A ‘Note’-able Study: How the Thinking in Music Curriculum Impacts Preschool-aged Individuals’ Cognitive Development

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Abstract

Previous researchers have found that students partaking in a music curriculum experienced a plethora of cognitive benefits such as an increase in their mathematic, literacy, and visuo-spatial skills. The aim of this study was to examine cognitive outcomes of the Thinking in Music curriculum on preschool students ages 3 to 5 years. The hypothesis was that students experiencing the Thinking in Music curriculum would produce greater improvements over pre-curriculum to post-curriculum time points on tasks assessing working memory, categorization, and executive functioning relative to their age-matched peers not receiving the curriculum. For the memory assessment, all participants decreased their attempted trials needed to reach a final score but did not improve on their total memory set score. Relative to participants in the control group, curriculum participants showed an increased ability to learn a new rule in the categorization task. Relative to participants in the control group, more curriculum participants completed the computerized attention task at both time points, both groups significantly improved on their hit reaction time, however neither group significantly improved on their percent omission errors or percent commission errors. Future researchers should continue to study the curriculum as well as increase the sample size and duration of the curriculum.

Keywords: Music curriculum, preschool, cognitive effects, Working Memory Capacity, attention, impulsivity, sort, sequence.
A ‘Note’-able Study: How the Thinking in Music Curriculum Impacts Preschool-Aged Individual’s Cognitive Development

Over time many preschools have incorporated varied modalities of learning in order to sharpen their students’ minds and to engage different types of learners. Previous research points toward the conclusion that “music makes you smarter” (Demorest & Morrison, 2000), but potentially such a claim has been overstated. I sought to examine this oft-repeated claim in relation to the Thinking in Music curriculum with preschool-aged students.

Previous research has documented significant improvement in reading and mathematics for 5-7 year old first grade students who experienced an enriched curriculum in music and visual arts (Gardiner et al. 1996). This curriculum was based on the Kodaly Method of Music Training (Chosky, 1981). This method focuses on musical pitch as well as emphasizes discriminating between rhythm pattern types and avoids counting rhythms (Gardiner, 2000). A teacher begins teaching pitch with two-note scales and progresses to expand to scales with more notes. Each level is represented by a different hand signal, thus providing a visual representation for “higher” and “lower” scale positions (Chosky, 1981). Also, Gardiner (2000) found this method to be particularly compelling as it was originally developed as a pedagogy to be provided to all students as part of their general education beginning in kindergarten. Traditionally, music education in Hungary was only given to students in secondary school, thus this revolutionary method introduced younger students to quality music education (Chosky, 1981).

In Gardiner’s study (Gardiner et al. 1996), half of the students participated in the music and visual-arts curriculum (lasting for an hour and forty minutes each week) that incorporated the Kodaly method, which emphasized sequence skill development. During this time, the other half of the students received standard arts classes that emphasized appreciation over skill (60
minutes a week). After seven months, test scores on the Metropolitan Achievement tests were compared across the two groups. They noted that those in the enriched music classes started behind the national average, but caught up on reading and were now ahead in math. While both groups included music, participants in the music-skills curriculum improved on reading and math, while participants in the music-appreciation program did not – thus indicating that it is the skill-learning aspect of this music curriculum that directly impacted academic performance.

Gardiner and colleagues (1996) also implemented this program the following year, when students were in second grade, and noted that students who had the program two years in a row did even better on reading and math than students who received the curriculum for only one year. Students in their first year did well, and students with no extra art and music did poorest on the tests. Thus this study indicates that specific music instruction can positively affect cognition as measured by standardized Metropolitan Achievement Tests.

Gardiner suggested that the students viewed the participation in the arts activities to be pleasurable and thus felt an increase in motivation to acquire skills related to the music program (Gardiner, 1996). He also suggested that their success in music class increased students’ feelings of positivity toward school and enhanced their ability to be more successful in their academic coursework. He proposed that such a curriculum would also encourage the development of other skills such as improving children’s ability to focus, conceptualize, and categorize information as well as specifically aid learning in the arts and other areas such as reading, writing, and mathematics.

Gardiner further attributed the students’ success to their ability to incorporate and internalize sequences, which he suggested are mechanisms affected by learning about pitch and melodies (1996). He suggested that in pitch engagement, there is a sequential representation of
ordering of discrete pitches from lower to higher according to vibration frequency. This up and down movement could potentially help learners directly with addition and subtraction. He suggested that this skill helps with “numberness” and involves a new way of thinking, as opposed to remembering numbers as just other words. Gardiner pointed out that the memorizing method for doing arithmetic requires students to remember more and more facts. However, if the child could learn how to move up and down the musical scale from pitch to pitch, then they would develop a new and more generalizable way of organizing numbers.

More recently, Zuk and colleagues (2013) examined how early language and reading abilities correlated with musical skills and elements of musical perception in Portuguese elementary aged-children. They investigated the relationship between cognitive-linguistic abilities (alphabet task, reading tasks, writing tasks, phonological tasks, rhythm production tasks, and memory tasks) and a music discrimination task. The music task was presented in the music classroom and all of the participants were asked to code for four sounds on the guitar. Zuk and colleagues’ (2013) results indicated a strong relationship between performance on the music task and linguistic variables. Their analyses revealed that performance on the Musical Sequence Transcription task related to reading ability and phonological processing, which were consistent with a previous report of a correlation between music perception and training, and reading and phonological processing skills (Zuk et al. 2013). They suggested that their results imply that schools may be able to use a music-based screening test to identify reading disabilities.

