A Rhythmic Musical Intervention

for Poor Readers: A Comparison of

Efficacy with a Letter-Based

Intervention

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This dissertation is submitted for the degree of Master of Philosophy.
Preface

This dissertation is the result of my own work and includes nothing which is
the outcome of work done in collaboration except where specifically indicated in
the text. This dissertation is 14,475 words long and hence does not exceed the
word limit laid out by the degree committee.
Abstract

There is growing evidence that children with reading difficulties show impaired auditory rhythm perception and impairments in musical beat perception tasks. Rhythmic musical interventions with poorer readers may thus improve rhythmic entrainment and consequently improve reading and phonological skills. Though musical interventions have been shown to improve reading skills, no studies, to my knowledge, have directly compared the effects of a musical program to the effects of a program which teaches grapheme-phoneme correspondences. Here I compare the effects of a musical intervention for poor readers with a software intervention of known efficacy based on rhyme training and grapheme-phoneme learning. The research question was whether the musical intervention would produce gains of comparable effect sizes to the grapheme-phoneme intervention for children who were falling behind in reading development. Broadly, the two interventions had similar benefits for phonology and literacy measures with large effect sizes. These findings support the predictions made by the temporal sampling theory.

Introduction

Even with explicit instruction, 5-17.5% of schoolchildren do not become fluent readers (Shaywitz, 1998). Remediations which combine phonological awareness training with phoneme-grapheme learning have shown to be very effective (Castles & Coltheart, 2004; Schneider, Roth, & Ennemoser, 2000). One computer-assisted reading intervention predicated on this concept is Graphogame Rime, which teaches letter-sound correspondences at the unit of the rime (Kyle, Richardson, Lyytinen, Esrkine, & Goswami, under review). Children who played Graphogame Rime showed significant improvements in reading, spelling, decoding of non-words, and phonological skills. However, not all poor readers benefit from such interventions (Torgesen, 2000). Interventions which target the underlying cognitive and perceptual abilities which underpin poor phonology may be able to help these “treatment resisters”. This study tests whether a theory-driven musical intervention can benefit poor readers to a similar extent that Graphogame Rime, a software of known efficacy, can. The musical intervention was developed on the basis of temporal sampling theory, which proposes that an underlying neural difficulty in processing the rise time of the amplitude envelope found across the IQ spectrum is one cause of the poor phonological skills developed by children who go on to become poor readers (Goswami, 2011; Kuppen et al., 2011). Temporal sampling theory was developed to explain why many poor readers have difficulty perceiving the amplitude envelope rise time (hereafter rise time), and
why this difficulty may lead to further difficulties with rhythmic entrainment, phonological awareness, linguistic prosody, and musical skills.

The amplitude envelope of speech is the variation in the intensity of the sounds made by the different articulators and is broadly equivalent to fluctuations in the overall loudness of speech. The envelope is dominated by the low frequency fluctuations that result from the production of syllables, and thus carries speech rhythm. In fact, the amplitude envelope is the key determinant of speech intelligibility. Sentences which are stripped of envelope information are unintelligible, whereas sentences which are stripped of fine structure information remain intelligible (e.g., Drullman & Festen, 1994; Shannon, Zeng, Kamath, & Wygonski, 1995). Of all the tested acoustic variables, rise time perception is the only common acoustic predictor of reading ability in English, Spanish, and Chinese (Goswami, Wang, et al., 2011). Furthermore, in a study containing 65 children, rise time was the only tested acoustic measure which significantly explained variance in all nine of the tested phonological awareness tasks. In particular, two interval forced-choice rise time discrimination explained 22% of variance in the oddity onset task, in which children heard 3 words and had to choose the word with the different onset (Richardson, Thomson, Scott, & Goswami, 2004). Rise time discrimination difficulties do not seem specific to dyslexia, but rather are found in all struggling readers, even those with low IQs. Kuppen, Huss, Fosker, Fegan, and Goswami (2011) found that low IQ struggling readers have trouble with rise time discrimination, whereas typically developing children and low IQ good readers do not. Therefore, rise time discrimination difficulties seem characteristic of all reading difficulties.

Varying rise time changes the P-centre of an auditory stimulus. The P-centre is the moment a stimulus is perceived to have occurred and is not the same as the onset of the stimulus. For a series of auditory stimuli to be perceived as being regularly timed, the P-centres of the stimuli must be evenly spaced. Making the rise time more gradual makes the P-centre appear later, whereas making the rise time more rapid shifts the P-centre towards the onset. In contrast, the decay and duration of acoustic stimuli do not seem to have an effect on the P-centre (Scott, 1998).

Since 1) detecting P-centres are critical to hearing regularity in a series of auditory stimuli, 2) the location of the P-centre is affected by the rise time of the auditory stimulus, and 3) dyslexics struggle with rise time discrimination, one would expect that dyslexics would struggle with beat regularities as a consequence of their impaired rise time discrimination. Research done with dyslexics on beat perception has
supported this hypothesis. Dyslexics are significantly impaired at tapping along to a metronome when the frequency of the taps is 2 and 2.5 Hz (Thomson & Goswami, 2008). Dyslexics are also impaired at detecting beats created by amplitude modulations in the acoustic stream (see Goswami, 2002 for review). Additionally, dyslexic children are impaired at determining whether or not two musical meters are the same or different.

In a study of 49 dyslexics and control age children, metrical perception was found to explain 28% of variance in phonological skills (as measured by rhyme oddity), 28% of variance in spelling, and 42% of variance in reading after age and IQ were controlled for (Huss, Verney, Fosker, Mead, & Goswami, 2011). In their study of 78 typically developing fourth year students (average age 8 years old), Douglas and Willatts (1994) found that rhythm, but not pitch, may significantly correlate with both reading and spelling abilities once vocabulary is partialled out. Dellatolas, Watier, Le Normand, Lubart, and Cheviré-Muller (2009) found that there is a linear relationship between rhythmic production and learning to read. In their study, they asked French kindergarten-aged children to mimic rhythms produced by the examiner by tapping a pencil against the table. Performance on the rhythmic reproduction task could predict reading skills in 2nd grade in both poor readers and typically developing children. The association could not be explained by other predictors such as socioeconomic status, memory, visual attention, visuo-spatial skills, or processing speed. David, Wade-Woolley, Kirby, and Smithrim (2007) found that rhythmic skills at a young age can predict reading abilities four years later. In a study of 53 children, they found that rhythmic production in 1st grade predicted non-word reading in 5th grade even after phonological awareness was accounted for. Furthermore, the rhythmic production skills also predicted word and non-word reading in 2nd and 3rd grades and non-word reading in 5th grade once rapid naming was accounted for. Like rise time discrimination, poor metrical perception seems to be common to all struggling readers, not just dyslexics. Low IQ poor readers performed significantly worse than control age children in a rhythm perception task where they had to identify the sequence of tones which did not occur at regular intervals. In contrast, low IQ good readers were indistinguishable from control age children at this task (Kuppen et al., 2011). These difficulties with metrical perception continue into adulthood, even in well-compensated dyslexics who are attending university. In a study of 37 adults (half dyslexic), Meyler and Breznitz (2005) found that dyslexics were significantly slower than controls at determining whether two rhythms consisting of pure tones were
identical. The dyslexics were also less accurate when the two rhythms were different.

Just like for non-speech acoustic stimuli, the P-centres of speech stimuli are determined by rise time (Scott, 1998). Furthermore, rise times within the speech envelope typically correlate with syllable onsets. Therefore, difficulty with rise time discrimination should lead to trouble dividing words into their component syllables and sub-syllabic units (such as onsets and rimes) (Goswami, Gerson, & Astruc, 2010). Studies with dyslexics show that, unlike typically developing children, they often do not have an understanding of syllable division before they begin schooling. It is believed that this understanding of syllable structure may help typically developing children quickly learn phoneme division after schooling begins (Goswami, 2002). In contrast, dyslexics often do not learn phoneme division as quickly as their peers. Their difficulty with phoneme division is probably caused by their difficulty with syllable division, which is a direct consequence of their rise time perception impairment.

In a study of 32 Greek first graders with normal IQ (half poor readers), the normal and poor readers differed significantly in all five measures of phonological awareness that were tested (all ps < 0.01). The phonological awareness measures spanned both small and large psycholinguistic grain sizes and included syllabic segmentation, syllabic deletion, phonemic segmentation, phonemic deletion, and an oddity task. Interestingly, phonological awareness of large psycholinguistic grain sizes was a better predictor for linguistic skills than awareness of small grain sizes; the most important predictor of word reading and word spelling was syllable deletion (Porpodas, 1999). Studies by Bowey et al. (1992) and Bruck (1992) confirmed that poor readers struggle with both large and small psycholinguistic grain sizes. In Bowey et al.’s (1992) study of 48 children (16 4th graders with normal reading skill (CA), 16 4th graders with poor reading skills, and 16 2nd graders with normal reading skills (RL)), the poor readers performed worse on both the onset/rime oddity and phoneme oddity tasks than the CA and RL matched children. Bruck (1992) found that dyslexic children performed worse than control age and reading level matched children on all four phonological awareness measures tested: syllable counting, onset deletion, phoneme deletion, and phoneme counting.

There is evidence to suggest that struggling readers’ trouble with segmenting words into syllables and onset-rime units is related to imprecise phonological representations for word forms in their vocabularies. Swan and Goswami (1997) asked children to name a series of pictures to measure the quality of their underlying phonological representations for those items. Dyslexics and poor readers with low
IQs were able to segment words that they could name into syllables and onset-rime units with the same level of accuracy as typically developing readers. In contrast, the dyslexics and poor readers with low IQs seemed to struggle with phoneme division for all words, even for words for which they had well-developed phonological representations as measured by the naming task.

Many studies with older children show that poor readers do acquire large grain phonological awareness but continue to struggle with phonemic division. A study of 29 Korean 5th graders found that poor readers and typically developing readers performed equally well on a syllable oddity task. However, struggling readers with both low and high IQ performed significantly worse than typically developing readers on a phoneme oddity task (e.g. mo-ki, bo-ki, ko-ki, sa-ki; sa-ki is different because its second phoneme differs from the second phonemes of the other targets). Interestingly, the scores of the two poor readers group did not differ (63% and 64% error for the high and low IQ groups respectively), and both of these scores were significantly worse than the typically developing readers’ score (17% error) (Kim & Davis, 2004). In a Dutch study of 14 dyslexics (mean age 11 years 5 months), the dyslexics performed significantly worse than both age-matched and reading-level matched controls at an initial consonant deletion task (de Gelder & Vroomen, 1991). A study using dyslexic adults found that the adults had acquired large grain phonological awareness appropriate for their reading ability; the adults performed equally well on the syllable counting and onset deletion tasks as third grade children. However, the children outperformed the adults on the two phoneme segmentation tasks, phoneme deletion and phoneme counting (Bruck, 1992). A longitudinal study in the Netherlands using 4th graders suggested that dyslexic children do have phonemic awareness, but it is more vulnerable than that of typically-developing children. The dyslexic children were able to delete phonemes from one syllable non-words with the same level of accuracy as typically developing children. However, they were significantly worse than typically developing children when they were asked to delete phonemes from two syllable non-words (de Jong & van der Leij, 2003).

In addition to phonological awareness, metrical stress sensitivity also predicts significant variance in literacy outcomes. Wood (2006) tested 31 children on a metrical stress sensitivity task. In this task, the children had to point to the object that matched the word they heard. However, the word was always mispronounced such that metrical stress was reversed (e.g. soFA as opposed to SOfa). Performance on this task significantly predicted spelling ability after phonological awareness was accounted for. Just like rhythmic skills and phonological awareness, metrical perception is correlated
with rise time discrimination. Accented syllables tend to have sharper rise times than non-accented syllables. Rise time perception difficulties will make it difficult to distinguish between accented and non-accented syllables. There is ample evidence to suggest that dyslexics struggle with metrical stress perception and production.

In a study where children at risk for dyslexia were asked to copy a syllabic stress pattern (e.g. MAma or maMA), the difference between the stressed and unstressed syllable was smaller in dyslexics as compared to controls (de Bree, Wijnen, & Zonneveld, 2006). Dyslexics continue to show deficits with syllabic stress till adulthood; dyslexic adults were significantly impaired at judging whether or not two different words had the same stress pattern (e.g. MIlitary and SEcondary have the same pattern) (Leong, Hämäläinen, Soltész, & Goswami, 2011).

Linguistic prosody is highly correlated with metrical stress perception. And, just like metrical stress perception, dyslexics struggle with linguistic prosody as a downstream consequence of their impaired rise time discrimination. Different consonants have different rise times, and accurate perception of rise time is needed to determine the p-centre of words which begin with different consonants. For example, “w” has a much slower rise time than “b”, so words beginning with “w” will have a later p-centre than words beginning with a “b”. If the words wear-bear-wear-bear were repeated in a sequence such that their onsets occurred at regular intervals, the speech would be perceived as having an irregular rhythm. In contrast, if their p-centres occurred at regular intervals, the words would sound rhythmic. Hence, to be able to hear the prosody of speech, one must be able to detect the p-centres of syllables. And, to detect the p-centres of syllables, one must be able to distinguish between different rise times. Since dyslexics struggle with rise time discrimination, it naturally follows that they must also struggle with linguistic prosody.

Dyslexics are significantly impaired at the Dee-Dee task, which tests their understanding of prosodic structure (Nakatani & Schaffer, 1978). In this task, participants are shown a picture. A voice then “says” the name of the picture, except all of the syllables are replaced with the sound “dee”. For example, “Harry Potter” would be “DEEdeeDEEdee”. Participants hear two answer choices, and have to choose the one with the correct prosody.

Not only are dyslexics impaired at basic auditory and linguistic tasks, but also at tasks which measure their musical competence. Dyslexics had lower performance on both a same/different rhythm task and a same/different melody task than a group of typically developing children matched for gender, age, and non-verbal IQ. Performance
on both of these same/different judgment tasks predicted phonemic awareness in dyslexics (Forrgeard et al., 2008). Anvari, Trainor, Woodside, and Levy (2002) found that both pitch and rhythm discrimination skills explain significant variance in phonological awareness in 5 year olds. Pitch processing, though not rhythm processing, was significantly correlated with reading. Strait, Hornickel, and Kraus (2011) found that performance on rhythmic and tonal same different tasks accounted for significant variance in reading skills in 29 good and poor readers between ages 8 and 18 years. Reading was assessed with both speeded word and non- word reading (Test of Word Reading Efficiency) and silent reading (Test of Silent Reading Fluency). In contrast to the findings by Anvari et al. (2002), these effects were primarily driven by the rhythmic task.

Dyslexics’ difficulties with melodies and rhythms may stem from their core deficit with rise time discrimination. Different musical instruments have different rise times (e.g. the same note produced by moving a bow slowly across a violin string has a slower rise time than if it was produced by a trumpet). In music, rise time is known as “attack time” and musicians must coordinate their attack times to play together (Gordon, 1986).

These difficulties found in dyslexics with processing the amplitude envelope, entraining to rhythms, and perceiving music are likely due to neural abnormalities. For example, poor readers have less sub-cortical enhancement for repeated syllables. The extent of subcortical enhancement is correlated with both musical aptitude and literacy skills. It is believed that good readers use subcortical enhancement to increase the precision of the neural response to oft-heard stimuli. This top-down control is believed to be strengthened through musical training (Strait et al., 2011).

