercorrelational analyses revealed that it is rhythm and not pitch that is significantly related to reading in children, and that rhythm also correlates with pitch, reading and phonological awareness. These findings were interesting and confirmed previous research, providing the opportunity for further analyses of variance in reading considering the contributions of each reading-related skill studied.

While pitch was noted to correlate with rhythm, it did not significantly correlate with any other dependent or independent variables in our correlational analysis and thus was not included in any further analysis. These findings suggests that pitch is not correlated with phonological awareness, prosody or reading, and thus is not a significant predictor of reading. There are a variety of reasons why we did not find pitch to be related to reading, and one notable difference between out study and other studies that did find a link between pitch and word reading is the age of our participants. In comparison to those previous studies (e.g., Anvari et al., 2002; Tsang & Conrad, 2011), our participants were older and within a more restricted age range, which enabled us to use more robust measures of word reading (i.e. word and non-word reading fluency tasks) as

opposed to relying upon measures of earlier developing preliteracy skills (i.e. letter identification tasks) as a measure of reading skills. Further research may be needed to monitor how the skills measured in this study change over the course of child development, and it is possible that there may be a stronger correlation between pitch and early or struggling readers.

Because the second objective of the current study was to clarify the contributions of prosody to reading, linear regression analyses was completed to determine precisely how much of the variance in reading could be attributed to each of the related skills (rhythm, prosody and phonological awareness). Based on previous research (David et al., 2007), we predicted that prosody would make unique contributions to reading. Our results indicated that pitch and rhythm together accounted for a portion of the variance in reading, and that when prosody was entered into the analysis, it contributed unique variance in reading that over and above that previously accounted for by pitch and rhythm. Once phonological awareness was entered into the analysis, however, it accounted for all variance in reading. These analyses indicate that rhythm, prosody and phonological awareness each contribute to reading to some extent, and it also indicates that rhythm and prosody make contributions to reading that are difficult to perceive given the significant contributions of phonological awareness to reading, due to shared variance among them.

The results of this analysis indicate that phonological awareness, as the most proximal reading-related skill included in this study, dominates measures of variance when incorporated before the less proximal measures of reading-related skills of rhythm and prosody. When controlling for variance attributed to phonological awareness, rhythm

is noted to make significant contributions to the variance in reading. Further, once prosody is incorporated, it accounts for variance beyond what is accounted for by rhythm, which indicates that prosody makes unique contributions to reading.

The current study has made several noteworthy contributions to the existing research literature on the relationship between music and reading. First, improving upon previous studies, we chose participants that were at an appropriate age range to engage in valid measures of reading, which ensured that we would were able to measure literacy skills and not be limited to preliteracy skills. Building upon previous research that examined the relationship between music and reading, the current study is the first study to our knowledge that incorporates pitch, rhythm, prosody, phonological awareness and reading in the same study, and to investigate the relationships between each variable as well as how they, in conjunction, make individual contributions to reading.

Limitations and Future Directions

As previously asserted, we typically think of prosody as the melodic element of language that encompasses both pitch and rhythm, and some researchers have considered rhythm to have a role in the organization of linguistic subsystems, which are enhanced and informed by prosody (Whalley & Hansen, 2006; Huss et al. 2011). Interestingly, in the current study, neither pitch nor rhythm correlated with prosody. However, Gordon et al., (2015) found that due to the underlying hierarchal and rule-based nature of rhythm and grammar, each process benefits from prosodic cues. It is possible that the correlation between rhythm and prosody may not have been evident in the current study due to our limited measures of reading. Our measures of reading consisted of speeded sight word

reading and decoding, which are insensitive measures of higher-level reading tasks, which include syntactic elements. To address this, future research should consider incorporating additional measures of reading.

Our study was also limited by the lack of pitch and rhythm production tasks like those used by David et al. (2007). The incorporation of musical production tasks in future research would provide a foundation upon which to make more direct result comparisons, and it would also provide additional insight into the relationship between music and reading as an expressive as opposed to receptive task. Additionally, our study was also limited by the length of time it took to complete each evaluation, which prevented us from incorporating additional measures of language, reading and music production. Finally, future research would benefit from a larger sample size divided into discrete age groups. This approach would provide additional insight into the relationship between music and reading and reading-related skills throughout development, and there may be differences in the significance of relationships between variables throughout literacy development.

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