Additional research has examined the effects of other music curricula on the development of visuo-spatial skills. Rauscher and colleagues (1997) conducted a study with children aged 4-6 years and examined the effects of music training on children’s spatial-temporal reasoning. The participants were divided into three groups: those who received private piano keyboard lessons,
those who received private computer lessons, and controls who did not receive either. They chose computer lessons given by a professional computer instructor in order to control for the motor and visual coordination and personal attention also offered by the piano keyboard lessons and professional keyboard instructors. They chose to use piano keyboards because a keyboard gives a visual linear representation of the spatial relationships between pitches. They provided their participants with 10-minute private keyboard lessons that consisted of performance exercises. The children studied pitch intervals, fine motor coordination, fingering techniques, sight-reading, music notation, and playing from memory.

The children were administered one spatial-temporal reasoning test (Object Assembly) and three spatial recognition tests (Geometric Design, Block Design, and Animal Pegs) from the Wechsler Preschool and Primary Scale of Intelligence Revised (WPPSI-R). Change was obtained by calculating the difference from pre-test scores to the post-test scores. Their results indicated that preschool children who received private piano keyboard lessons showed significant improvement on a spatial-temporal test relative to their peers who received computer lessons and controls. Thus, they concluded that the piano instruction itself, not one-on-one instruction or keyboard practice, was the cause of the behavioral change. They concluded that music training could produce long-term cognitive modifications, specifically with regard to academic subjects that involve spatial-temporal reasoning such as math and science.

Music curricula have also been hypothesized to improve math skills in preschool-aged children. Harris (2005) explored the effects of music instruction in Montessori classrooms on the development of math skills. A sample of 190 3-5 year olds was divided into an experimental group, which received six months of music-enriched Montessori instruction, and a control group that received traditional Montessori instruction. The music instruction for the experimental group
focused on concepts of pitch, dynamics, duration, timbre and form as well as skills in moving, playing, listening, singing, and organizing sounds. Both groups were pre- and post-tested with a range of math skills assessed. Results indicated that children in the music group had higher math skills in all three age groups relative to their control peers.

Harris (2008) hypothesized that music is a particularly effective method for developing cognitive skills in a broad range of learners because it encompasses multiple skills and behaviors that generalize to other domains of cognition. The Harris (2008) study is important as it indicates a shift from looking at the traditionally studied effects of music curricula on mathematics and visuo-spatial skills, to more broad topics such as other cognitive skills and development.

Our research focused on the Thinking in Music (TiM) curriculum and its potential to affect multiple cognitive domains. TiM was created to apply Gardiner’s previous work to preschoolers. According to Gardiner,

_Thinking in Music_ is a program for preschool aged children aimed at introducing young people to the joys and values of music and other arts, at the same time helping them to develop themselves and learn more affectively… The goal of _Thinking in Music_ is to develop cognitive and physical skills that will lead to strategies promoting learning and engagement. Specifically, these activities help young children: develop strategies to improve focusing, conceptualizing, and categorizing, develop mental skills which will aid academics, sports, and daily life, and develop a foundation for further learning in music and other arts (Gardiner, 2011).

Thus, the curriculum was designed to affect particular emotional, social, and cognitive domains, and the curriculum contains specific methods that are supposed to affect those domains. With previous research in mind, this research study focused on three cognitive domains that Gardiner
explicitly states will benefit from the TiM curriculum: working memory, categorization, and attention. I created a wait-list control design with age-matched peers whereby one group of students would receive the curriculum first and the other group would receive it second. The first phase includes a comparison of curriculum and non-curriculum participants.

I examined how student’s working memory capacity is affected by participation in the TiM curriculum. I used the Missing Scan Task (MST), a modified version of the Digit Span Task that uses stuffed animals to represent a memory set. I predicted that relative to the students who were not exposed to the TiM curriculum, the students receiving it would have more improved working memory capacity between their pre-tests and post-tests.

I also examined how student’s categorization and set-switching skills are affected by participation in the TiM curriculum. To assess categorization, I used a modified version of the Dimensional Change Card Sort (DCCS) with small motor toys rather than cards. I predicted that relative to the students who were not exposed to the TiM curriculum, the students receiving it would have more improved categorization and set-switching ability between their pre-tests and post-tests.

I also examined how student’s attention and executive functioning is affected by participation in the TiM curriculum. To assess attention, I used the Conner’s Kiddie Continuous Performance Task, a standardized visual scan task that was normed for 4-7 year olds. I predicted that relative to the students who were not exposed to the TiM curriculum, the students receiving it would have more improved attention and executive functioning between their pre-tests and post-tests.

I used the three aforementioned tabletop tasks to determine whether these several aspects of students’ cognitive development changed as a result of participating in the *Thinking in Music*
curriculum. I conducted both between and within subjects analyses in order to determine what growth can be accounted for by the TiM curriculum rather than typical cognitive development due to aging and a general preschool curriculum, which includes informal music throughout the day. This study sought to examine specific skills that Gardiner claimed would be improved by this particular music curriculum and to provide preliminary documentation of the efficacy of the TiM curriculum.

**Method**

**Participants**

The participants in this study included 3-5 year olds enrolled in a selected preschool for the 2017-2018 school year. We recruited 33 participants to participate in the curriculum itself, 32 of whom consented to also be a part of the individual pre- and post-curriculum assessments. All of the participants were minors, but they gave their verbal assent each time I studied them individually. Prior to data collection, their guardians signed two consent forms on their child’s behalf that were approved by the Brandeis IRB. Please see Appendix A for the first consent form that allowed for participation in the group assessment of the curriculum. Please see Appendix B for the second consent form that allowed for participation in the individual tabletop tasks. Upon receipt of signed consent forms, a demographic questionnaire was provided for parents to complete. Please see Appendix C for the demographic questionnaire. The questionnaire asked about the number of individuals in the household, language, ethnicity, parents or guardians marital status, range of household income per year, and level of education of both parents or guardians.