Dyslexics also show less right-lateralization when processing the syllable rate of compressed speech and sinusoidal white noise with a rate of 2 Hz (Abrams, Nicol, Zecker, & Kraus, 2009; Hämäläinen, Rupp, Soltész, Szücs, & Goswami, 2012). 2 Hz is the approximate rate of stressed syllables in natural speech (Goswami, 2011), suggesting that this difficulty with phase-locking to a 2 Hz rate may make stressed syllables less salient to infants who have rise time perception difficulties. Infants rely on patterns of stressed and unstressed syllables to segment continuous speech into meaningful units. For example, infants are more likely to map a novel iambic word onto an action and a novel trochaic word onto an object, since most disyllabic English verbs are iambic, whereas disyllabic nouns tend to be trochaic (Curtin, Campbell, & Hufnagle, 2012). Since speech segmentation is critical in infancy, difficulty with
segmentation arising from rise time difficulties may lead to poorer phonological representations. Weaker phonological representations will make it difficult to identify common phonological elements across words in the lexicon, which is crucial for phonological awareness tasks (Hämäläinen et al., 2012).

Furthermore, since dyslexics have trouble extracting information from the amplitude envelope, they may over-rely on different auditory cues, such as spectral cues. This hypothesis has been supported using both behavioural and neural measures. For example, though dyslexics are significantly impaired at distinguishing between two syllables (ba-wa) when using amplitude onset cues, they are better than typically developing readers when using spectral cues (Goswami, Fosker, Huss, Mead, & Szucs, 2011). Magnetoencephalography experiments have shown that dyslexics show more entrainment to modulations in the 50-70 Hz range than controls do (Lehongre, Ramus, Villiermet, Schwartz, & Giraud, 2011), which is the approximate frequency range of these fast spectral cues (Goswami, Fosker, et al., 2011). This over-reliance on spectral cues may explain why dyslexics are more sensitive to allophonic variation, or acoustically different versions of the same phoneme (Bogliotti & Serniclaes, 2008; Goswami, Fosker, et al., 2011).

Musical experience is capable of altering the neural circuits that process auditory stimuli. Professional musicians show enhanced activity in the planum temporale as compared to other adults when categorizing the phonemes /ka/ and /da/. The professional musicians are also more accurate in the reduced-spectrum condition, suggesting that musical experience can enhance one’s ability to process speech (Elmer, Meyer, & Jäncke, 2012).

Since one of the root causes of dyslexia is a lack of phonological awareness, one possible intervention would be to train children specifically in this ability. Silva and Capellini (2011) trained dyslexic children using tasks which included syllable division, rhyme awareness, and phoneme manipulation. The children showed significant gains in both reading and phonological awareness. Schneider, Roth, and Ennemoser (2000) trained German kindergarten children at-risk for dyslexia in both phonological awareness and letter-sound knowledge and compared them to a group of unseen typically-developing children. By second grade, there were no significant differences between the two groups in terms of decoding ability or spelling.

Rather than directly training phonological awareness, another possible approach would be to train children in music, with hopes that those skills will translate to phonological awareness. Since rise time perception is believed to be the root cause of
dyslexics’ trouble with both phonological awareness and rhythmic/musical skills, it might be possible to train rise time discrimination via a rhythmic musical intervention and the improved rise time discrimination may then translate to better phonological awareness. Essentially, music and language may share a sound category learning mechanism (Degé & Schwarzer, 2011), which could be trained using musical interventions. Certain brain regions are recruited during both music and language processing (Koelsch, 2006; Patel, 2003) and these neural structures can be altered with musical training (Elmer et al., 2012; Norton et al., 2005; Strait et al., 2011).

Past intervention studies have suggested that musical training can positively impact reading and spelling abilities. Degé and Schwarzer (2011) developed a musical training program based on the “shared sound category learning mechanism hypothesis”, which hypothesizes that language and music share the same sound category learning mechanism, and hence phonological skills can be trained through musical activities. They found that German preschoolers (4- to 5-year olds) who received musical training which included joint singing and drumming, dancing, rhythmic exercises, basic notation skills, and interval training showed improvement in phonological awareness at the large psycholinguistic grain sizes of the syllable and rime that was equivalent to improvements made by a group of children who received direct training on phonological awareness. Both groups showed significantly more improvement than a control group who received a sports intervention. Since phonological awareness and reading ability are significantly correlated (Ziegler & Goswami, 2005), one would expect that these heightened phonological skills would transfer to reading.

Overy (2003) found that boys, eight to nine years of age, showed significant improvement in both phonological skills and spelling, though not reading, after receiving musical training focused on rhythm. Overy listed several theories of why musical training may impact reading, but did not espouse any particular theory. The theories listed include the “rapid temporal processing hypothesis”, which proposes that dyslexics have trouble perceiving rapidly presented sounds such as the formants in speech, the “magnocellular deficit hypothesis” which proposes that dyslexics struggle with the visual aspects of reading, the “double deficit hypothesis” which claims that rapid naming problems compound dyslexics’ phonological problems, and the “cerebellar hypothesis” which posits that, in addition to reading impairments, dyslexics also have motor deficits. Overy (2003) also acknowledged Goswami’s (2002) theory that dyslexics have a “deficit in the perceptual experience of rhythmic
developing phonological awareness has recently been questioned, as people with
time does not improve perception. Goswami (2003) lists several reasons why the “magnocellular
deficit hypothesis” is incorrect. One of the most compelling reasons was that children
with Williams Syndrome and Autism also have dorsal stream deficits. However, children with Williams Syndrome develop normal decoding skills for their
IQs and children with Autism often have very strong decoding skills. Vaessen,
Gerretsen, and Blombert (2009) did a study testing the double deficit hypothesis. They
found that naming speed is probably just a measure of phonological processing speed,
and is not completely dissociable from phonological awareness. They did not find a
significant portion of the population who only had difficulties with naming speed.
Finally, naming speed did not make any unique contributions to reading accuracy or
spelling. White et al. (2006) found that only a subset of dyslexics has motor
difficulties and there are dyslexics who have a phonological impairment in the
absence of a motor impairment. Therefore, they concluded that the “cerebellar
hypothesis” was incorrect; motor deficits were not central to dyslexia. Along the same
lines, Thompson and Goswami (2008) found that though dyslexics were significantly
impaired at tapping to a metronome, they were not impaired at the pegboard task
which solely tested their manual dexterity.

Another study (Moreno et al., 2009) done with children of the same age found
that children who received 6 months of musical training which taught rhythm,
melody, harmony, and timbre showed significant increases in their reading abilities as
compared to a group who received training in painting. However, the theoretical
framework upon which the study was designed was completely different than that of
the Overy study or the present study. Moreno et al. believed that musical training
improves pitch perception, both in music and in speech. This improved pitch
perception in speech has positive effects on literacy. Similarly, Rauscher and
Hinton's (2011) study with five-year olds was also based on the idea that the pitch is
the link between musical and linguistic skills. The study found that children who
received violin instruction improved in phonological awareness as compared to
children who received swimming classes or no extra-curricular lessons. However, as
playing a violin requires both pitch and rhythm, it is unclear which of these musical
skills is more strongly correlated with phonological awareness. The role of pitch in
developing phonological awareness has recently been questioned, as people with
amusia often have intact phonological skills (Goswami, 2011). The present study solely focuses on rhythm and does not include any tonal components. Hence, it will allow us to examine whether or not musical training impacts literacy through its effects on pitch perception.

Musical training has also been shown to help with exception word reading through its effect on memory. Moreno, Friesen, and Bialystok (2011) found that children with music training, as compared to art training, were better at mapping familiar words onto unfamiliar symbols. This process is very similar to memorizing exception words, because those words cannot be decoded using phonological processes and must be memorized. Similarly, Moreno et al. (2009) found that children who received music training, as opposed to art training, were significantly better at reading exception words, though no group differences were seen for regular words.

Though studies have shown that musical training can lead to improvement in phonological awareness, spelling, and reading, as far as I know, no single study has directly compared the effects of musical training and teaching letter sound correspondences. Hence, this study sought to directly compare the benefits of a musical intervention and an intervention which taught letter-sound correspondences via a computer game. The computer game that I used to teach letter-sound correspondences is Graphogame Rime. Its precursor, Graphogame, which teaches letter-sound correspondences at the level of the phoneme (small grain size), was originally developed for the transparent Finnish language. Children showed larger literary gains after playing this game than after a teacher taught them the same information (Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2010). The English version of this game, Graphogame Rime, teaches words both in terms of onset-rime and in terms of their individual phonemes (large and small grain sizes). This approach was used because English, unlike Finnish, has an inconsistent orthography and is most consistent at the level of the rime. This version of the game was shown to be more effective for English-speaking children than a version which taught purely phoneme-grapheme correspondences (Kyle et al., under review).

I predicted that Graphogame Rime would improve children’s phonological skills at both large (rime) and small (phoneme) grain sizes. I expected that the game would improve rhyme awareness since the children were explicitly taught words in rime families. The game even included some levels in which the children had to choose the word that rhymed with the word they heard, further enforcing their rhyming skills.
Additionally, I expected that the children would improve at phoneme deletion, a task which required an understanding at the level of the phoneme. I expected that the additional exposure to words and the reinforcement of phoneme-grapheme correspondences would improve the children’s word and non-word reading and their spelling. However, I did not expect this intervention to assist with rise time discrimination or working memory.

The novel musical intervention was theoretically motivated by the temporal sampling theory. It focused on rhythm, but in addition incorporated the theoretically related factors of syllable stress and rise time discrimination (Goswami, 2011). Rhythmic tasks included clapping and marching along to music, tapping to a metronome, distinguishing between various speeds on a metronome, and reproducing a short rhythmic sequence. Games which taught syllable stress included the Dee-Dee game (see above for description). Children also had to identify words and poems read with the correct syllabic stress pattern. Finally, children had to chant along with music that played a different note on each syllable.

I expected that the musical intervention would aid only large psycholinguistic grain sizes; improvement would be seen for rhyme awareness but not for phoneme deletion. Rhythmic perception is linked to the ability to divide words into onsets and rimes, which is crucial for rhyme awareness. Awareness of phonemes develops as children learn phoneme-grapheme correspondences. Since phoneme-grapheme correspondences were not being taught in the musical intervention, I did not expect children to develop phonemic awareness. I did expect to see improvements in reading and spelling, since an understanding of speech rhythm is correlated with both of these measures. Furthermore, since musical training has been shown to have a positive effect on memory, I expected the children to improve in both their short term memories and their exception word recognition. Since some of the words in the reading test were exception words (e.g. “to”), I expected the musical training to help children remember these words after they were exposed to them in class. I also expected the children to improve at rise time discrimination since they were trained explicitly in this auditory task.

Another phonological task was rapid naming, in which children have to name pictures as quickly as possible. This task measures a participant’s ease of access to a phonological entry. I did not expect the music group to show benefits in the rapid naming task, since the intervention was not designed to train this skill. The predictions for Graphogame are a bit more complex. Lovett, Steinbeck, and Fritjers (2000) trained
students to identify words both using grapheme-phoneme correspondences and by dividing words into onsets and rimes. This strategy was similar to Graphogame, except a teacher rather than a computer delivered the intervention. There were no intervention results on rapid naming speed. However, since Graphogame, unlike a teacher, presents stimuli at an accelerating rate on the screen, there may be gains seen in rapid naming (Saine et al., 2010).

A mathematics task was also given at both pre- and post-test to see if any improvements after training were specific to reading or generalized to other cognitive abilities. I did not expect the Graphogame group to improve in mathematics. The musical intervention was not specifically designed to train mathematical abilities. However, a metaanalysis of six music training studies which worked with preschool and elementary school children concluded that musical training does improve mathematical abilities (Vaughn, 2000). Therefore, gains in mathematical abilities may be seen.

Though I expected both interventions to train slightly different skill sets, broadly speaking I expected both interventions to train phonological awareness, reading, and spelling. My main theoretical question was: Can a theoretically-driven musical training program produce similar effect sizes for literacy and phonology outcome measures as Graphogame Rime, a computer program which has been shown to positively impact these outcomes for this age group?

Children were referred by their schools to the study if they were showing a failure to progress in reading at the expected level for their peer group, and were in Year 2 (6 – 7 years old). As will be seen, the children nominated had relatively low language skills and relatively low cognitive ability. One difference between the present study and most dyslexic studies is that I included participants with low IQs. However, I feel that excluding participants based on IQ is unnecessary. According to the temporal sampling theory, neural entrainment difficulties are found in all poor readers, irrespective of IQ. Stanovich (1996) listed four reasons why there should be no theoretical differences between low and high IQ struggling readers in terms of the root cause of their difficulties. Firstly, many struggling readers, not just those with high IQs, have similar difficulties with language segmentation which leads to poor phonological awareness. Furthermore, reading-IQ discrepancy does not constitute a unique phenotypic pattern of word recognition. Additionally, heritability of reading difficulties does not differ significantly between people of low and high IQ. Finally, there is no evidence suggesting that the neuroanatomical abnormalities found in traditionally-defined dyslexics are not present in low-IQ struggling readers.
Studies with both low and high IQ struggling readers have supported Stanovich’s claims. Poor readers with low IQs have similar trouble with rise time discrimination, rhythmic perception (Kuppen et al., 2011), and phonological awareness (Kim & Davis, 2004; Swan & Goswami, 1997) as dyslexics. Domain- general skills (e.g. IQ) do not explain significant variance in single-word reading but domain-specific skills (e.g. phonological awareness) explain approximately 33% of variance (Shatil & Share, 2003). Since all struggling readers have similar deficits, we felt that all struggling readers may benefit from these interventions.

Methods

Participants

19 Year 2 children participated in the study. All of them attended one of four schools in Cambridgeshire and were identified by their class teachers as struggling readers. Written, informed consent was obtained from the parents/legal guardians of all of the participants. The study was approved by the Cambridge Psychology Research Ethics Committee. 10 children participated in the musical intervention (mean age = 6.9, SD = 0.3, 6 male) and 9 children in the Graphogame intervention (mean age = 6.7, SD = 0.4, 5 male). The children from each school were divided evenly between the two intervention groups. The groups were chosen to minimize group differences on the pre-test. There were no group differences on the basis of pre-test performance, described below (all ps > 0.1). Further participant information can be found in Table 1.

Pre-tests Only

Expressive Vocabulary

Children’s expressive vocabulary was assessed with the Vocabulary subtest of the Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1991). This subtest required the children to give oral definitions for words which increased in difficulty. The raw score is converted to a standard score with a mean of 10 and a standard deviation of 3.

Non-verbal Ability

Non-verbal ability was assessed using the Block Design of the WISC-III (Wechsler, 1991). Children were asked to copy small geometric designs using two, four, or nine plastic cubes. The designs gradually increased in complexity. The raw score is converted to a standard score with a mean of 10 and a standard deviation of 3.

Receptive Vocabulary
Table 1: Baseline Measures by Intervention Group

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<th>Music Group</th>
<th>Graphogame Group</th>
<th>t-statistic (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>10</td>
<td>9</td>
<td>--</td>
</tr>
<tr>
<td>Age (years)</td>
<td>6.89 (0.28)</td>
<td>6.74 (0.36)</td>
<td>1.02 (0.32)</td>
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<tr>
<td>Expressive Vocabulary</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(standard score)</td>
<td>7.30 (4.00)</td>
<td>6.11 (3.10)</td>
<td>0.72 (0.48)</td>
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<tr>
<td>Non-verbal Ability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(standard score)</td>
<td>8.20 (4.05)</td>
<td>8.33 (4.03)</td>
<td>0.07 (0.94)</td>
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<tr>
<td>Receptive Vocabulary</td>
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<td></td>
</tr>
<tr>
<td>(standard score)</td>
<td>103.20 (16.70)</td>
<td>99.78 (7.46)</td>
<td>0.56 (0.58)</td>
</tr>
<tr>
<td>Intensity Discrimination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(dB)</td>
<td>9.74 (5.91)</td>
<td>5.89 (5.23)</td>
<td>1.49 (0.15)</td>
</tr>
<tr>
<td>Duration Discrimination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ms)</td>
<td>160.26 (23.67)</td>
<td>131.97 (51.05)</td>
<td>1.57 (0.13)</td>
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<tr>
<td>Frequency Discrimination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(semitones)</td>
<td>1.55 (0.52)</td>
<td>1.37 (0.47)</td>
<td>0.76 (0.46)</td>
</tr>
<tr>
<td>Rise Time Discrimination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ms)</td>
<td>208.29 (71.47)</td>
<td>180.74 (87.39)</td>
<td>0.75 (0.46)</td>
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<tr>
<td>Word Reading</td>
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<tr>
<td>(standard score)</td>
<td>95.50 (7.50)</td>
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<td>Non-word Reading</td>
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<td></td>
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<tr>
<td>(standard score)</td>
<td>97.70 (7.93)</td>
<td>99.22 (10.96)</td>
<td>0.34 (0.73)</td>
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<tr>
<td>Spelling</td>
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<td></td>
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<tr>
<td>(standard score)</td>
<td>98.70 (9.97)</td>
<td>98.11 (13.01)</td>
<td>0.11 (0.91)</td>
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<tr>
<td>Rhyme Awareness</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(out of 20)</td>
<td>9.50 (4.86)</td>
<td>8.89 (4.37)</td>
<td>0.29 (0.78)</td>
</tr>
<tr>
<td>Phonemic Awareness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(out of 20)</td>
<td>5.30 (3.53)</td>
<td>7.11 (4.65)</td>
<td>0.96 (0.35)</td>
</tr>
<tr>
<td>Phonological Access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Errors (max = 40)</td>
<td>1.40 (1.51)</td>
<td>1.44 (1.13)</td>
<td>0.07 (0.94)</td>
</tr>
<tr>
<td>Phonological Access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed (seconds)</td>
<td>56.80 (15.19)</td>
<td>58.11 (13.27)</td>
<td>0.20 (0.84)</td>
</tr>
<tr>
<td>Memory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(out of 30)</td>
<td>10.60 (4.74)</td>
<td>12.33 (3.20)</td>
<td>0.92 (0.37)</td>
</tr>
<tr>
<td>Mathematical Ability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(standard score)</td>
<td>88.60 (10.04)</td>
<td>83.89 (15.70)</td>
<td>0.79 (0.44)</td>
</tr>
</tbody>
</table>

Data are presented as mean (standard deviation). Both intervention groups were compared in a series of two-tailed, equal variance t-tests and the resulting t-statistics and p-values are shown. The groups do not significantly differ on any of the pre-test measures (all ps > 0.10).
Receptive vocabulary was measured using the British Picture Vocabulary Scale
– II (BPVS-II, Dunn, Dunn, Whetton, & Burley, 1997). Children were asked to point
to the picture which matched the word that the experimenter read aloud. The words
increased in complexity as the task progressed. The raw score is converted to a
standard score with a mean of 100 and a standard deviation of 15.

Auditory Measures
All of the auditory measures employed the “Dinosaur game” threshold
estimation program which was originally created by Dorothy Bishop (University of
Oxford, 2001) and adapted by Martina Huss (University of Cambridge). The amended
program utilized an adaptive staircase procedure (Levitt, 1971). The game started with
a 2-up 1-down staircase which changed in a 3-up 1-down staircase after the 2
reversal. The game ended after 8 response reversals or 40 trials, whichever occurred
first. The threshold score was calculated using the mean of the last four reversals. A
lower threshold indicates better performance. Stimuli were presented binaurally
through headphones with a 500 ms inter-stimulus interval. The rise time, frequency,
and duration tasks utilized an AXB format. The children heard three cartoon characters
(each of which is a different colour: red, white, or yellow) generate a tone. Two of the
characters (one of which is always the white one) create the same tone. The third tone
is different than the other two. The children have to choose which cartoon character is
different, the red or the yellow. The intensity game only had two cartoon characters
and utilized a 2IFC format. Feedback was given on every trial. Training trials were
given before the test began.

Intensity Discrimination Task
The standard was a pure tone with duration of 200 ms and a frequency of 500 Hz.
The children had to choose the cartoon character that made the softer sound.

Duration Discrimination Task
The standard was a pure tone with a duration of 400 ms and a frequency of
500 Hz. The duration of the third tone ranged logarithmically between 400 and 600
ms. The children had to choose the tone whose duration was a different length.

Frequency Discrimination Task
The standard was a pure tone of 500 Hz and a duration of 200 ms. The
maximum pitch difference between the stimuli presented in this task was 3 semitones.
The children had to choose the tone that had the higher pitch.

Intervention Procedure and Tasks
The intervention, including pre- and post-testing, took approximately four
months. Participants were seen approximately twice a week, though this did vary slightly. Participants in the musical intervention were seen for 19 sessions and completed 4-5 tasks during each session. Depending on the participant, these sessions typically took 20-30 minutes to complete. Participants in the Graphogame intervention were seen for 19 sessions which were approximately 25 minutes long. One participant in the Graphogame group only completed 15 sessions, but given the small group sizes, I included his data. All of the children in the musical intervention group were seen one-on-one. Most of the children in the Graphogame group were seen one-on-one, however, due to time constraints, three children were, on occasion, seen in pairs. All interventions were carried out by the same experimenter, AB.

Musical Intervention

The musical intervention consisted of 12 tasks, of which children would do 4-5 in each session. For a detailed schedule of which tasks were done during which sessions, see Appendix A. The tasks can be broadly split into two categories: purely rhythmic tasks and tasks which sought to link language and rhythm. The rhythmic tasks included tapping along to metronome, deciding whether two tempos were the same or different speed, deciding whether two short rhythmic sequences were the same or different, singing a short rhythmic sequence, and completing a rise time discrimination task.

Rhythmic Entrainment: Tapping along to a Metronome

The stimuli were delivered over headphones and the children were instructed to tap the space bar at the same time as the stimulus. The stimuli were programmed using Audacity software. Presentation software was used to capture the timings of children’s taps. The Presentation scripts were written by Victoria Leong (University of Cambridge). The tempos used were 60, 80, 100, 120, and 140 bpm. Despite the tempo, the participant heard 35 taps. Therefore, faster tempos had shorter durations. Each participant heard each tempo twice, once during the first 10 sessions and again during the final 9 sessions. This allowed us to see if the children were becoming more accurate with their rhythmic entrainment. The tapping data was analysed using circular statistics.

Differentiating between Two Tempos

Stimuli were delivered using TempoPerfect Metronome Software. The children heard two beats and they had to determine whether or not they were the same speed. If the two tempos were different, the difference was much greater at the beginning of the intervention than at the end to make the task more difficult as the intervention progressed. This task was
scored based on whether or not the child responded correctly. If the child answered incorrectly, the researcher played the two beats for him/her again and encouraged him/her to either look at the metronome (where graphics displayed a ball bouncing on the beat) or clap along to the beat so that he/she could see or feel the correct answer.

Differentiating between Two Rhythmic Sequences

The children heard two short rhythmic sequences, each containing four beats and separated by four beats. There was no tonal information in the rhythmic sequences; all notes were a high G in treble clef. The children had to determine whether the two rhythmic sequences were the same or different. The rhythmic sequences were composed by the author and played using ForteFree Software. The rhythmic sequences became more complex, and the differences less salient, as the intervention progressed. This task was scored on whether or not the child answered correctly. If the child was incorrect, the researcher encouraged him/her to look at the sheet music presented on the computer while listening to the rhythmic sequences so that he/she could visually see the rhythms. The software highlights the notes on the screen as it plays through the rhythmic sequences, making the rhythmic differences more visually salient. Stimulus materials can be found in Appendix B.

Singing a Rhythmic Sequence

Participants heard a short rhythmic sequence which ranged from 4 to 8 beats long. The rhythmic sequence had no tonal information; all of the notes were the high G in treble clef. The participants were encouraged to mimic the rhythm using the syllable “la”. If required, the researcher assisted them in learning and practicing the rhythmic sequence. All of the rhythmic sequences were composed by the author and played using ForteFree software. The rhythmic sequences were designed to become more difficult as the intervention progressed. This task was scored on a scale of one to five (1= incorrect number of notes; 2= correct number of notes, wildly incorrect rhythm; 3= longer notes relatively longer, shorter notes relatively shorter but rhythm still significantly incorrect; 4= rhythm approximately correct; 5= rhythm sang perfectly). This task was recorded so that the researcher could re-play what the child had sung to score it accurately. Stimuli can be found in Appendix C.

Rise Time Discrimination Task

See pre- and post-tests (below) for a description of this task. The children did the task without the practice trials.

Tasks which linked music and language included clapping and marching to a
song, chanting and playing hand clap games, reading poetry, and playing a game which teaches syllable structure.

Clapping and Marching to a Song

The children would hear the same song in two consecutive sessions. During the first session, they would be asked to clap along to the beat. During the second, they would be asked to march along to the beat. The researcher would demonstrate if they were struggling. The songs were chosen based on three criteria. First of all, they had to have age-appropriate lyrics. Secondly, they had to be fast enough to march to. Finally, they had to have very salient rhythms, typically with a drum sounding on every beat. The tasks were scored on a scale of one to five (1= could not do the task; 2= made mistakes even while doing it with the researcher; 3= made no mistakes while doing it with the researcher but could not do it unaided; 4= made some mistakes, but was able to correct them without assistance; 5= could do the task perfectly without assistance). See Appendix D for lyrics to the selected songs.

Chanting and Playing Hand Clap Games

The children would work on the same hand clap game during two consecutive sessions. During the first session, the children would learn to chant a portion of the song. During the second session, the children would learn the hand motions that accompanied it. The chants were approximately ordered by level of difficulty. See Appendix E for stimulus materials.

The author composed pieces using ForteFree Software which mimicked the rhythm of the chant, but had no tonal information (all of the notes were the high G in treble cleft). The researcher would first chant the entire song to the child. Then, the researcher would teach the child the first couple of lines. The researcher read out loud all of the lyrics and encouraged the child to memorize them, so that the child did not have to be able to read to perform this task. The child was especially encouraged to make sure that all of his/her words lined up with the notes in the music. The child was then asked to chant the first couple of lines along with the music. This task was scored on a scale of 1-5 (1= could not do task, 2= could chant with one or more mistakes with the researcher, 3= could chant with zero mistakes with the researcher, 4= could chant with the music with one or more mistakes, 5= could chant with the music with no mistakes).

During the second session, the researcher taught the children the hand motions that accompanied the chant that they had learnt. This task was scored on a scale of 1-5 (1= could not do the task; 2= significant problems with both chanting and clapping;
3= made several mistakes with either chanting or clapping, but could do the other task with no mistakes; 4= made 1-2 mistakes; 5= performed the task perfectly).

**Poetry**

The researcher read a poem to the child and then asked the child three questions about it. The poems were chosen to be highly rhythmic and child-friendly. The first question regarded syllable stress. A recorded voice of the experimenter would say one word, which was in the poem, with both the correct and incorrect syllabic stress patterns. The child had to determine the correct way of saying the word. If the child got the answer wrong, the researcher explained the correct answer to him/her. The second question regarded the number of syllables in a word. The child was asked whether or not replacing a word in the poem with another word of similar meaning would “mess up” the rhythm of the poem. The words were chosen so that if they had the same number of syllables, then they also had the same syllabic stress pattern. Therefore, if the words had the same number of syllables the rhythm would not be messed up, and vice versa. A recorded voice of the experimenter would read a portion of the poem, first with the original word and then with its replacement. The child had to determine whether the rhythm in the second reading was “messed up”. If the child answered incorrectly, the researcher encouraged him/her to clap out the number of syllables in the two words, so that he/she could hear whether or not the words had the same number of syllables. The third question regarded the overall rhythm of the poem. A recording of the experimenter presented a portion of the poem twice, once with the correct rhythm and once with a distorted rhythm. The child had to choose the reading that “fit the poem better”. If the child got it wrong, the researcher helped him/her understand why the other option was correct. This task was scored on whether or not the child answered the questions correctly. See Appendix F for the poems and questions used within the task.

**Dee-Dee Game**

The Dee-Dee game was used to enhance the participant’s understanding of linguistic prosody. In this game, the child sees a picture of a popular fictional character or movie. The child has to name the picture so that the researcher can ascertain whether or not the child knows the reference. If the child does not know the reference, the researcher will provide the name. The computer then says the name of the picture twice, once correctly and once incorrectly. However, all phonological information is stripped, and every syllable is replaced by the sound “dee”. The child needs to listen to the syllabic stress pattern in order to decide
which answer choice is correct (see Goswami, Gerson, et al., 2010). The children played this game four times throughout the intervention. Before the children played for the first time, they looked at all of the pictures and tried to name them. If they did not know any, the researcher provided the name. This was done to minimize the number of times the researcher needed to assist the children during the game. Due to very poor performance seen in all participants during the first game, the researcher helped the children during the second and third games. During the second game, the researcher repeated the name of the picture while emphasising the prosody. During the third game, the researcher clapped the syllables for the children. The fourth game the children played unaided.

**Graphogame Intervention**

Graphogame Rime (a computer-assisted reading intervention developed in Finnish by Heikki Lyysinen and Ulla Richardson, University of Jyvaskyla and adapted for English by Fiona Kyle and Usha Goswami, University of Cambridge) taught phoneme-grapheme correspondences through the grain size of the rime. In the earlier levels, children were introduced to single letters (e.g. “a” and “t”). In the following level, they were introduced to rimes that were real words (e.g. “at”). In the next level, they were taught how onsets could be added to these rime families to make words (e.g. c + at = cat). As the game progressed, CCVC and CVCC words and families that had more complex or less familiar rimes (e.g. –irt, -udge) were introduced. The aim of this game was to teach children spelling-sound correspondences at the grain size with the highest orthographic consistency.

During the game, the children heard words recorded by a female speaker with a Southern British accent. A series of targets were then shown in balls, falling from the top of the screen. The children had to choose the target which matched the word they heard before the targets reached the bottom of the screen (see Fig. 1). The children progressed through a series of streams, each of which was sub-divided into levels. The children received a game token at the end of each level as motivation. Every few levels, the tokens could be swapped for a more exciting reading game. For example, in one fun level, a train drove across the screen and on each of its compartments a different target was printed. The children had to click on the compartments which contained the targets they heard. Some levels encouraged spelling skills, in which children had to click on the letters or rime units in the correct order to form the word that they heard. Many levels were preceded by a visual demonstration which made phoneme-grapheme correspondences more explicit.
Figure 1: One Level in Graphogame
Children would hear the word “ship” and would have to choose the falling ball containing that word before it dropped off the screen.

Each level was played three times or until the child’s accuracy was at 80%, whichever occurred first. If the child failed to get 80% accuracy on his/her first or second time playing the level, the computer automatically gave the child an individualized training level in which it selected targets that the child did know and presented them with targets the child was struggling with. Then, the previous level was presented again.