Lemberg Children’s Center was the selected preschool site. They offer childcare to 76 children aged 6 weeks to 6 years. They have two infant rooms (ages 2 months to 21 months), two
toddler rooms (ages 22 months to 32 months), and two preschool rooms (ages 33 months to kindergarten enrollment). Both of their preschool classrooms are mixed-ages, so students range from 3-5 years old in both classrooms and together they have 41 students enrolled in their preschool program.

Children in the sample were required to meet two selection criteria: (a) ≥ 3 years of age and (b) be able to communicate assessment responses in English. The sample was slightly overrepresented by males (57.58%, N=19) as opposed to females (42.42%, N=14), and participant ages ranged from 3-5 years ($M = 51.40$ months, $SD = 8.23$). The sample was mostly composed of students of Caucasian and Asian descent (Caucasian N = 22, Hispanic N = 1, Asian/Pacific Islander N = 7, White and Asian/Pacific Islander N=1, Other N =2). Of the 31 participants that we had demographic information about, 29 participants’ parents were married, 1 couple was living together, and 1 came from a divorced household. Of this same group of 31 students, we had no information about the range of household income for 4 participants, 1 came from a $0-50,000 range, 1 came from a $75,000-100,000 range, 4 came from a $100,000-125,000 range, and 21 came from a $125,000+ range. With regard to parent education, of the 31 students, for parent 1, 2 did not provide information, 7 had a college diploma, 11 had a Master’s Degree and 13 had a Professional Degree. Of the 31 students who we had demographic information about, for parent 2, 2 did not provide information, 1 had some college, 6 had a college diploma, 9 had a Master’s Degree and 15 had a Professional Degree.

**Measures**

**Group Instruction**
This study was a semi-randomized wait-list control model and thus consisted of two groups of participants. One group received the curriculum first, while the other served as a wait-list control. To address fidelity to the TiM curriculum and child engagement, every TiM lesson was video- and audio-recorded during each period. Students participated in the TiM lessons only if their guardians consented to their participation in the group assessment and therefore could be video and audio recorded. Analyses of these videotapes is not included in this thesis.

**Individual Assessment**

The students participated in one-on-one tasks with the experimenter at two time points. For some of the assessments, time 1 was pre-curriculum, but for other assessments, time 1 was mid-curriculum. Time 2 was always post-curriculum. Each enrolled participant completed three cognitive tasks at the beginning and end of the first time period. Generally, participants had only one task per meeting, so as to avoid distraction and frustration with the assessment. Each participating student completed all three tasks at each time point: a memory task—the Missing Scan Task, a categorization and executive functioning task—a modified version of the Dimensional Change Card Sort, and an attention task—the Conner’s Kiddie Continuous Performance Task-2. These three tasks will be expanded upon below.

To assess working memory capacity and cognitive control processes, I used the Missing Scan Task (MST), a modified version of the Digit Span Task. Roman et al. (2014) has verified that the MST is a feasible and valid method for assessing Working Memory Capacity in preschool children as young as 3 years of age. The Missing Scan Task is particularly good for preschool-aged students because of the simplicity of instructions, reduced demand on sustained-sequential processing, and expected lower floor effect. Thus, the MST was a particularly good measure for students in our study aged 3-5 years old.
In this task, 65 plush beanbag animals are used as test stimuli. The child sits across from the experimenter where a small cardboard box with a picture of a house is placed on the table facing the child. Out of the child’s line of sight, a bag is placed under the table with the plush animals. The experimenter explains that they will play a memory game and then brings out two randomly selected plush beanbag animals and places them on the table in front of the child. The two beanbag animals therefore represent a memory set size of two and are used to train each child. The child is given approximately 10 seconds to look at the beanbag animals in the memory set and name them out loud, before the experimenter puts them into the house. Two-to-three seconds later, one plush beanbag animal is brought back out and the experimenter asks the child “which one is missing?” Once a child correctly completes the trial, the experiment begins. While the assessment originally suggested that 3-4 year olds begin with a set size of three beanbag animals and 5-6 year olds begin with a set-size of four beanbag animals, so as to keep the child interested in the task, we modified the task so that all students began with a memory set size of three to avoid floor effects.

After one correct trial, the memory set size is increased by one item; therefore, if a child started with three beanbags and correctly notes which one is missing, the next trial will include four beanbag animals. If the child incorrectly names the missing animal, the memory set size is tested again with new items. The Missing Scan Task concludes when the child fails to correctly name the missing animal on two trials of the same memory set size or correctly completes a memory set size of 10. We determined the longest set that each individual child could correctly scan with no errors. Please see Appendix D for the script of the Missing Scan Task assessment.

To examine categorization and set-switching abilities, I used a modified version of the Dimensional Change Card Sort (DCCS; Zelazo, 2006). Traditionally, the participant begins by
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sorting cards with colored objects on them following a modeled rule (blue ones in location A and red ones in location B). In our “color game”, that means sorting purple ones in location A and yellow ones in location B. Then they will be told that the sorting rule is changed and will be instructed instead sort by shape (yellow ones in location A and purple ones in location B). Such a task has been used and validated as a measure of executive functioning by multiple developmental psychologists. Since we are working with 3-5 year-olds, we had them sort by two dimensions, in order to challenge all of our students and avoid ceiling effects. We decided to use real objects that are about 2 inches in length in the hope that the physical objects (rather than just an image on a piece of a paper) would better engage the students in the process. At time 1, our stimuli were purple buses and yellow planes and we had two silver buckets. One bucket had an image of a yellow bus on it, while the other had an image of a purple plane. At time 2, our stimuli were orange boats and green cars and we had two silver buckets. One bucket had an image of a green boat on it and the other bucket contained an image of an orange car. In both cases, the items varied on two dimensions, shape and color, and therefore could be sorted differently according to the different rules.

Such a task has been used and validated as a measure of executive functioning (Perner & Lang, 2002, Carlson, Mandell & Williams 2004). Perner & Lang examined 3 and 4 year olds with card sorting tasks and their results indicated that 3-year olds seemed to do well with simple reversal shift task but had challenges with the DCCS task when they had to switch from one sorting dimension to another and were much more likely to follow the pre-switch rules. Their research bolsters the point that this task measures more than just categorization, as we expect that all 3 year-olds can do this. Rather, it importantly measures how quickly and effectively a child can switch their behavior based on a new instruction.
Since we studied 3-5 year-olds, I used the color-sorting rule as well as the shape-sorting rule. Please see the Appendix E and Appendix F for the script of the Dimensional Change Card Sort assessment. I switched the identity of the first dimension from time 1 (color) to time 2 (shape) to objectively determine that initial sorting did not vary across the two dimensions.

To examine attention, I used a modified version of a Visual Scan Task, the Conners Kiddie Continuous Performance Task 2 (KCPT-2; Conners, 2012). We selected this standardized assessment for several reasons. First of all, it was an already created computer program that assesses attention and impulsivity and therefore it gave us an output of hit reaction time (milliseconds), omission errors and commission errors both measured in percentages, over the course of five blocks. We felt that having a program that could collect this information for us and could offer different Inter-Stimulus Intervals (1.5 and 3 seconds) evenly spread throughout all five blocks would be beneficial. The assessment has 150 total targets and 50 non-targets. These are spread evenly over the course of the blocks with a total of 30 targets per block and 10 non-targets per block.

It is a computerized task in which children are asked to respond selectively to many target stimuli (a bike, boat, horse, train, scissors, and a plane) by pressing the spacebar on a computer and to refrain from responding to a soccer ball (the non-target stimulus). The program offers a one-minute practice round in which the instructor provides feedback to the participant. Once the participant has demonstrated that they have understood the basic rules of the activity, the participant proceeds to do the 7.5 minute task alone, with positive feedback given by the experimenter every block (every 1.5 minutes) as well as encouragement to stay on task if necessary.
The program generates a report that measures hit reaction time (measured in milliseconds), percent omission errors (missing a target stimulus, therefore not pressing the spacebar when s/he sees any other image that is not the soccer ball), and percent commission errors (responding to a non-target stimulus, therefore pressing the spacebar when s/he sees the soccer ball). Previous research, (Muller, Kerns, & Konkin, 2012) found good test-retest reliability for omission errors and modest test-retest reliability for commission errors.

The Conners Kiddie Continuous Performance Task 2 (KCPT-2) is normed for 4-7 year olds, thus performance of 3 year olds could not be compared to normative data. Because our aim was not to compare performance to norms, the data could still be validly compared across our two participant groups. The fact that the task purposefully uses pictures rather than letters should ostensibly be good for children who cannot yet read, but can still recognize images. Since this task consisted of five blocks, we recognize that some of our participants may not be able to complete all of the blocks, however we maintain that this data is still helpful and relevant for our study. Please see Appendix G for the script of the Conner’s Kiddie Continuous Performance Task -2 assessment.

Procedure

All students enrolled in the two preschool-aged classrooms in the 2017-2018 classroom were recruited to be a part of this study. Between both classrooms, 33 students’ parents and guardians consented for them to be a part of the group assessment. Of these 33 students, 32 of their parents consented for them to partake in individual assessments. 16 of these students were chosen to receive the curriculum in Phase 1, while the other 17 served as a wait-list control, with the expectation that they would receive the curriculum in Phase 2. Participants and controls were semi-randomized to control for age across the two groups.
Students selected to be in the curriculum for Phase 1 attended a 30 minute lesson every Wednesday morning for nine weeks. Students in the curriculum group were divided into two groups. Students in the purple group generally attended a lesson from 9:15 – 9:45am. Students in the blue group generally attended a lesson from 9:45 – 10:15am. These lessons took place in the music room in the preschool and generally were composed of 1 instructor, 1 college-aged Teacher’s Assistant, and 8 participants.

Results

Attendance in the curriculum lessons was recorded for students in the curriculum group. The first lesson occurred on January 17, 2018 and the last lesson took place on March 28, 2018. On average, students attended 7.63 out of the 9 total sessions. Every student attended more than half of the sessions, with the lowest attendance being 5 classes and the highest attendance being 9 classes. At times, students would attend the earlier or later session - depending on when they arrived at school on a given Wednesday. While this may have had negative consequences on the consistency and group dynamic, it allowed more students in the curriculum group to more often attend the lessons.

Each video recording of the individual testing sessions for the MST memory task and DCCS sorting task was coded by two independent coders. Agreement between coders for final scores of the MST memory task across participants at time 1 was $r=.99$; at time 2, agreement was $r=.99$. Agreement between coders for final scores on the post-switch trials on the DCCS sorting task at time 1 was $r=.99$; at time 2, agreement was $r= 1.00$.

In order to test Hypothesis 1, that students receiving the TiM curriculum would have improved working memory capacity between their pre-tests and post-tests as well as relative to their age-matched peers not receiving the curriculum at time 2, we ran a repeated measures
mixed ANOVA with time (pre- and post-curriculum) as the within-subjects factor and curriculum group (2) as the between subjects factor and final score on the Missing Scan Task as the dependent variable. Time 1 assessments for the missing scan task occurred in mid-December to late January and time 2 assessments occurred in late March. Please see Table 1 for the descriptive statistics.