Though this game was solely computer-based, the experimenter would help the children with particularly difficult levels and give them encouragement throughout the task. If the children needed a break during the session, the experimenter would spend some time either talking to them or playing games. One participant specifically asked for a piece of paper so that he could write down the new words he was learning and the experimenter complied and assisted him with writing them down. Furthermore, though the musical intervention was instructor-mediated, all but one of the activities in the musical intervention employed a computer (see Table 2). Though the interventions varied in terms of social interaction and computer interaction, I tried to balance computer use and social interaction across the two interventions as much as possible.
Table 2: The Amount of Computer Interaction in the Various Musical Intervention Tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Computer as Instructor</th>
<th>Researcher as Instructor but Stimuli Presented by Computer</th>
<th>Researcher as Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhythmic Entrainment</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differentiating between Two Tempos</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differentiating between Two Rhythmic Sequences</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singing a Rhythmic Sequence</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rise Time Discrimination Task</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clapping to a Song</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marching to a Song</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chanting Hand Clap Games</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Playing Hand Clap Games</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Poetry</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Dee-Dee Game</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pre- and Post-Tests

Auditory Measure: Rise Time Discrimination

One auditory game utilizing the dinosaur platform was used during pre- and post-test. All of the tones had a duration of 800 ms. The standard tone had a 15 ms linear rise time envelope, 735 ms steady state, and a 50 ms linear fall time. The third tone varied the linear onset rise time logarithmically and the longest rise time was 300 ms. The children had to choose the tone that had the different rise time. The practice trials were only given during pre-test. During post-test, the task was completed twice and an average threshold was calculated.

Reading Measures

Reading was assessed using two subsets of the Test of Word Reading Efficiency, Form A (TOWRE; Torgersen, Wagner, & Rashotte, 1999): Sight Word Efficiency and Phonemic Decoding Efficiency. The tests give participants 45 seconds to read as many words or non-words, respectively, as they can. The raw score is the number of items read correctly. This is converted to a standard score which has a mean of 100 and a standard deviation of 15.

Spelling

Spelling was assessed using the spelling test from the British Ability Scale II
(BAS II, Elliott, 1997). Participants had to spell words which the experimenter orally dictated. The words got more difficult as the test progressed. The ability score is based on the number of words correctly spelled and the difficulty level at which the participant began the test. This is converted to a standard score which has a mean of 100 and a standard deviation of 15.

*Phonological Awareness*

*Rhyme Awareness*

Rhyme awareness was assessed using the rhyme oddity task. The children listened to a recorded voice through headphones saying three words or non-words, two of which rhymed. The children had to name out loud the item which did not rhyme with the other two (e.g. curl, hurl, fern). The task utilized digitized speech created from a native female speaker with a standard Southern British accent (see Goswami, Huss, Mead, Fosker, & Verney, 2012). There were 2 practice trials and 20 experimental trials. Scores out of 20 were used for analysis.

*Phonemic Awareness*

Phonemic awareness was assessed using the phoneme deletion task. The children listened to a recorded voice with a standard Southern British accent saying a non-word and were told to remove one phoneme from that non-word. Once that phoneme was removed, a real word was created. The children had to say that real word out loud (e.g. “splo without the ‘p’ is slow”) (see Corriveau, Pasquini, & Goswami, 2007). There were 3 practice trials and 20 experimental trials. Scores out of 20 were used for analysis.

*Phonological Access*

The ease with which participants could access phonological entries was assessed using the Rapid Automatized Naming task (RAN). The children had to name familiar pictures from dense orthographic neighbourhoods. The time it took them to complete the task and the number of errors they made are used for analysis (see Kuppen et al., 2011).

*Memory*

The digit span from the Wechsler Adult Intelligence Scale – III (WAIS – III, Wechsler, 1997) was used to assess phonological short-term memory and working memory. The children repeated strings of digits both forwards and backwards. The strings got longer as the task progressed. The raw score is the number of strings correctly recited.

*Mathematical Ability*
Mathematical ability was assessed using the Numerical Operations subtest of the Wechsler Individual Achievement Test – II (WIAT – II; Wechsler, 2004). In this subtest, children are asked to identify and write numbers, count, and solve basic arithmetic problems. The raw score is the number of problems solved correctly. The raw score is then converted to a standard score with a mean of 100 and a standard deviation of 15.

Results

Effect of Intervention

To examine changes in auditory, reading, phonological processing, spelling, and mathematical abilities as a function of group a series of paired t-tests were performed. Since the sample sizes were small, I first used the Shapiro-Wilk test to make sure that all assumptions for the t-test were met (i.e. the pre-test scores, post-test scores, and the difference between the scores were all normally distributed). If they were met, I carried out the paired t-test. If they were not met, I used a Wilcoxon signed rank test. Results are displayed in Table 3. The external reliabilities of the measures are presented in Table 4. The data showed that there was very little variability in the number of errors made in rapid naming (the standard deviation for each group on both pre- and post-test ranged between 1 and 1.5). Furthermore, the reliability of this measure was very low (r = 0.26, p = 0.27). This measure will not be considered furthered due to its limited variability and low reliability. The results for the other nine measures will be presented.

Given my small sample size, it did not make sense to run a separate ANOVA for each pre- and post-test measure. If I had done so, I would have had to use the Bonferroni correction to counteract the problem of multiple comparisons, which would have reduced my power too much for the results to be meaningful. Rather, I aggregated the z-scores of the eight measures known to be related to reading (word and non-word reading, spelling, rhyme oddity, phoneme deletion, rapid naming speed, rise time discrimination, and digit span) into one measure, hereafter known as the overall reading measure. For the rise time discrimination and rapid naming tasks the inverse of the z-score was used because, for these tasks, a lower score indicates a better score. This aggregation increased the reliability of the measure (see Table 5 for pre- and post-test averages of the overall reading measure).
Table 3a: Pre- and Post-test Measures for the Musical Intervention: Tasks which Did Not Meet Normality Assumptions for Parametric Tests

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre-test Score</th>
<th>Post-test Score</th>
<th>z-score (p-value)</th>
<th>Effect Size (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time Discrimination Threshold (ms)</td>
<td>208.29 (71.47)</td>
<td>128.69 (90.13)</td>
<td>-1.99 (0.05)</td>
<td>0.44</td>
</tr>
<tr>
<td>RAN Errors (max = 40)</td>
<td>1.40 (1.51)</td>
<td>0.80 (1.32)</td>
<td>-1.16 (0.25)</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 3b: Pre- and Post-test Measures for the Musical Intervention: Tasks which Did Meet Normality Assumptions for Parametric Tests

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre-test Score</th>
<th>Post-test Score</th>
<th>t-statistic (p-value)</th>
<th>Effect Size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOWRE Word Reading (raw score) (out of 104)</td>
<td>21.00 (7.01)</td>
<td>25.00 (7.83)</td>
<td>2.30 (0.05)</td>
<td>0.73</td>
</tr>
<tr>
<td>TOWRE Non-word Reading (raw score) (out of 63)</td>
<td>8.00 (3.40)</td>
<td>11.30 (3.71)</td>
<td>3.01 (0.01)</td>
<td>0.95</td>
</tr>
<tr>
<td>RAN Speed (seconds)</td>
<td>56.80 (15.19)</td>
<td>51.70 (9.86)</td>
<td>1.39 (0.20)</td>
<td>0.44</td>
</tr>
<tr>
<td>Phoneme Deletion (out of 20)</td>
<td>5.30 (3.53)</td>
<td>8.10 (4.15)</td>
<td>2.47 (0.04)</td>
<td>0.78</td>
</tr>
<tr>
<td>WIAT Numerical Operations (raw score)</td>
<td>9.30 (1.57)</td>
<td>8.80 (1.40)</td>
<td>0.79 (0.45)</td>
<td>0.25</td>
</tr>
<tr>
<td>Oddity Rhyme (out of 20)</td>
<td>9.50 (4.86)</td>
<td>12.80 (4.10)</td>
<td>3.19 (0.01)</td>
<td>1.01</td>
</tr>
<tr>
<td>Digit Span (out of 30)</td>
<td>10.60 (4.74)</td>
<td>12.10 (3.48)</td>
<td>2.24 (0.05)</td>
<td>0.71</td>
</tr>
<tr>
<td>BAS Spelling (ability score) (out of 200)</td>
<td>57.70 (9.88)</td>
<td>63.20 (8.27)</td>
<td>2.86 (0.02)</td>
<td>0.90</td>
</tr>
</tbody>
</table>
Table 3c: Pre- and Post-test Measures for the Graphogame Intervention: Tasks which Did Not Meet Normality Assumptions for Parametric Tests

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre-test Score</th>
<th>Post-test Score</th>
<th>z-score (p-value)</th>
<th>Effect Size (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time Discrimination</td>
<td>180.74 (87.39)</td>
<td>106.72 (91.34)</td>
<td>-1.72 (0.09)</td>
<td>0.41</td>
</tr>
<tr>
<td>Threshold (ms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Span (out of 30)</td>
<td>12.33 (3.20)</td>
<td>12.89 (3.06)</td>
<td>-1.19 (0.24)</td>
<td>0.28</td>
</tr>
<tr>
<td>RAN Speed (seconds)</td>
<td>58.11 (13.27)</td>
<td>48.44 (12.75)</td>
<td>-2.43 (0.02)</td>
<td>0.57</td>
</tr>
<tr>
<td>RAN Errors (max = 40)</td>
<td>1.44 (1.13)</td>
<td>1.22 (1.39)</td>
<td>-0.41 (0.68)</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 3d: Pre- and Post-test Measures for the Graphogame Intervention: Tasks which Did Meet Normality Assumptions for Parametric Tests

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre-test Score</th>
<th>Post-test Score</th>
<th>t-statistic (p-value)</th>
<th>Effect Size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOWRE Word Reading (raw score) (out of 104)</td>
<td>16.56 (9.13)</td>
<td>24.44 (11.48)</td>
<td>6.09 (&lt;0.01)*</td>
<td>2.03</td>
</tr>
<tr>
<td>TOWRE Non-word Reading (raw score) (out of 63)</td>
<td>7.22 (3.15)</td>
<td>10.56 (3.84)</td>
<td>3.85 (&lt;0.01)*</td>
<td>1.28</td>
</tr>
<tr>
<td>BAS Spelling (ability score) (out of 200)</td>
<td>53.89 (12.17)</td>
<td>64.00 (13.16)</td>
<td>4.19 (&lt;0.01)*</td>
<td>1.40</td>
</tr>
<tr>
<td>Phoneme Deletion (out of 20)</td>
<td>7.11 (4.65)</td>
<td>9.22 (4.60)</td>
<td>3.03 (0.02)</td>
<td>1.01</td>
</tr>
<tr>
<td>Oddity Rhyme (out of 20)</td>
<td>8.89 (4.37)</td>
<td>11.22 (3.38)</td>
<td>1.66 (0.14)</td>
<td>0.55</td>
</tr>
<tr>
<td>WIAT Numerical Operations (raw score)</td>
<td>8.00 (2.69)</td>
<td>9.78 (1.72)</td>
<td>4.10 (&lt;0.01)*</td>
<td>1.37</td>
</tr>
</tbody>
</table>

Pre- and post-test scores are displayed as mean (standard deviation). For Tables 3a and 3c, z-scores, p-values, and effect sizes (r) were calculated using the Wilcoxon signed rank test. For Tables 3b and 3d, t-statistics, p-values, and effect sizes (d) were calculated using paired t-tests. The * indicates a p-value ≤ 0.005, the critical value when using the Bonferroni to correct for multiple comparisons.
Table 4: Reliabilities of Pre- and Post-test Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Reliability (r-value)</th>
<th>Reliability (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAN Errors</td>
<td>0.26</td>
<td>0.27</td>
</tr>
<tr>
<td>WIAT Numerical Operations</td>
<td>0.47</td>
<td>0.04*</td>
</tr>
<tr>
<td>Rise Time Discrimination</td>
<td>0.55</td>
<td>0.01*</td>
</tr>
<tr>
<td>Oddity Rhyme</td>
<td>0.62</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>TOWRE Non-word Reading</td>
<td>0.63</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>RAN Speed</td>
<td>0.68</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>Phoneme Deletion</td>
<td>0.76</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>BAS Spelling</td>
<td>0.79</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>TOWRE Word Reading</td>
<td>0.84</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>Digit Span</td>
<td>0.90</td>
<td>&lt; 0.01*</td>
</tr>
</tbody>
</table>

The reliability measures were calculated by correlating the pre- and post-test raw scores. Since the rise time discrimination task was given twice at post-test, the reliability was calculated with the pre-test measures and both post-test measures separately. Then, the two reliabilities were averaged together.

I ran an Intervention Group x Time (pre- or post-test) repeated measures ANOVA on the overall reading measure to see if the participants significantly improved over the course of the intervention and if there were any differences between the two intervention groups. There was a significant effect of Time, F(1,17) = 119.56, p < 0.01, with a very large effect size, partial \( \eta^2 \) = 0.88.

Participants improved significantly between pre- and post-tests. The effects of Intervention Group and the interaction between Intervention Group and Time were both non-significant, \( p = 0.94 \) and \( p = 0.61 \) respectively, suggesting that in both groups participants improved comparable amounts.

I had hypothesized that some of the measures included in the overall reading measure would be more strongly impacted by one intervention than by the other. I expected both interventions to improve word and non-word reading, spelling and rhyme awareness. However, I expected the musical intervention to improve digit span and rise time discrimination to a greater degree, whereas the Graphogame intervention was expected to improve phoneme deletion and rapid naming speed to a greater degree. Hence, I aggregated z-scores from the four measures I expected both interventions to impact into a “literacy and rhyme measure”, the z-scores from the two tasks that I expected the musical intervention to have a greater impact on into a “rise time and memory measure”, and the z-scores from the two tasks that I expected the Graphogame intervention to have a greater impact on into the “phoneme deletion and rapid naming measure” (see Table 5 for pre- and post-test averages of the aggregate measures). I then ran Intervention Group x Time (pre- or post-test) repeated measures ANOVAs on these three measures.
Table 5: Pre- and Post-test Scores of Aggregate Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Musical Intervention</th>
<th>Graphogame Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>Overall Reading</td>
<td>-2.52 (4.80)</td>
<td>2.35 (4.09)</td>
</tr>
<tr>
<td>Literacy and Rhyme</td>
<td>-0.87 (2.83)</td>
<td>1.68 (2.40)</td>
</tr>
<tr>
<td>Rise Time and Memory</td>
<td>-0.93 (1.60)</td>
<td>0.35 (1.51)</td>
</tr>
<tr>
<td>Phoneme Deletion and Rapid Naming</td>
<td>-0.72 (1.34)</td>
<td>0.32 (1.38)</td>
</tr>
<tr>
<td>Phonological Skills</td>
<td>-0.98 (2.00)</td>
<td>0.82 (1.98)</td>
</tr>
<tr>
<td>Literacy</td>
<td>-0.61 (2.06)</td>
<td>1.18 (2.13)</td>
</tr>
</tbody>
</table>

Pre- and post-test scores of aggregate measures are displayed as mean (standard deviation). The overall reading measure is a sum of the z-scores of the eight tasks known to be related to reading (word and non-word reading, spelling, rhyme oddity, phoneme deletion, rapid naming speed, rise time discrimination, and digit span). The literacy measure is a sum of the z-scores of the tasks I expected both interventions to benefit (word and non-word reading, spelling, and rhyme oddity). The rise time and memory measure is a sum of the z-scores of the tasks I expected only the musical intervention to benefit (rise time discrimination and digit span). The phoneme deletion and rapid naming measure is a sum of the z-scores of the tasks I expected only the Graphogame intervention to benefit (phoneme deletion and rapid naming speed). The phonological skills measure is a sum of the z-scores of the tasks which test phonological skills (rhyme oddity, phoneme deletion, and rapid naming speed). The literacy measure is a sum of the z-scores of the tasks which test literacy skills (word and non-word reading and spelling). The fact that the pre-test scores are negative and the post-test scores are positive reflects the improvement that the participants made over time.

For the literacy and rhyme measure, I expected to see an effect of Time, but not an effect of Intervention Group nor an interaction between Intervention Group and Time. Both of these hypotheses were borne out. There was a significant effect of Time, F(1,17) = 51.30, p < 0.01 with a very large effect size, partial $\eta^2 = 0.75$. Neither Intervention Group nor the interaction between the two factors explained significant variance, $p = 0.53$ and $p = 0.45$ respectively.

Since the residuals for the rise time and memory measure were skewed right, I log transformed the data before running the ANOVA. I expected to see both a significant effect of Time and a significant interaction between the two factors. Though I did see a significant effect of Time, F(1,17) = 38.92, $p < 0.01$, with a very
large effect size, partial $\eta^2 = 0.70$, the interaction was not significant, $p = 0.51$. The main effect of Intervention Group was also non-significant, $p = 0.44$. Similarly, for the phoneme deletion and rapid naming measure, I expected to see both a significant effect of Time and a significant interaction between the two factors. Though I did see a significant effect of Time, $F(1,17) = 18.91$, $p < 0.01$, with a very large effect size, partial $\eta^2 = 0.53$, the interaction was not significant, $p = 0.72$. The main effect of Intervention Group was also non-significant, $p = 0.56$. These results suggest that the two interventions did not differentially impact the tasks as I had predicted that they would.

The WIAT Numerical Operations subtest was not included in the overall reading measure because it was not expected to correlate with reading skills. A separate Intervention Group x Time (pre- or post-test) repeated measures ANOVA was used to analyse this measure. The results from this test must be interpreted with caution since this study was too underpowered to analyse individual measures and the WIAT had low reliability ($r = 0.47$, $p = 0.04$). There was a significant Intervention Group x Time interaction, $F(1,17) = 8.35$, $p = 0.01$, with a large effect size, partial $\eta^2 = 0.33$. Post-hoc paired t-tests revealed that the children in the musical group did not significantly improve, $p = 0.45$. However the children in the Graphogame group did significantly improve, $t(8) = 4.10$, $p < 0.01$, with a large effect size, $d = 1.37$.

**Effect of Reading Interventions on Math Performance**

It was surprising that the Graphogame group significantly improved in mathematical ability but the music group did not. The WIAT Numerical Operations subtest does not contain any word problems or written instructions, so the reading improvement cannot explain this effect. I decided to explore whether these results were an artefact of the test administered. In the Numerical Operation subtest, the first seven problems involve number recognition, counting, and writing dictated numbers. Problem 8 and onwards involve basic arithmetic (addition, subtraction, multiplication, and division). When administering the subtest, the experimenter is meant to start at problem number 1 for 6-year old participants and at problem number 8 for 7-year old participants. If the participant did not correctly answer problems 8, 9, or 10, then the previous problems were administered in reverse order until the participant correctly answered 3 consecutive problems. Any problems preceding the problem administered first were scored as correct. Many participants were 6 years old at pre-test and 7 years old at post-test. Therefore, at post-test, many participants did not have to complete the first few problems. It is possible that the participants would have incorrectly answered the unadministered problems if they
had been 6 years old and had to start the test at the beginning. Therefore, their scores may have been inflated simply because they had gotten older, not because their mathematical abilities had improved. Another concern was that many children were correctly solving arithmetic problems, but had orthographic errors in writing their answers: either writing the digits in the incorrect orientation or switching the two digits (e.g. 04 instead of 40). Using the original scoring criteria, these problems were scored as incorrect. If Graphogame helped with orthography, perhaps the children in that group were simply getting better at writing their answers correctly, not at arithmetic.

To determine whether or not participants were truly improving in their mathematical abilities, the WIAT Numerical Operations subtest was rescored in two different ways. In both methods, only problems from number 8 onwards (i.e. the problems that all participants saw at both pre- and post-test) were counted. In the first method, answers written with orthographic errors were counted as incorrect whereas in the second method answers with orthographic errors were counted as correct (see Table 6 for pre- and post-test averages using both scoring methods). Intervention Group x Time (pre- or post-test) repeated measures ANOVAs were used to analyse the WIAT Numerical Operations scores using both scoring methods. There was no significant interaction between Intervention Group and Time, \( p = 0.31 \) and \( p = 0.83 \), for the first and second methods respectively. Furthermore, there was no effect of Intervention Group, \( p = 0.79 \) and \( p = 0.97 \) respectively. These results suggest that there was no true effect of intervention type on mathematical improvement; the significant interaction seen previously was simply an artefact of the test administered. Furthermore, the main effect of Time was also non-significant, \( p = 0.31 \) and \( p = 0.14 \) for the first and second method respectively. This suggests that neither intervention improved mathematical abilities. This is not surprising, since both interventions were specifically designed to improve reading and were not expected to more generally improve other academic skills.
### Table 6: WIAT Numerical Operations Scores Using Different Scoring Criteria

<table>
<thead>
<tr>
<th>Intervention Group</th>
<th>Scoring Criteria No. 1</th>
<th></th>
<th>Scoring Criteria No. 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>Pre-test</td>
<td>Post-test</td>
<td></td>
</tr>
<tr>
<td>Graphogame</td>
<td>2.33 (1.73)</td>
<td>3.00 (1.73)</td>
<td>2.44 (1.67)</td>
<td>3.11 (1.69)</td>
<td></td>
</tr>
<tr>
<td>Music</td>
<td>2.50 (1.35)</td>
<td>2.50 (1.08)</td>
<td>2.50 (1.35)</td>
<td>3.00 (1.63)</td>
<td></td>
</tr>
</tbody>
</table>

Scoring criteria No. 1 means that only problems 8 and onwards on the WIAT Numerical Operations subtest were scored. Scoring criteria No. 2 means that only problems 8 and onwards on the WIAT Numerical Operations subtest were scored and answers written with orthographic errors were counted as correct. Mean raw scores (standard deviations) at both pre- and post-test are shown.

### Are the Correlations Predicted by the Temporal Sampling Theory Present in our Data Set?

In addition to seeing whether or not the interventions were effective, I was curious to see whether or not pre-test data contained the correlations predicted by the temporal sampling theory. According to the temporal sampling theory (Goswami, 2011), dyslexics have trouble with rise time discrimination and rhythmic entrainment. These difficulties then translate to difficulties with phonological awareness. Poor phonological awareness leads to difficulties with reading and spelling. My participants were different than those in most studies in that they had low language and cognitive abilities, whereas many studies only employ participants who have a specific reading deficit, despite high IQ. I wanted to know if the temporal sampling theory was supported by my unique subject group. Therefore, I tested whether rise time sensitivity was significantly associated with phonological awareness and whether phonological awareness, in turn, was significantly correlated with literacy in my sample. To increase the reliability of my correlations, I report the results from two aggregate scores: a phonological skills measure (sum of z-transformed rhyme oddity, phoneme deletion, and rapid naming speed pre-test scores) and a literacy measure (sum of z-transformed word and non-word reading and spelling pre-test scores). Pre- and post-test averages by
intervention group for these aggregate measures can be found in Table 5. Correlations between individual tasks as well as aggregate measures can be found in Table 7. One correlation between the individual tasks to note is the surprisingly low correlation between rise time discrimination and rhyme awareness ($r = 0.29, p = 0.21$).

Rise time discrimination inverse $z$-transformed pre-test scores throughout the entire sample were moderately correlated with phonological skills aggregate scores at pre-test, $r = 0.41$, though this correlation was not quite significant, $p = 0.07$. The phonological skills aggregate score at pre-test was significantly correlated with the literacy measures aggregate score at pre-test, $r = 0.58, p = 0.01$ (see Fig. 2). Therefore, my pre-test data seems to support the temporal sampling theory, though the correlation between auditory measures and phonological skills was weaker than expected.

| Table 7: Correlations between Phonological Awareness Scores and Auditory/Literary Measures |
|-----------------------------------------------|---------------------------------|-----------------|----------------------|
| Rise Time Discrimination                      | Rhyme Oddity                  | 0.29 (0.21)    |
|                                              | Phoneme Deletion              | 0.46 (0.04)*   |
|                                              | Rapid Naming Speed           | 0.12 (0.62)    |
|                                              | Phonological Skills Measure   | 0.41 (0.07)    |
| Word Reading                                  | 0.40 (0.08)                  |
|                                              | 0.22 (0.36)                  |
|                                              | 0.53 (0.02)*                 |
|                                              | 0.54 (0.01)*                 |
| Non-word Reading                              | 0.17 (0.41)                  |
|                                              | -0.08 (0.75)                 |
|                                              | 0.25 (.30)                   |
|                                              | 0.27 (0.24)                  |
| Spelling                                      | 0.49 (0.03)*                 |
|                                              | 0.37 (0.11)                  |
|                                              | 0.47 (.04)*                  |
|                                              | 0.63 (<0.01)*                |
| Literacy Measure                              | 0.52 (0.02)*                 |
|                                              | 0.21 (0.39)                  |
|                                              | 0.51 (0.02)*                 |
|                                              | 0.58 (0.01)*                 |

Correlations are displayed as $r$-value (p-value). For the Rise Time Discrimination Task, inverse $z$-scores are used in correlations because in this task a lower score is considered better. The literacy measure is an aggregate of the word and non-word reading and spelling $z$-scores. The phonological skills measure is an aggregate of the rhyme oddity, phoneme deletion, and rapid naming speed $z$-scores. The * indicates p-value < 0.05.

**Rhythmic Entrainment**

I used the rhythmic entrainment data to test whether or not the participants in the musical intervention were improving in their rhythmic accuracy throughout the course of the intervention. When analyzing the rhythmic entrainment data I elected to use circular statistics when analyzing my data, as opposed to linear statistics, to accommodate for my participants’ inaccuracy. With linear statistics, one must find the time difference between each stimulus and its corresponding response to calculate the asynchrony of each response.
Then, one must average all of the asynchronies together. However, some of my
participants had multiple responses during one inter-stimulus interval or did not respond at
all to some of the stimuli. Furthermore, some of their responses were halfway between two
stimuli. Hence, it was difficult to pinpoint the corresponding stimulus for each response, as
is required for linear statistics.

Circular statistics take advantage of the regular repetition of the stimulus
and compare it with the periodicity of a circle. Circular statistics transform each
inter-stimulus interval (ISI) into a unit circle, with the stimulus aligned at 0
radians. For example, if a response was to occur 150 ms after a stimulus during a
600 ms ISI, it would correspond to an angle of \( \pi/2 \) radians. In this way, every
response can be plotted along the circumference of the circle.

**Figure 2:** Scatter plot showing correlations between auditory, phonological, and
literacy measures  The blue line depicts the correlation between inverse \( z \)-
transformed scores on the rise time discrimination task (x-axis) and the phonological
skills measure (sum of \( z \)-transformed scores on rhyme oddity, phoneme deletion and
rapid naming speed tasks) (y-axis). The red line depicts the correlation between the
phonological skills measure (x-axis) and the literacy measure (sum of \( z \)-transformed
scores on the word and non-word reading and spelling tasks) (y-axis). Rise time
discrimination was moderately correlated with phonological skills, \( r = 0.41 \), though this
correlation was not quite significant, \( p = 0.07 \). Phonological skills and literacy were
significantly correlated, \( r = 0.58, p = 0.01 \)

From these responses, the mean vector \( \mathbf{R} \) can be calculated. It has two non-
parametric components, the mean direction \( \theta \), which is analogous to the mean asynchrony
in linear statistics, and the mean resultant length \( R \). \( R \) always varies between 0 and 1 and is
inversely related to variance in asynchronies in a linear calculation. An \( R \) of 1 implies that
responses always occur at the same time relative to the stimulus (perfect synchrony). An \( R \)
of 0 can either mean that the responses were evenly distributed around the circle, or the responses had a bimodal distribution. Visual inspection of the raw data showed no evidence of bimodal distributions. Therefore, we assumed that a low $\overline{R}$ indicated low synchronization accuracy (see Kirschner & Tomasello, 2009 for more information about circular statistics). The MATLAB code needed to analyse the data was written by Alan Power (University of Cambridge).

For each participant, I calculated their $\overline{R}$ and $\overline{\theta}$ during each rhythmic entrainment session. In my calculation, I included all responses that fell after the 5th stimulus, to allow some time for entrainment, and before where the 36th stimulus would have occurred. As each participant saw each rate (60, 80, 100, 120, and 140 bpm) twice throughout the intervention, once during the first half and once during the second half, I could measure improvement in rhythmic entrainment throughout the course of the intervention. I used the Wilcoxon signed rank test to compare the first time each participant saw a particular rate to the second time. Only three of the ten participants became significantly more synchronized throughout the intervention (i.e. significant change in $\overline{R}$) ($p$s < 0.05). For $\overline{\theta}$ calculations, I used the absolute value of $\overline{\theta}$, so that I could assess whether or not the participants were tapping closer to the stimulus, despite whether they were anticipating the stimulus or responding slightly after the stimulus had occurred. The Wilcoxon signed rank test revealed that only two of the participants significantly reduced their asynchrony magnitudes (i.e. significant change in $\overline{\theta}$) ($p$s < 0.05). One participant improved in terms of both $\overline{\theta}$ and $\overline{R}$; see Figure 3 for example data from this participant.

Though the majority of participants did not improve, an interesting pattern emerged regarding which participants did improve. Specifically, participants who had the most trouble with rhythmic entrainment initially were the most likely to improve throughout the intervention. I ran a correlation between the mean $\overline{R}$ of the first attempts at each rate (a measure of initial aptitude) and the mean difference in $\overline{R}$ between the second and first attempt at each rate (a measure of improvement). A positive difference indicates that participants became more synchronized. This correlation was highly significant, $r = -0.90$, $p < 0.01$, suggesting that participants who were the least synchronized at the beginning of the intervention showed the greatest improvement. Similarly, for $\overline{\theta}$, I ran a circular correlation between the mean absolute value of $\overline{\theta}$ of the first attempts at each rate (a measure of initial aptitude) and the mean difference in absolute value of $\overline{\theta}$ between the second and first attempt at each rate (a measure of improvement). A negative difference indicates that the participants’ responses became closer to the stimuli. The circular correlation trended towards significance, $r = -0.68$, $p = 0.09$, suggesting that participants who had the greatest asynchronies at the beginning of the intervention showed the greatest improvement.
**Figure 3a:** Linear plot of a participant’s first attempt at 120 bpm rate

**Figure 3b:** Circular plot of a participant’s first attempt at 120 bpm rate
Example figures from the circular statistics calculations. For the linear plots (a and c), the blue lines represent the stimuli and the red lines represent the responses. For the circular plots (b and d), 0 is pointing east and the circle reads counter-clockwise. The red squares around the circumference represent each response during the trial. The vector R is depicted with the red line within the circle. Note how in figure a, the participant sometimes responded with the stimulus and was sometimes completely out of phase with the stimulus. By the second time point depicted in figure c, the participant has significantly improved and his/her responses were almost always near the stimulus. This pattern is captured by the circular analyses. In figure b, the responses are widely distributed around the circle, thus the vector has a small magnitude. Furthermore, the vector is very far from 0 radians, the location of the stimulus. In contrast, the responses in figure d are tightly clustered, thus the vector has a larger magnitude. Furthermore, the vector is much closer to 0 radians.
An extension of the temporal sampling theory is that there should be a correlation between improvement in rhythmic entrainment and improvement in reading. I ran a correlation between the mean difference in $\overline{R}$ between the second and first attempt at each rate (a measure of improvement in rhythmic entrainment) and the difference between the post-test and pre-test overall reading measure (a measure of improvement in reading). The two measures were strongly correlated, $r = 0.58$, though this correlation was not quite significant, $p = 0.07$ (see Fig. 4) Hence, I had marginally reliable results supporting the hypothesis that improvement in rhythmic entrainment should be correlated with improvement in reading.