Results indicated no main effects for time \( (F(1) = 0.01, p = .93, \text{partial } \eta^2 = .00, \text{observed power } = .05) \) or for curriculum group \( (F(1) = 0.02, p = .90, \text{partial } \eta^2 = .00, \text{observed power } = .05) \) and no time by curriculum interaction \( (F(1) = 0.74, p = .40, \text{partial } \eta^2 = .03, \text{observed power } = .13) \). Thus, there was no change in the ultimate memory set size attained by participants from pre- to post-curriculum, and no difference between the groups.

We also assessed how many of the two allotted attempts per memory set were required for a participant to achieve their final score. Please see Table 2 for the descriptive statistics. We ran a repeated measures mixed ANOVA on number of attempts and noted no significant differences between those in the curriculum and those not in the curriculum \( (F(1) = 0.27, p = .61, \text{partial } \eta^2 = .01, \text{observed power } = .08) \). However both groups appeared to need fewer attempts over time, thus indicating that this measure is sensitive to the time length of Phase 1 of our study \( (F(1) = 10.462, p = .003, \text{partial } \eta^2 = .26, \text{observed power } = .88) \).

To assess Hypothesis 2, that the students receiving the TiM curriculum would have improved categorization and set-switching ability between their pre-tests and post-tests, as well as relative to their age-matched peers at time 2 not receiving the curriculum, I ran a repeated measures ANOVA on the number of correct trials on the categorization task, with dimension as a within subjects factor (color, shape), time as a within subjects factor (pre- and post-curriculum), and curriculum group as the between subjects factor. Time 1 assessments for the dimensional
change card sort task occurred in mid-late February and time 2 assessments occurred in late March. Please see Table 3 for descriptive statistics. Please see Figure 1 for the means and standard error bars of the DCCS Task for time 1. Please see Figure 2 for the means and standard error bars of the DCCS Task for time 2.

Neither main effects of time \((F(1) = 0.00, p = .96, \text{partial } \eta^2 = .00, \text{observed power} = .05)\) or dimension \((F(1) = 0.11, p = .75, \text{partial } \eta^2 = .00, \text{observed power} = .06)\) were significant. I observed a significant interaction between time and dimension \((F(1) = 6.35, p = .018, \text{partial } \eta^2 = .18, \text{observed power} = .68)\). This was a medium-large effect size. This interaction indicated that participants made fewer categorization errors across the six pre-switch trials than the six post-switch trials. I also observed a trend for the curriculum participants to outperform the non-curriculum students, but this effect was marginal \((p = 0.069)\).

As a subset of Hypothesis 2, I also assessed the initial post-switch trial to see if there was any difference between curriculum and non-curriculum students in their ability to switch sorting dimension. Please see Table 4 for the descriptive statistics. There was not a main effect of time \((F(1) = 0.51, p = .48, \text{partial } \eta^2 = .02, \text{observed power} = .11)\) or a main effect of curriculum \((F(1) = 1.56, p = .22, \text{partial } \eta^2 = .05, \text{observed power} = .23)\). I noted a marginally significant interaction between time and curriculum \((F(1) = 3.33, p = .079, \text{partial } \eta^2 = .11, \text{observed power} = .42)\). A post hoc contrast revealed that the curriculum students outperformed the non-curriculum students only at time 2 \((p = .046)\), with all curriculum students successfully switching to the new sorting rule on the first trial. Please see Figure 3 for the means and standard error bars of the initial post-switch trial for DCCS.

For Hypothesis 3, I predicted that the students receiving the TiM curriculum would have improved performance on the KCPT-2 attention assessment between their pre-curriculum and
post-curriculum time points as well as relative to their age-matched peers not receiving the curriculum. Better performance on this task is reflected in lower hit reaction times (HRTs), fewer commission errors (erroneous responses to the non-target stimulus), and fewer omission errors (erroneous misses of the target stimuli). Time 1 assessments for the KCPT-2 task occurred in the beginning of March and time 2 assessments occurred in the beginning of April.

I ran a repeated measures ANOVA on the hit reaction time (milliseconds) on the KCPT-2 task, with time as a within subjects factor (pre- and post-curriculum), block as an additional within-subjects factor (1-5), and curriculum group as the between subjects factor. Please see Table 5 for descriptive statistics of hit reaction time. Neither main effects of block (F(1) = 7.95, p = .12, partial eta² = .17, observed power = .55) nor curriculum (F(1) = 0.09, p = .77, partial eta² = .01, observed power = .06) were significant. We did observe a main effect for time (F(1) 5.05, p = .048, partial eta² = .34, observed power = .53) indicating that participants were faster at time 2 than time 1.

There was no interaction between time by block (F(1) = 7.32, p = .14, partial eta² = .16, observed power = .51) nor block by curriculum (F(1) = 5.19, p = .29, partial eta² = .12, observed power = .37) nor time by curriculum (F(1) = 1.65, p = .23, partial eta² = .14, observed power = .21). There was also no interaction between time by block by curriculum (F(1) = 0.21, p = 1.00, partial eta² = .01, observed power = .06). Please see Figure 4 for hit reaction time at time 1. Please see Figure 5 for hit reaction time at time 2.

I ran a repeated measures ANOVA on the percent of omission errors on the KCPT-2 task, with time as a within subjects factor (pre- and post-curriculum), block as an additional within-subjects factor (1-5), and curriculum group as the between subjects factor. Please see Table 6 for descriptive statistics of percent omission errors.
Neither main effects of time ($F(1) = 0.20, p = .661$, partial $\eta^2 = .01$, observed power = .07), nor curriculum ($F(1) = 0.23, p = .64$, partial $\eta^2 = .01$, observed power = .08) were significant. We did observe a significant interaction between time and curriculum ($F(1) = 4.47, p = 0.044$, partial $\eta^2 = .15$, observed power = .53).