**Figure 4:** Correlation between Improvement in Rhythmic Entrainment and Improvement in Reading

Improvement in rhythmic entrainment is defined as the mean difference in $\overline{R}$ between the second and first attempt at each rate. Improvement in reading is defined as the difference between the post-test and pre-test overall reading measure. The correlation was strong, $r = 0.57$, though not quite significant, $p = 0.07$.

I was also curious to see whether my participants showed the same general trends found in previous studies using populations with different demographics. Previous tapping literature has shown that nonmusicians tapping in synchrony with a metronome tend to tap before the tone (there is a negative mean asynchrony) (see Repp, 2005 for review). When I averaged the $\overline{g}$ values for each participant across all ten trials, eight of the ten participants had negative mean asynchronies. Hence, my participants did follow the same trends noticed previously. They were entraining to the rhythm and attempting to predict when the tone would occur, rather than simply responding to the tone.

**Does IQ Affect Response to Intervention?**

I chose to use garden-variety poor readers, as opposed to dyslexics, in this
study because I predicted that the effectiveness of the interventions would not be dependent on IQ. To test this hypothesis, I ran an Intervention Group x Time (pre- or post-test) repeated measures ANOVA on the overall reading measure with non-verbal IQ (z-transformed raw scores on the block design pre-test) as a covariate. The Time x Intervention Group x non-verbal IQ interaction was highly significant, \(F(1,15) = 10.17, p = 0.01\). This interaction suggests that participants responded differently to the interventions depending on their IQs. To tease apart this interaction, I ran correlations between the participants’ non-verbal IQs and the differences between the pre and post overall reading measures (the measure of improvement), for each intervention group. In the music group, non-verbal IQ was significantly correlated with improvement, \(r = 0.63, p = 0.04\). In contrast, in the Graphogame group, IQ was significantly negatively correlated with improvement, \(r = -0.72, p = 0.02\) (see Fig. 5). This finding is the opposite of what I expected, as I had expected that IQ would have no effect on intervention outcome. Since I only had one measure of non-verbal IQ and sample size is small, I note that these associations may not be reliable.

**Figure 5:** Correlation between Non-verbal IQ and Response to Intervention
The overall reading measure is an aggregate measure of the eight tasks known to be related to reading (word and non-word reading, spelling, rhyme oddity, phoneme deletion, rapid naming speed, rise time discrimination, and digit span). Improvement is measured by the subtracting the pre-test score from the post-test score. Note how children with higher IQs improved more following the musical intervention than children with lower IQs, \(r = 0.63, p = 0.04\). The opposite pattern was found for the Graphogame intervention, \(r = -0.72, p = 0.02\).
Discussion

Effect of Intervention

The main research question of this study was whether training the perceptual and cognitive skills that may underpin poor phonological development and poor reading via a musical intervention would show benefits for reading and phonological development, and whether these benefits would be equivalent to those that result from the direct training of reading and phonology. Broadly, the data suggested that the musical training was as effective for most aspects of phonology and literacy as the direct intervention (via Graphogame Rime), even though sub-lexical phonological awareness and letter-sound correspondences were not taught in the musical intervention. I did not find any differences between the interventions on any of the aggregate measures.

The two main limitations of this study are that my sample sizes were small and I was not able to include a control group which did not receive any training. The latter is due to the fact that participating schools requested that all their poor readers receive some kind of intervention. Hence, when both intervention groups received comparable benefits on a particular post-test, it cannot be determined if this benefit was due to the interventions themselves or due to schooling, maturation, or test-retest effects. However, a small-scale intervention study done with 6-7 year old children (i.e. the same age as the children in the current study) has shown that Graphogame Rime does improve scores on the word and non-word reading, spelling, phoneme deletion, and rhyme oddity tasks as compared to an unseen control group. Rapid naming, digit span, rise time discrimination, and mathematical abilities were not measured (Kyle et al., under review). Therefore, since the musical intervention produced gains comparable to those that the Graphogame intervention produced, and if we assume that Graphogame is an effective intervention, then we can tentatively conclude that both interventions benefit phonology and literacy to an equal degree, and these benefits are due to the interventions themselves.

Further analysis with the mathematics test revealed that neither intervention significantly improved arithmetic skills. If the gains seen in reading had been due to schooling, maturation, or test-retest effects, presumably the same forces would have improved arithmetic abilities as well. Since the improvement seen was specific to reading, and did not generalize to other academic areas, this provides further support for my claim that the reading improvement seen was due to the interventions themselves.

It was surprising that I did not find any significant differences between the two intervention groups. Perhaps, I was simply underpowered to see any differences. I acknowledge that further studies must be done with larger sample sizes so that
separate ANOVAs can be run for each outcome measure. Only then will we be able to closely examine differences between the interventions. Furthermore, future studies must include control groups so that we can confirm Kyle et al.’s (under review) findings and more rigorously test whether or not the improvement seen is due to the interventions delivered.

**Examining the Predictions of the Temporal Sampling Theory**

The musical intervention was theoretically based on the temporal sampling theory. The only *a priori* reason to believe that rhythmic training should influence literacy is if the main tenet of the temporal sampling theory is true, that reading difficulties arise from phonological difficulties that are due in part to difficulties with neural entrainment. This intervention study provided modest support for the temporal sampling theory. Firstly, the musical intervention led to literacy gains of comparable effect sizes as direct training in letter-sound correspondences. Furthermore, I found that improvement in rhythmic entrainment over the course of the intervention was strongly correlated with an increase in the overall reading score between pre- and post-test. In addition to the intervention outcomes, the trends found in the pre-test data also supported the temporal sampling theory. The theory postulates that poor phonological awareness stems in part from difficulties with rise time discrimination and that reading difficulties are a result of this poor phonological awareness. These predicted correlations were found in my pre-test data. Rise time discrimination was moderately correlated with phonological awareness. The correlation was not quite significant, but this could be due to the low reliability in the rise time measure. Similarly, the low reliability in the rise time measure could explain the lack of correlation between rise time discrimination and rhyme oddity (see Table 4). Phonological awareness, in turn, was significantly correlated with literacy skills. Overall, both the trends found in my pre-test data and the intervention outcomes provide support for the temporal sampling theory.

**Effect of IQ on Intervention Outcome**

I was surprised to find that participants with lower non-verbal IQs tended to improve more following the Graphogame intervention, whereas participants with higher non-verbal IQs tended to improve more following the musical intervention. According to the temporal sampling theory, one of the causes of poor phonological skills found in *all* poor readers, despite IQ, is difficulty with neural entrainment. Hence, children across the IQ spectrum should have received similar benefits from the interventions.

It is possible that an unmeasured variable, attention, was driving these results. Attention Deficit and Hyperactivity Disorder has not only been found to be
correlated with low IQ scores, but this co-occurrence has genetic origins (Kuntsi et al., 2004). Therefore, my measure of non-verbal IQ may have been also measuring variance in attention. Children with a genetic marker for Attention Deficit and Hyperactivity Disorder, DRD4 7-repeat, were shown to benefit more than children without the genetic marker from a reading computer game which gives immediate feedback, similar to Graphogame. The children with the DRD4 7-repeat were also shown to benefit less than the other children when they played the same game, but without the immediate feedback (Kegel, Bus, & Ijzendoorn, 2011). In a classroom situation, it is simply impossible to give every single child constant and immediate feedback. Hence, the children with low IQ scores (and presumably poor attention) may have reading difficulties, not due to a core phonological deficit, but because they do not pay attention in class. However, once they are given an opportunity to play a reading- based computer game which does give constant and immediate feedback, such as Graphogame, they improve tremendously. In contrast, the struggling readers with high non-verbal IQ scores, whom presumably are able to pay attention in class and learn even when there is not constant and immediate feedback, do have reading difficulties caused by a core phonological deficit and hence were more helped by the musical intervention. Future studies which directly measure attention are clearly needed.

The Theoretical Context of this Intervention Study

Though past musical interventions have shown positive effects on literacy, this was the first musical intervention which was based on the temporal sampling framework. Because the temporal sampling framework stresses rhythm, and not pitch, this intervention included only rhythmic activities. Even when the children were chanting hand clap games along with the music, the music only provided rhythmic information and was void of all tonal information. In contrast, previous intervention studies (Degé & Schwarzer, 2011; Moreno et al., 2009; Overy, 2003; Rauscher & Hinton, 2011) have employed both pitch and rhythm into their interventions, making it difficult to tease apart the independent contributions of each. This study showed significant gains in literacy using a purely rhythmic intervention, suggesting that previous hypotheses which placed more importance on pitch were incorrect (Moreno et al., 2009; Rauscher & Hinton, 2011).

The intervention did employ gross motor movements (e.g. clapping and marching to the beat), suggesting that I may have trained motor coordination deficits and lending support to the “cerebellar deficit hypothesis”. However, past research has shown that dyslexics only have trouble with rhythmic motor activities and not with dexterity tasks which do not require rhythm (Thomson & Goswami, 2008). Since I only trained rhythmic motor activities, and not balance or dexterity in
general, I feel that the temporal sampling framework better explains my intervention results. Furthermore, the clapping and marching was only a fraction of the intervention, and most of the tasks did not employ large movements. Therefore, I do not think that such large training effects would have been seen if the training effects were due to the training of motor coordination.

The temporal sampling framework posits that the phonological impairments seen in dyslexia are due, in part, to difficulties with neural entrainment. This framework was developed primarily based on correlational studies. However, the true test that rhythmic entrainment difficulties cause phonological deficits would be a training study, such as the present one. This study furthered the temporal sampling framework by showing that a rhythmic intervention can improve literacy skills to the same extent that teaching letter-sound correspondences can. Furthermore, the temporal sampling framework, as it was originally envisioned, was only applicable to dyslexia. This study employed both low and normal IQ poor readers and provided limited evidence that the temporal sampling framework is also applicable to low IQ poor readers. The study showed that low IQ poor readers have many of the same auditory deficits as dyslexics and that musical training can help their reading and phonological awareness. However, the study did suggest that low IQ poor readers may benefit more from being taught letter-sound correspondences whereas high IQ readers may benefit more from the musical intervention.

**Future Study Design**

Children are more likely to voluntarily do an intervention which they enjoy, and hence they will get more benefit from it. Here I will briefly discuss which intervention activities the children enjoyed so that future interventions can be designed to be maximally enjoyable, and hence maximally effective. Most children found playing 30 minutes of Graphogame too tiring, so future interventions should have shorter sessions. Furthermore, the game could be changed so that tokens can be swapped for exciting reading games more often, which the children typically enjoyed.

Within the musical intervention, the children typically enjoyed rhythmic entrainment, differentiating between two tempos, differentiating between two rhythmic sequences, the rise time discrimination task, chanting and playing hand clap games, and poetry. Many of the children did not like clapping and marching to a song and would complain that their hands hurt or they were getting tired. However, some children reported that they had started clapping along to the beat of the music while listening to the radio at home. Including intervention activities which children will voluntarily do at home will increase the amount of intervention time and possibly continue benefitting the children even after the intervention is
completed. Many of the children did prefer the song “Kill the Beast” because it was from a Disney movie and they were familiar with it. Perhaps, the intervention could be redesigned to include songs from movies that children are familiar with, rather than pop songs which many children of this age group are unfamiliar with. Many children did not enjoy singing a rhythmic sequence simply because they found the task too challenging. The children may enjoy mimicking rhythms on drums or other fun instruments more than with their voice. Finally, many of the children did not enjoy the Dee-Dee game simply because it was too challenging for them, and hence they got discouraged. Perhaps an easier game which also targets syllable stress should be designed for this age group. For example, the game could say the name of a movie with the correct and incorrect syllabic stress, without replacing each syllable with “dec” (e.g. HArry POtter vs. hARRY pOTTer). Improving future intervention designs along the lines suggested above should hopefully make the interventions not only more enjoyable, but also more effective.

Furthermore, the reliability data suggest that some of the pre- and post-test measures should be changed for this sample population. The WIAT Numerical Operations subtest had very low reliability, probably because there were very few problems that the children knew how to solve. Perhaps an easier mathematical test should be used instead when testing low ability children of this age group. The rise time discrimination task also showed low reliability. Perhaps low ability children of this age group need more than 40 trials to calculate accurate estimates of their rise time discrimination thresholds.

**Conclusion**

This small-scale intervention study suggests that a theoretically-driven musical intervention based on rhythm and linking metrical structure in music and language can have benefits for the development of literacy and phonological awareness. Further studies including an unseen control group are needed to explore whether these gains are greater than those that occur with the natural passage of time, and to see whether such benefits would accrue to all children who receive musical training, or only to children with lower language skills and lower cognitive ability (those trained here). It would also be interesting to study whether a combination of the two approaches would be most beneficial, and whether (for example) the musical intervention should precede the letter-based training. Since the musical intervention trains the rhythmic perception and rhythmic entrainment skills that, by hypothesis, are important for the development of phonological awareness (Goswami, 2011), it seems reasonable that the musical intervention should be delivered first. Then, once those prerequisite auditory abilities are in place, the Graphogame intervention could
be delivered so that children can learn grapheme-phoneme correspondences via the psycholinguistic units (rimes) trained by the musical intervention.

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Works Cited


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Appendix A

Schedule of Tasks for the Musical Intervention

Session 1

1. Clapping to a Song
   a. All Star by Smash Mouth
2. Differentiating between Two Tempos
   a. 90 vs. 130 bpm
3. Differentiating between Two Rhythmic Sequences
   a. #1
4. Rise Time Discrimination Task
5. Chanting Hand Clap Game
   a. Miss Mary Mack

Session 2

1. Marching to a Song
   a. All Star by Smash Mouth
2. Rhythmic Entrainment
   a. 60 bpm
3. Singing a Rhythmic Sequence
   a. #1
4. Playing Hand Clap Game
   a. Miss Mary Mack
Session 3

1. Clapping to a Song
   a. Dancing Queen by Abba
2. Differentiating between Two Tempos
   a. 70 vs. 70 bpm
3. Differentiating between Two Rhythmic Sequences
   a. #2
4. Rise Time Discrimination Task
5. Poetry
   a. At the Zoo by William Makepeace Thackeray

Session 4

1. Marching to a Song
   a. Dancing Queen by Abba
2. Rhythmic Entrainment
   a. 80 bpm
3. Singing a Rhythmic Sequence
   a. #2
4. Chanting Hand Clap Game
   a. Miss Susie

Session 5

1. Clapping to a Song
   a. Footloose from the Footloose Original Soundtrack
2. Differentiating between Two Tempos
   a. 85 vs. 55 bpm
3. Differentiating between Two Rhythmic Sequences
   a. #3
4. Rise Time Discrimination Task
5. Playing Hand Clap Game
   a. Miss Susie
Session 6

1. Marching to a Song
   a. Footloose from the Original Footloose Soundtrack

2. Rhythmic Entrainment
   a. 100 bpm

3. Singing a Rhythmic Sequence
   a. #3

4. Poetry
   a. Danny O’Dare by Shel Silverstein

Session 7

1. Clapping to a Song
   a. Build me Up Buttercup by The Foundations

2. Differentiating between Two Tempos
   a. 170 vs. 200 bpm

3. Differentiating between Two Rhythmic Sequences
   a. #4

4. Rise Time Discrimination Task

5. Chanting Hand Clap Game
   a. Pat-a-cake

Session 8

1. Marching to a Song
   a. Build me up Buttercup by The Foundations

2. Rhythmic Entrainment
   a. 120 bpm

3. Singing a Rhythmic Sequence
   a. #4

4. Dee-Dee Game
   a. No assistance

5. Playing Hand Clap Game
   a. Pat-a-cake
Session 9
1. Clapping to a Song
   a. Just the Two of Us by Will Smith
2. Differentiating between Two Tempos
   a. 140 vs. 140 bpm
3. Differentiating between Two Rhythmic Sequences
   a. #5
4. Rise Time Discrimination Task
5. Poetry
   a. The Star by Jane Taylor

Session 10
1. Marching to a Song
   a. Just the Two of Us by Will Smith
2. Rhythmic Entrainment
   a. 140 bpm
3. Singing a Rhythmic Sequence
   a. #5
4. Chanting Hand Clap Game
   a. Smarties

Session 11
1. Clapping to a Song
   a. Man! I Feel like a Woman! by Shania Twain
2. Differentiating between Two Tempos
   a. 190 vs. 190 bpm
3. Differentiating between Two Rhythmic Sequences
   a. #6
4. Dee-Dee Game
   a. Experimenter named stimuli while stressing syllabic stress pattern
5. Playing Hand Clap Game
   a. Smarties
Session 12

1. Marching to a Song
   a. Man! I feel like a Woman! by Shania Twain

2. Rhythmic Entrainment
   a. 60 bpm

3. Singing a Rhythmic Sequence
   a. #6

4. Poetry
   a. Bear In There by Shel Silverstein

Session 13

1. Clapping to a Song
   a. Independent Women by Destiny’s Child

2. Differentiating between Two Tempos
   a. 65 vs. 85 bpm

3. Differentiating between Two Rhythmic Sequences
   a. #7

4. Rise Time Discrimination Task

5. Chanting Hand Clap Game
   a. Rockin’ Robin

Session 14

1. Marching to a Song
   a. Independent Women by Destiny’s Child

2. Rhythmic Entrainment
   a. 80 bpm

3. Singing a Rhythmic Sequence
   a. #7

4. Dee-Dee Game

5. Playing Hand Clap Game
   a. Rockin’ Robin
Session 15

1. Clapping to a Song
   a. Fireflies by Owl City
2. Differentiating between Two Tempos
   a. 65 vs. 65 bpm
3. Differentiating between Two Rhythmic Sequences
   a. #8
4. Dee-Dee Game
   a. Experimenter named stimuli while clapping out syllabic stress pattern
5. Poetry
   a. The First Tooth by Charles and Mary Lamb

Session 16

1. Marching to a Song
   a. Fireflies by Owl City
2. Rhythmic Entrainment
   a. 100 bpm
3. Singing a Rhythmic Sequence
   a. #8
4. Chanting Hand Clap Game
   a. Down by the Banks

Session 17

1. Clapping to a Song
   a. Kill the Beast from Beauty and the Beast
2. Differentiating between Two Tempos
   a. 110 vs. 110 bpm
3. Differentiating between Two Rhythmic Sequences
   a. #9
4. Rise Time Discrimination Task
5. Playing Hand Clap Game
   a. Down by the Banks
Session 18

1. Marching to a Song
   a. Kill the Beast from Beauty and the Beast

2. Rhythmic Entrainment
   a. 120 bpm

3. Singing a Rhythmic Sequence
   a. #9

4. Poetry
   a. Peanut-Butter Sandwich by Shel Silverstein

Session 19

1. Marching to a Song
   a. I Whip my Hair by Willow Smith

2. Rhythmic Entrainment
   a. 140 bpm

3. Differentiating between Two Rhythmic Sequences
   a. #10

4. Dee-Dee Game
   a. No assistance

5. Chanting Hand Clap Game
   a. Bo-bo
Appendix B

Sheet Music for the “Differentiating between Two Rhythmic Sequences” Task

#1

#2

#3

#4

#5
Appendix C

Sheet Music for the “Singing a Rhythmic Sequence” Task

#1

#2

#3

#4

#5

#6
Appendix D

Lyrics to the Songs Used in the “Clapping and Marching to a Song” Tasks

**All Star**
Somebody once told me the world is gonna roll me
I ain't the sharpest tool in the shed
She was looking kind of dumb with her finger and her thumb
In the shape of an "L" on her forehead

Well the years start coming and they don't stop coming
Fed to the rules and I hit the ground running
Didn't make sense not to live for fun
Your brain gets smart but your head gets dumb

So much to do so much to see
So what's wrong with taking the back streets
You'll never know if you don't go
You'll never shine if you don't glow

[Chorus:]
Hey now you're an All Star get your game on, go play
Hey now you're a Rock Star get the show on, get paid
And all that glitters is gold
Only shooting stars break the mold

It's a cool place and they say it gets colder
You're bundled up now but wait 'til you get older
But the meteor men beg to differ
Judging by the hole in the satellite picture

The ice we skate is getting pretty thin
The waters getting warm so you might as well swim
My world's on fire how about yours
That's the way I like it and I never get bored

[Repeat Chorus 2x]

Somebody once asked could you spare some change for gas
I need to get myself away from this place
I said yep what a concept
I could use a little fuel myself
And we could all use a little change

Well the years start coming and they don't stop coming
Fed to the rules and I hit the ground running
 Didn't make sense not to live for fun
Your brain gets smart but your head gets dumb

So much to do so much to see
So what's wrong with taking the back streets
You'll never know if you don't go
You'll never shine if you don't glow

[Repeat Chorus]
**Dancing Queen**

See that girl, watch that scene, dig in the Dancing Queen

Friday night and the lights are low
Looking out for the place to go
Where they play the right music, getting in the swing
You come in to look for a king
Anybody could be that guy
Night is young and the music's high
With a bit of rock music, everything is fine
You're in the mood for a dance
And when you get the chance...

You are the Dancing Queen, young and sweet, only seventeen
Dancing Queen, feel the beat from the tambourine
You can dance, you can jive, having the time of your life
See that girl, watch that scene, dig in the Dancing Queen

You're a teaser, you turn 'em on
Leave them burning and then you're gone
Looking out for another, anyone will do
You're in the mood for a dance
And when you get the chance...

You are the Dancing Queen, young and sweet, only seventeen
Dancing Queen, feel the beat from the tambourine
You can dance, you can jive, having the time of your life
See that girl, watch that scene, dig in the Dancing Queen
Footloose
I’ve been working so hard
I’m punching my card
Eight hours for what?
Oh, tell me what I got

I’ve got this feeling
That time’s just holding me down
I’ll hit the ceiling or else I’ll tear up this town
Tonight I gotta cut

Loose, footloose kick of your Sunday shoes
Please, Louise pull me off a my knees
Jack, get back c’mon before we crack
Lose your blues everybody cut footloose

And you’re playing so cool
Obeying every rule
I dig a way down in your heart
You’re burning, yearning for songs

Somebody to tell you
That life ain’t passing you by
I’m trying to tell you
It will if you don’t even try
You can fly if you’d only cut

Loose, footloose kick off your Sunday shoes
Oowhee, Marie shake it, shake it for me
Whoa, Milo, c’mon, c’mon let’s go
Lose your blues everybody cut footloose

Cut footloose
Cut footloose
Cut footloose

We got to turn me around
And put your feet on the ground
Now take a hold of the phone
Whoa, I’m turning it loose

Loose, footloose kick off your Sunday shoes
Please, Louise, pull me off a my knees
Jack, get back c’mon before we crack
Lose your blues now everybody cut footloose

Loose, footloose kick of your Sunday shoes
Please, Louise pull me off a my knees
Jack, get back c’mon before we crack
Lose your blues

Everybody cut everybody cut
Everybody cut everybody cut
Everybody cut everybody cut
Everybody everybody cut footloose
Build me Up Buttercup
Why do you build me up (Build me up)
Buttercup baby just to
let me down (Let me down)
And mess me around
And then worst of all (Worst of all)
You never call baby
When you say you will (Say you will)
But I love you still
I need you (I need you)
More than anyone darlin'
You know that I have from the start

So build me up (Build me up)
Buttercup
Don't break my heart
I'll be over at ten
You tell me time and again
But you're late
I wait around and then
I went to the door
I can't take any more
It's not you
You let me down again

Baby Baby
Try to find a little time
And I'll make you happy
I'll be home
I'll be waiting beside the phone
Waiting for you.

Why do you build me up....
To you I'm a toy
But I could be the boy
You adore
If you'd just let me know
Although you're untrue
I'm attracted to you
All the more
Why do I need you so Baby Baby.....

ooh ooh ooh
Why do build me up .....
Just the Two of Us
Just the two of us, yeah
Just the two of us
Just the two us

From the first time the doctor placed you in my arms
I knew I’d meet death ‘for I’d let you meet harm
Although questions arose in my mind, would I be man enough?
Against wrong, choose right and be standin’ up
From the hospital that first night
Took an hour just to get the car seat in right
People drivin’ all fast, got me kinda upset
Got you home safe, placed you in your bassinette

That night I don’t think one wink I slept
As I slipped out my bed, to your crib I crept
Touched your head gently, felt my heart melt
‘Cause I know I loved you more than life itself

Then to my knees, and I begged the Lord please
Let me be a good daddy, all he needs
Love knowledge, discipline too
I pledge my life to you, uh

Just the two of us, we can make it if we try
Just the two of us
Just the two of us, building castles in the sky
Just the two of us, you and I

Five years old, bringing comedy
Everytime I look at you I think man a little me just like me
Wait an’ see gonna be tall makes me laugh ‘cause
You got your dads ears an’ all
Sometimes I wonder, what you gonna be?
A General, a Doctor, maybe a MC
Haha, I wanna kiss you all the time
But I will test that butt when you cut outta line
True dat uh uh uh why you do dat?
I try to be a tough dad, but be makin’ me laugh
Crazy joy, when I see the eyes of my baby boy
I pledge to you, I will always do
Everything I can show you how to be a man
Dignity, integrity, honor an’ I don’t mind if you lose
Long as you came with it an’ you can cry, ain’t no shame in it

It didn’t work out with me an’ you mom
But yo, push come to shove you was conceived in love
So if the world attacks, and you slide off track
Remember one fact, I got your back

Just the two of us, we can make it if we try
Just the two of us
Just the two of us, building castles in the sky
Just the two of us, you and I

It’s a full time job to be a good dad
You got so much more stuff than I had
I gotta study just to keep with the changin’ times
101 Dalmations on you CD-ROM
See me, I’m tryin’ to pretend I know
On my PC where that CD go

But yo, ain’t nuthin’ promised, one day I’ll be gone
Feel the strife, but trust life does go wrong
But just in case, it’s my place to impart
One day some girl’s gonna break your heart
And ooh ain’t no pain like from the opposite sex
Gonna hurt bad, but don’t take it out on the next son
Throughout life people will make you mad
Disrespect you and treat you bad
Let God deal with the things they do
‘Cause hate in your heart will consume you too
Always tell the truth, say your prayers
Hold doors, pull out chairs, easy on the swears
You’re living proof that dreams come true
I love you and I’m here for you, uh

Just the two of us, we can make it if we try
Just the two of us
Just the two of us, building castles in the sky
Just the two of us, you and I

Just the two of us
Just the two of us, building castles in the sky
Just the two of us, you and I

Just the two of us, I’m always here for you
Whatever you need just call on me
Whatever you need I’ll be there for anytime
You and I

Just the two of us
Just the two of us, building castles in the sky
Just the two of us, you and I
Man! I Feel like a Woman!

Gonna let it all hang out
Wanna make some noise-really raise my voice
Yeah, I wanna scream and shout
No inhibitions-make no conditions
Get a little outta line
I ain't gonna act politically correct
I only wanna have a good time

The best thing about being a woman
Is the prerogative to have a little fun and...

Oh, oh, oh, go totally crazy-forget I'm a lady
Men's shirts-short skirts
Oh, oh, oh, really go wild-yeah, doin' it in style
Oh, oh, oh, get in the action-feel the attraction
Color my hair-do what I dare
Oh, oh, oh, I wanna be free-yeah, to feel the way I feel
Man! I feel like a woman!

The girls need a break-tonight we're gonna take
The chance to get out on the town
We don't need romance-we only wanna dance
We're gonna let our hair hang down

The best thing about being a woman
Is the prerogative to have a little fun and...

Oh, oh, oh, go totally crazy-forget I'm a lady
Men's shirts-short skirts
Oh, oh, oh, really go wild-yeah, doin' it in style
Oh, oh, oh, get in the action-feel the attraction
Color my hair-do what I dare
Oh, oh, oh, I wanna be free-yah, to feel the way I feel 
Man! I feel like a woman!

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Men's shirts-short skirts
Oh, oh, oh, really go wild-yah, doin' it in style
Oh, oh, oh, get in the action-feel the attraction
Color my hair-do what I dare
Oh, oh, oh, I wanna be free-yah, to feel the way I feel
Man! I feel like a woman!

I get totally crazy
Can you feel it
Come, come, come on baby
I feel like a woman
Independent Women

Charlie's Angels, Come on
Uh uh uh

Question: Tell me what you think about me
I buy my own diamonds and I buy my own rings
Only ring your cell-y when I'm feelin’ lonely
When it's all over please get up and leave
Question: Tell me how you feel about this
Try to control me boy you get dismissed
Pay my own fun, oh and I pay my own bills
Always 50/50 in relationships

The shoes on my feet
I've bought it
The clothes I'm wearing
I've bought it
The rock I'm rockin'
'Cause I depend on me
If I wanted the watch you're wearin'
I'll buy it
The house I live in
I've bought it
The car I'm driving
I've bought it
I depend on me
(I depend on me)

All the women who are independent
Throw your hands up at me
All the honeys who makin' money
Throw your hands up at me
All the mommas who profit dollas
Throw your hands up at me
All the ladies who truly feel me
Throw your hands up at me

Girl I didn't know you could get down like that
Charlie, how your Angels get down like that
Girl I didn't know you could get down like that
Charlie, how your Angels get down like that

Tell me how you feel about this
Who would I want if I would wanna live
I worked hard and sacrificed to get what I get
Ladies, it ain't easy bein' independent
Question: How'd you like this knowledge that I brought
Braggin' on that cash that he gave you is to front
If you're gonna brag make sure it's your money you flaunt
Depend on no one else to give you what you want

The shoes on my feet
I've bought it
The clothes I'm wearing
I've bought it
The rock I'm rockin'
'Cause I depend on me
If I wanted the watch you're wearin'
I'll buy it
The house I live in
I've bought it
The car I'm driving
I've bought it
I depend on me
(I depend on me)

All the women who are independent
Throw your hands up at me
All the honeys who makin' money
Throw your hands up at me
All the mommas who profit dollars
Throw your hands up at me
All the ladies who truly feel me
Throw your hands up at me

Girl I didn't know you could get down like that
Charlie, how your Angels get down like that
Girl I didn't know you could get down like that
Charlie, how your Angels get down like that

Destiny's Child
Wassup?
You in the house?
Sure 'nuff
We'll break these people off Angel style

Child of Destiny
Independent beauty
No one else can scare me
Charlie's Angels

Woah
All the women who are independent
Throw your hands up at me
All the honeys who makin' money
Throw your hands up at me
All the mommas who profit dollars
Throw your hands up at me
All the ladies who truly feel me
Throw your hands up at me

Girl I didn't know you could get down like that
Charlie, how your Angels get down like that

[repeat until fade]
Fireflies

You would not believe your eyes
If ten million fireflies
Lit up the world as I fell asleep

'Cause they fill the open air
And leave teardrops everywhere
You'd think me rude
But I would just stand and stare

I'd like to make myself believe that planet earth turns slowly
It's hard to say that I'd rather stay awake when I'm asleep
'Cause everything is never as it seems

'Cause I'd get a thousand hugs
From ten thousand lightning bugs
As they tried to teach me how to dance

A foxtrot above my head
A sock hop beneath my bed
A disco ball is just hanging by a thread (thread, thread)

I'd like to make myself believe that planet earth turns slowly
It's hard to say that I'd rather stay awake when I'm asleep
'Cause everything is never as it seems
When I fall asleep

Leave my door open just a crack
Please take me away from here
'Cause I feel like such a insomniac
Please take me away from here
Why do I tire of counting sheep
Please take me away from here
When I'm far too tired to fall asleep

To ten million fireflies
I'm weird cause I hate goodbyes
I got misty eyes as they said farewell (said farewell)

But I'll know where several are
If my dreams get real bizarre
'Cause I saved a few and I keep them in a jar (jar, jar)

I'd like to make myself believe that planet earth turns slowly
It's hard to say that I'd rather stay awake when I'm asleep
'Cause everything is never as it seems
When I fall asleep

I'd like to make myself believe that planet earth turns slowly
It's hard to say that I'd rather stay awake when I'm asleep
'Cause everything is never as it seems
When I fall asleep

I'd like to make myself believe that planet earth turns slowly
It's hard to say that I'd rather stay awake when I'm asleep
Because my dreams are bursting at the seams
Kill the Beast
Gaston: The beast will make off with your children, he'll come after them in the night. We're not safe 'till his head is mounted on my wall. I say we kill the beast!