I also observed a main effect of block ($F(1) = 176.70, p = .000$, partial $\eta^2 = .63$, observed power = 1.00), indicating that the number of omission errors increased overall as the task progressed. There was no interaction of block by curriculum ($F(1) = 3.88, p = .49$, partial $\eta^2 = .04$, observed power = .30) nor time by block ($F(1) = 7.16, p = .14$, partial $\eta^2 = .06$, observed power = .53). I also observed a significant interaction between time and block and curriculum ($F(1) = 15.51, p = .006$, partial $\eta^2 = .13$, observed power = .89). Post-hoc comparisons revealed a significant group difference at time 1, block 3 ($p = .043$) and time 1, block 4 ($p = .040$). At both blocks in 3 and blocks 4 in time 1, the curriculum group produced fewer percent omission errors than the non-curriculum group. Please see Figure 6 for percent omission errors at time 1. Please see Figure 7 for percent omission errors at time 2.

I ran a repeated measures ANOVA on the percent commission errors on the KCPT-2 task, with time as a within subjects factor (pre- and post-curriculum), block as an additional within-subjects factor (1-5), and curriculum group as the between subjects factor. Please see Table 7 for descriptive statistics of percent commission errors.

Neither main effects of time ($F(1) = 0.13, p = .73$, partial $\eta^2 = .01$, observed power = .06), nor curriculum ($F(1) = 0.95, p = .34$, partial $\eta^2 = .04$, observed power = .16) were significant. I did observe a main effect of block ($F(1) = 39.90, p = .000$, partial $\eta^2 = .28$, observed power = 1.00), indicating that the scores by block were significantly different from
each other with an overall pattern of increasing from block 1 to block 2 and then steadily decreasing over each consecutive block.

Neither main interactions of time by block \((F(1) = 1.32, p = .86, \text{partial } \eta^2 = .01, \text{observed power} = .12)\), curriculum by block \((F(1) = 4.51, p = .35, \text{partial } \eta^2 = .04, \text{observed power} = .34)\), nor time by curriculum were observed \((F(1) = 0.13, p = .73, \text{partial } \eta^2 = .01, \text{observed power} = .06)\). I did observe a significant interaction between time, block, and curriculum \((F(1) = 10.35, p = .041, \text{partial } \eta^2 = .09, \text{observed power} = .71)\). Please see Figure 8 for percent commission errors at time 1. Please see Figure 9 for percent commission errors at time 2. Post hoc comparisons were non-significant for blocks 1-5. A post hoc comparison indicated a marginal difference in time 2, block 2 with the curriculum group getting a higher percent of commission errors \((p = .03)\).

**Discussion**

The general aim of this study was to measure the cognitive effects of the Thinking in Music curriculum on preschool aged children. The initial hypothesis of the study was that students receiving the TiM curriculum would have improved working memory capacity between their pre-tests and post-tests, as well as relative to the performance at time 2 of their age-matched peers not receiving the curriculum. The results indicated that the groups’ mean scores did not shift dramatically over time. It could be that this measure is not sensitive enough to time or it could also be a reflection of the minimal time between the two time points. We know that working memory capacity is developing throughout this age period, however we must look more into our ability to measure that change during such a short time period.

Another potential indicator of why I was less likely to see change over time is that I was more careful in the second round to not choose an animal to leave in the house that a participant
seemed to show an affinity for, in order to make it a more fair memory assessment. Students who showed an affinity for particular animals often made a request to either bring them back out or leave them in the house and I did not think it would be a fair memory assessment to just go along with their request. This exemplifies a larger drawback of this assessment, as it is challenging as a researcher to randomly select which animal to leave in the house. One could avoid this problem in the future by prior to the session generating a pseudo-randomized order of what animals are brought out, where they are placed on the table, and which animal stays in the house.

Also, it is important to choose animals to leave in the house that were placed in different locations when in front of the participant, so the participant does not subconsciously learn to only pay attention to the animal placed in one spot on the table (e.g. on the right). Therefore the assessment necessitates some choice made by the researcher, which could decrease the validity of this assessment. This problem is also solvable through a pseudo-randomized order of what animals are brought out, where they are placed on the table, and which animal stays in the house.

Another potential flaw inherent in this method is the contamination from trial to trial. I only observed this occasionally, but it certainly occurred that students would guess an animal in the house that was used in a previous round. Experiencing so many new stimuli offers a fresh perspective for each round, but may prove overwhelming for some participants. One could avoid this problem in the future by offering a larger break in between trials.

According to Roman and colleagues (2014), 3 year olds in their study had a mean score of 4, and 5 year olds had a mean score of 6. Our participants aged 3-5 had a mean score lower than that which may suggest that their working memory capacity is low relative to Roman and colleagues’ sample, or there may have been some overall flaw in the administration that lowered all of the participants’ scores. Roman and colleagues (2014) randomly chose which animals to
bring onto the table and which ones to bring out of the house. The presentation was also randomized for each child. While I generally tried to do this as well, I also tried to control for an affinity effect – that some participants indicated favorites and non-favorites of stuffed animals. Thus I tried to choose non-favorites so as to avoid choosing an animal that was too strongly ingrained in their working memory, which may have interfered with their memory.

Although participants’ final score on the missing scan task did not appear sensitive to the pre/post time period overall, the number of attempted trials to reach each score showed an effect. Since each student could try a memory set twice to achieve that score, all students tended to decrease their attempts needed to reach each score from pre-curriculum to post-curriculum. This indicated that the measure has some sensitivity to the pre/post time period in our study. This sensitivity as well as the participants’ engagement indicate that it may be worthwhile to maintain the missing scan task or a similar measure of working memory in future iterations of this study.