Man: We're not safe until he's dead.  
Man 2: He'll come stalking us at night.  
Woman: Set to sacrifice our children to his monstrous appetite.  
Man 3: He'll wreak havoc on our village if we let him wander free!

Gaston: So it's time to take some action boys!  
It's time---to---fol---low---me!

Through the mist, through the woods, through the darkness and the shadows. It's a nightmare but it one exciting ride. Say a prayer, then we're there, at the drawbridge of a castle, and there's something truly terrible inside.

It's a beast, he's got fangs razor sharp ones. Massive paws, killer claws for the feed. Hear him roar, see him foam, but we're not coming home, 'till he's dead, good and dead. Kill the beast.

Belle: NO! I won't let you do this!  
Gaston: If you're not with us, you're against. Bring the old man!  
Maurice: Get your hands off me!  
Gaston: We can't have them running off to warn the creature. Belle: Let us out!  
Gaston: We'll rid the village of this beast, who's with me?!
Chorus:
Get your torch, mount you horse,

Gaston:
Through your courage to the stinking place.

Chorus:
We're counting on your stud to lead the way.
Through a mist to the wood, where we see a haunted castle,
something's lurking that you don't see every day.
It's a beast, just as tall as a mountain,
We won't rest 'till he's good and deceased.
Steady fourth, tally ho! Grab your sword, grab your bow!
Let's get on and here we go!

Gaston: We'll lay siege to the castle, and bring back his head!

Belle: We have to warn the beast. This is all my fault.
Oh papa what are we going to do?!
Maurice: Now, now. We'll think of something.
Chip: AWWWWWW!

Chorus: We don't like what we don't...
understand and in fact it scares us,
and this monster is mysterious at least.
Bring your guns, bring your knives,
save children and your wives,
so save our village and our lives!
LET'S KILL THE BEAST!

Cogsworth: I knew it, I knew it was foolish to get our hopes up.
Lumiere: Maybe it would have been better if she'd never come at all.
Dog barks
Lumiere: Could it be?
Mrs Potts: Is it she?
Lumiere: Scara bleu! Invaders!
Cogsworth: Encroachers!
Mrs Potts: and they 'ave the mirror!
Cogsworth: Warn the master. If it's a fight they want,
we'll be ready for them. Who's with me! Arrrgh!

Gaston: Take whatever booty you can find, but remember!
THE BEAST IS MINE!

Castle Furnishings:
Find a place, stand aside, we go marching into battle,
unafraid of all the things you just decreed.

Village chorus:
Raise the ram, sing this song,
here we come at fifty strong.
If fifty frenchmen can be wrong,
let's kill the beast!
I Whip my Hair
I whip my hair back and forth
I whip my hair back and forth (just whip it)
I whip my hair back and forth
I whip my hair back and forth (whip it real good)
I whip my hair back and forth x4

Hop up out the bed turn my swag on
Pay no attention to them haters
Because we whip ‘em off
And we ain’t doin’ nothin’ wrong
So don’t tell me nothin’
I’m just trying to have fun
So keep the party jumping
So what’s up? (yeah)
You know they don't know what to do
we turn our back and whip our hair…
shake ‘em off (x4)

Don’t let haters get me off my grind
Keep my head up and I know I’ll be fine
Keep fighting until I get there
When I’m down and I feel like giving up

(chorus x3)
I whip my hair back and forth
I whip my hair back and forth (just whip it)
I whip my hair back and forth
I whip my hair back and forth (whip it real good)
I whip my hair back and forth x4

Imma get more shine in a little bit
soon as I hit the stage
applause I’m hearing it
whether it’s black stars, black cars, I’m feeling it

But can’t none of them will whip it like I do
I, I gets it in mm-yeah go hard
When they see me pull up
I whip it real hard x2
Real hard
I Whip it real hard

Don’t let haters get me off my grind
Keep my head up and I know I’ll be fine
Keep fighting until I get there
When I’m down and I feel like giving up

(chorus x2)
I whip my hair back and forth
I whip my hair back and forth (just whip it)
I whip my hair back and forth
I whip my hair back and forth (whip it real good)
I whip my hair back and forth x4

(x2)
All my ladies if you feel it
Come on, do it, do it
Whip your hair (whip your hair)
Don’t matter if it’s long, short
Do it, do it whip your hair!
Your hair, your hair

(chorus x3)
I whip my hair back and forth
I whip my hair back and forth (just whip it)
I whip my hair back and forth
I whip my hair back and forth (whip it real good)
I whip my hair back and forth x4
Appendix E
Sheet Music for the "Chanting and Playing Hand Clap Games" Tasks
Miss Mary Mack

Miss Mary Mack Mack Mack All dressed in black black black With silver buttons
but-tons but-tons All down her back back back
She asked her mother mother mother For fifty cents cents cents To see the el-e-phants
el-e-phants el-e-phants Jump over the fence fence fence

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They jumped so high high high They touched
the sky sky sky They didn't come back back back
Till the fourth of July July July
Miss Susie

Miss Susie had a baby she named Tiny

Tim She put him in the bath tub to see if he could swim

He drank up all the water He ate up all the soap

He tried to eat the bath tub but it didn’t fit down his throat

Miss Susie called the doctor Miss Susie called the nurse

Miss Susie called the lady with the alligator purse

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In came the doctor
In came the nurse
In came the lady with the alligator purse
Mumps

said the doctor
Measles said the nurse
Hiccups said the

lady with the alligator purse
Miss Susie punched the

doctor Miss Susie kicked the nurse
Miss Susie thanked the

lady with the alligator purse
Pat-a Cake

Pat-a cake Pat-a cake baker's man Bake me a cake as fast as you can

Pat it and prick it and mark it with a B and put it in the oven for baby and me

Patt-y cake Patt-y cake baker's man Bake me a cake as fast as you can

Roll it up Roll it up and throw it in a pan Patt-y cake Patt-y cake baker's man
When you eat your smarties do you eat the red ones last? Do you suck them very slowly or crunch them very fast? Eat that candy coated chocolate but tell me when I ask. When you eat your smarties do you eat the red ones last?
Rockin' Robin

He rocks in the tree top all day long hop-pin' and a bop-pin' and a sing-in' the song

All the lit-tle birds on J. Bird Street Love to hear the ro-bin go-in' tweet tweet tweet

Rock-in' rob-in' tweet twee da lee Rock-in' rob-in' tweet twee da lee Oh rock-in' rob-in' well you

real-ly gon-na rock to-night Eve-ry lit-tle swal-low eve-ry chick-a-dee
eve-ry lit-tle bird in the tall oak tree The wise old owl The big black crow

flap-pin' them wings say-in' go bird go He rocks in the tree-top all day long
Hop-pin' and a bop-pin' and a sing-in' the song
All the lit-tle birds on J. Bird Street

Love to hear the rob-in go-in' tweet tweet tweet
Down by the Banks

Down by the banks of the hank-y pank-y where there bullfrog jumps from bank to bank with

eeps opps I wanna piece of pie Piece of pie too sweet I wanna piece of meat Piece of meat to tough I wanna ride a bus Bus too full I wanna ride a bull Bull too black I want my mon-ey back Mon-ey back too green I want a jell-y bean Jell-y bean not cooked I wanna read a book Book too red I wanna go to bed Bed not made I want some lem-o nade Lem-o nade too sour I got that funk-y pow-er
Bo-bo

Bo bo ski watt-en tott-en nay nay nay nay boom boom boom


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Appendix F

Poems and Questions Used in the Task “Poetry”

At the Zoo
First I saw the white bear, then I saw the black;
Then I saw the camel with a hump upon his back;
Then I saw the grey wolf, with mutton in his maw;
Then I saw the wombat waddle in the straw;
Then I saw the elephant a-waving of his trunk;
Then I saw the monkeys-mercy, how unpleasantly they-smelt!

1. Which is the right way of saying this word?—camel or camell?

2. Would the rhythm of the poem be messed up if I replaced the word “wolf” with “buffalo”? (Read the poem from the beginning, read line 3 with both words)

3. Which fits the poem better?
   First I saw the white bear, then I saw the black;
   Then I saw the camel with a hump upon his back
   OR
   First I saw the white bear, then I saw the black;
   Then I saw the camel with a hump upon his back
Danny O’Dare

Danny O’Dare, the dancin’ bear,
Ran away from the County Fair,
Ran right up to my back stair
And thought he’d do some dancin’ there.
He started jumpin’ and skippin’ and kickin’,
He did a dance called the Funky Chicken,
He did the Polka, he did the Twist,
He bent himself into a pretzel like this.
He did the Dog and the Jitterbug,
He did the Jerk and the Bunny Hug.
He did the Waltz and the Boogaloo,
He did the Hokey-Pokey too.
He did the Bop and the Mashed Potata,
He did the Split and the See Ya Later.
And now he’s down upon one knee,
Bowin’ oh so charmingly,
And winkin’ and smilin’—it’s easy to see
Danny O’Dare wants to dance with me.

1. Which is the right way of saying this word, county or county?

2. Would the rhythm of the poem be messed up if I replaced the word “jumpin’ “ with the word “singin’ “? (Read poem from the beginning, read line 5 with both words)

3. Which fits the poem better?

   Danny O’Dare, the dancin’ bear
   Ran away from the County Fair
   Ran right up to my back stair

   OR

   Danny O’Dare, the dancin’ bear
   Ran away from the County Fair
   Ran right up to my back stair
The Star

Twinkle, twinkle, little star,
How I wonder what you are!
Up above the world so high,
Like a diamond in the sky.

When the blazing sun is gone,
When he nothing shines upon,
Then you show your little light,
Twinkle, twinkle, all the night.

Then the traveler in the dark,
Thank you for your tiny spark,
He could not see which way to go,
If you did not twinkle so.

In the dark blue sky you keep,
And often through my curtains peep,
For you never shut your eye,
Till the sun is in the sky.

As your bright and tiny spark,
Lights the traveler in the dark-
Though I know not what you are,
Twinkle, twinkle, little star.
1. Which is the right way of saying this word, curtains or curtains?
2. Would the rhythm of the poem be messed up if I replaced the word “blazing” with “hot”? (Read poem from the beginning, reading line 5 with both words)
3. Which fits the poem better?
   When the blazing sun is gone,
   When he nothing shines upon,
   Then you **show** your **little light**
   OR
   When the blazing sun is gone,
   When he nothing shines upon,
   Then **you** show **your little light**
Bear In There

There's a Polar Bear
In our Frigidaire--
He likes it 'cause it's cold in there.
With his seat in the meat
And his face in the fish
And his big hairy paws
In the buttery dish,
He's nibbling the noodles,
He's munching the rice,
He's slurping the soda,
He's licking the ice.
And he lets out a roar
If you open the door.
And it gives me a scare
To know he's in there--
That Polary Bear
In our Fridgitydaire.

1. Which is the right way of saying this word, licking or licking?
2. Would the rhythm of the poem be messed up if you replaced the word “cold” with “freezing”? (Read poem from the beginning, read line 3 with both words)
3. Which fits the poem better?
   He's nibbling the noodles,
   He's munching the rice,
   He’s slurping the soda?
   OR
   He's nibbling the noodles,
   He's munching the rice,
   He’s slurping the soda
The First Tooth

Through the house what busy joy,
Just because the infant boy
Has a tiny tooth to show!
I have got a double row,
All as white, and all as small;
Yet no one cares for mine at all.
He can say but half a word,
Yet that single sound's preferred
To all the words that I can say
In the longest summer day.
He cannot walk, yet if he put
With mimic motion out his foot,
As if he thought he were advancing,
It's prized more than my best dancing.

1. Which is the right way of saying this word, motion or motion?
2. Would the rhythm of the poem be messed up if you replaced the word “summer” with “autumn”?
   (He can say but half a word,
    Yet that single sound's preferred
    To all the words that I can say
    In the longest summer/autumn day)
3. Which fits the poem better,
   Through the house what busy joy
   Just because the infant boy
   OR
   Through the house what busy joy
   Just because the infant boy
Peanut-Butter Sandwich

I'll sing you a poem of a silly young king
Who played with the world at the end of a string,
But he only loved one single thing—
And that was just a peanut-butter sandwich.
His scepter and his royal gowns,
His regal throne and golden crowns
Were brown and sticky from the mounds
And drippings from each peanut-butter sandwich.
His subjects all were silly fools
For he had passed a royal rule
That all that they could learn in school
Was how to make a peanut-butter sandwich.
He would not eat his sovereign steak,
He scorned his soup and kingly cake,
And told his courtly cook to bake
An extra-sticky peanut-butter sandwich.
And then one day he took a bite
And started chewing with delight,
But found his mouth was stuck quite tight
From that last bite of peanut-butter sandwich.
His brother pulled, his sister cried,
The wizard pushed, his mother cried,
"My boy's committed suicide
From eating his last peanut-butter sandwich!"
The dentist came, and the royal doc.
The royal plumber banged and knocked,
But still those jaws stayed tightly locked.
Oh darn that sticky peanut-butter sandwich!
The carpenter, he tried with pliers,
The telephone man tried with wires,
The firemen, they tried with fire,
But couldn't melt that peanut-butter sandwich.
With ropes and pulleys, drills and coil,
With steam and lubricating oil—
For twenty years of tears and toil—
They fought that awful peanut-butter sandwich.
Then all his royal subjects came.
They hooked his jaws with grapplin' chains
And pulled both ways with might and main
Against that stubborn peanut-butter sandwich.
Each man and woman, girl and boy
Put down their ploughs and pots and toys
And pulled until kerack! Oh, joy—
They broke right through that peanut-butter sandwich
A puff of dust, a screech, a squeak—
The king's jaw opened with a creak.
And then in voice so faint and weak—
The first words that they heard him speak
Were, "How about a peanut-butter sandwich?"

1. Which is the right way of saying it, delight or delight?
2. Would the rhythm of the poem be messed up if you replaced “kingly” with “stately”?
   (He would not eat his sovereign steak,
   He scorned his soup and kingly/stately cake)
3. Which fits the poem better?
   I'll sing you a poem of a silly young king
   Who played with the world at the end of a string
   OR
   I'll sing you a poem of a silly young king
   Who played with the world at the end of a string?