I also observed that at time 2, eight students asked for a hint or clue about the animal that was currently in the house. While this number did not differ significantly either by class or by curriculum, it appeared to increase in the total group over time. In the future, I recommend coding for that factor from the beginning, as it may indicate an important level of curiosity or problem-solving that may undergo important developmental change during the preschool years.

The sorting task (dimensional change card sort) revealed more differences between the curriculum group and the non-curriculum group. First of all, I chose to use small, 3D objects rather than line drawings on cards as I thought that the objects may help students remain engaged with the activity. According to Zelazo (2006), most 3-year-olds perseverate during the post-switch phase, showing that they know the correct sorting rule but are incapable of producing the correct response. However at time 1, ten of the eleven 3-year olds in our sample scored a total
score of 6/6 on the post-switch trial and 1 of the eleven students scored a total score of 0/6. At time 2, eight of the eleven 3-year olds scored a total score of 6/6, two of the eleven scored a total score of 0/6, one of the eleven scored a total score of 4/6, but she appeared to get a bit distracted during the task. These results indicate that our sample of 3 year-olds performed better on this assessment relative to expectations put forth by previous research. These results could also be reflective of the three dimensional nature of the stimuli. In relation to typically used 2D picture cards, 3D stimuli may potentially be easier for young children to use due to their kinesthetic nature and therefore could allow children to demonstrate this executive function at an earlier age.

I chose to begin with color and then switch the dimension to shape for time 1 and then to begin with shape and switch to color for time 2. At time 1, our buckets had a yellow bus and purple plane and our stimuli were yellow planes and purple buses. At time 2, our buckets had an image of a green boat and orange car and our stimuli were green cars and orange boats. This counterbalancing allowed us to demonstrate that participants performed nearly perfectly during the six pre-switch trials of the task, regardless of what dimension the sorting was applied to, and that difficulties during post-switch trials were also observed regardless of which dimension the objects were being sorted.

I observed a significant interaction between time and dimension, which indicated that participants did indeed do better on the six pre-switch trials than the six post-switch trials, regardless of dimension. This replicates previous work (Perner & Lang, 2002, Carlson, Mandell & Williams 2004). I also saw a trend for the curriculum participants to outperform the non-curriculum participants which bolsters the fact that this assessment should continue to be used and would likely show more significance over a longer period of the curriculum and with a larger sample size. However, it is important to note that, in general, the participants either understood
the post-switch rule perfectly and received a total of 6/6 (100% correct) or could not switch the sorting rule at all and received a total of 0/0 (0% correct).

When I restricted the analysis of the sorting task to the initial post-switch trial, I observed a marginally significant interaction between time and curriculum. Post hoc analyses indicated that students in the curriculum improved significantly more than their non-curriculum age-matched peers, with students in the curriculum having a score of 1/1 (100% success rate) on the initial post-switch test trial at the post-curriculum time point. This suggests that the *Thinking in Music* curriculum may have an impact on task-switching abilities in preschool children.

A possible limitation to the way I administered the sorting task was that I used open buckets which may have been confusing to some of the participants. Once I explained the new rule for the new game (post-switch), some students would empty the buckets and switch their contents to the other bucket (thus making sure that all the stimuli were sorted according to the new rule). Not every student did this, however it happened quite often. When students did not actively choose to switch the stimuli, they would often look back in the bucket as they were about to sort a new stimulus and look puzzled or verbally noted confusion as to why there was a mixture of colors and shapes in the same bucket. This may have contributed to some participants’ failure to learn the new rule. In the future, buckets with tops could be purchased, so the contents will not be distracting on future trials.

Every student was able to do this task on the pre-switch trial, thus there were no floor effects and clearly each participant was capable of sorting two-dimensional objects on the basis of a single dimension. However, there may have been some ceiling effects, as almost all of the older participants were able to do both rounds successfully (total score of 100%). In the future, offering a third dimension may increase sensitivity, particularly for the older students. In the
traditional DCCS task, that would entail using photos with borders as the third dimension.

Because I was using three dimensional objects, one would have to introduce a dimension such as size amongst our stimuli.

The final assessment was a visual scan task, the Conner’s Kiddie Performance Task – 2. While this task was designed and normed for four to seven year olds, I thought that it would be useful in generating data related to attention and inhibition in our complete age range of three to five. I modified the practice round to be semi interactive, thus I provided verbal feedback to the participants, helping to insure that they understood the rules and were able to actually do the assessment by themselves. During the assessment, I would provide positive feedback every 1.5 minutes (every block), so as to make sure they were still engaged. If I saw a participant getting distracted, I would gently try to redirect their behavior to the assessment.

In general, it was the case that most participants could understand the task and were able to perform it for some length of time. However, only half of the students completed all five blocks at both time points. Many students stopped performing the task, generally around the beginning of the third block – about three minutes into the assessment. This fact limited our statistical analyses of hit reaction time to only those participants who could complete the task at both time points, seven students in the curriculum group and five students in the non-curriculum group. Nevertheless, I observed a significant interaction, with the curriculum group getting faster from time 1 to time 2.

Non-completion of the task affected analyses of commission errors and omission errors differently than analyses of reaction time. When a participant did not complete a block, a 100% omission rate and 0% commission rate were recorded. While this is a logical approach for
omission errors, it artificially deflates the commission analyses, thus we are cautious in interpreting the findings for commission errors.

Hit reaction time varied across the two points, with both groups getting faster with time. This may suggest that as students develop they will get faster. It may also be indicative of the fact that it was their second introduction to the same task and therefore they mastered responding quickly.

Omission errors did not vary across the two time points, which may be attributed to the fact time 1 and time 2 were about a month apart for this assessment. There was, however, a significant interaction of time and curriculum as well as of block by time by curriculum, both of which are good indicators that the assessment may be sensitive to experiencing the curriculum. That being said, students in the curriculum produced more omission errors from the pre-curriculum to the post-curriculum time point, which is contrary to what would be expected. Omission errors are generally considered an indicator of inattentiveness, therefore this suggests that students not in the curriculum were more attentive than students in the curriculum.

Like omission errors, there was no overall effect of time on commission errors, which again may be attributed to the relatively short time between pre- and post-curriculum measurements. There was a significant interaction of time and curriculum as well as of block by time by curriculum, both of which are good indicators that the assessment is sensitive to experiencing the curriculum. However, again as in the omission results, what I observed was that students not in the curriculum produced a lower percentage of commission errors across the two time points and across the five blocks of the task. Commission errors are generally considered an indicator of impulsivity, and our results suggest that experience in the curriculum did not positively affect impulsive behavior on a visual scan task.
It is possible that the music curriculum does not directly address inattentiveness or impulsivity. Currently our sample is too small to draw any meaningful conclusions from, however if future results followed this trend, it would be possible to guess that TiM may not directly address attention. Interpreting the results from the KCPT-2 is limited as there was only a month in between the first assessment (halfway through the curriculum) and the second assessment. It is specifically limited with regard to hit reaction time as we were only able to analyze results from students who completed the entire assessment at both time points (seven from the curriculum, five from the non-curriculum group). Beyond the challenging nature of the task, students struggled to keep their hand near the spacebar and thus reacted slowly to the stimuli often pressing the spacebar after a new stimulus had appeared on the screen. In the future, I recommend using a mouse or indicating a space for students to rest their hand in order to gain a more accurate picture of their omission errors and commission errors.

Our first important limitation of this study was the small sample size. There were only 33 students enrolled in the study and only 32 of whom were enrolled in the individual assessments. Due to the semi-randomized age-matched peers of control and non-control groups, only 15 students were receiving the curriculum as well as completing the individual assessments. This small number limits our statistical power and the generalizability of our results. This N was even smaller for the KCPT-2 tasks, as students had to complete all five blocks in order to assess their hit reaction time, thus limiting our N even more for this assessment.

Overall, the participants came from very well-educated and wealthy families, thus indicating that there may be important differences between the Lemberg Children’s Center population and other preschool populations in the United States. Also, the implementation took
place at a single preschool site and should be expanded in the future to more sites to increase the N, as well as diversity of the sample, thus allowing for the results to be more generalizable.

A second overall limitation was the small number of curriculum lessons the students experienced. It is likely that seven to nine lessons is not sufficient to elicit the developmental changes that the curriculum is designed to produce. In the future, the curriculum should begin in the fall, so each group can have three months to participate in it. Alternatively, there should be a switch in methodology from wait-list controls to controls and therefore one can conduct the curriculum with a group of students over the course of the entire year, thus allowing the instructor and students to progress significantly further with the TiM material.

Another flaw, was that the researcher filmed every curriculum session and therefore knew who was or was not receiving this curriculum, and conducted the individual assessments. This may have introduced unconscious biases in conducting the assessments. In the future, it would be preferable for the individual who conducts the table-top assessments to be blind to curriculum participation to avoid any potential biases.

Another limitation was that the curriculum itself competed with stations and play time in the classroom, thus some students had a challenging time leaving their friends in order to attend the Thinking in Music lessons on Wednesday mornings. Depending on how participants felt about their respective classrooms as well as the TiM classes, it may have colored the way they experienced being pulled out of class to attend Thinking in Music. On occasion, students were late or early and therefore switched whether they attended the first group (9:15am – 9:45am) or the second group (9:45am – 10:15am). This caused some inconsistency in the makeup of each TiM class which may have had an effect on some of the students. In the future, it would be
preferable to find a later time thus ensuring that students would be able to more consistently attend the same TiM class.

Other factors remained constant – the same instructor and TA implemented all of the curriculum classes. The TA was relatively musical and was able to help the instructor by providing an example of what students should be doing with their voices and bodies. She was also able to help with some behavioral concerns, although at points the instructor had to offer discipline and structure for some students and therefore the instructor was not always able to focus on implementing the curriculum. From my observations, it is helpful having assistance when implementing the TiM curriculum.

In summation, the evidence indicates that the measures were generally good as they gave us notable results and tended to engage the participants. I think the Missing Scan Task was a good measure, but could be tweaked to account more for randomly choosing animals as well as affinity effects and contamination effects. I think the Dimensional Change Card Sort task was an excellent choice for sorting and learning new rules and would be even better if future researchers add in a third dimension to avoid ceiling effects. An attention and executive function task is essential for studying this material, however it seems like a modified version of the Conner’s Kiddie Continuous Performance Task-2 task that is a bit shorter would be more beneficial for this age-range. Most of the assessments demonstrated a group by time interaction, thus indicating that they were generally good measures and demonstrated trends for both successes and failures of the Thinking in Music curriculum.
References


Table 1.

Descriptive Statistics (Means and Standard Deviations) of the Missing Scan Task.

<table>
<thead>
<tr>
<th></th>
<th>Time 1</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum</td>
<td>$M = 3.43$</td>
<td>$M = 3.71$</td>
</tr>
<tr>
<td></td>
<td>($SD = 1.09$)</td>
<td>($SD = 1.20$)</td>
</tr>
<tr>
<td></td>
<td>$M = 3.65$</td>
<td>$M = 3.41$</td>
</tr>
<tr>
<td>Non-Curriculum</td>
<td>($SD = 1.22$)</td>
<td>($SD = 1.33$)</td>
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</tbody>
</table>
Table 2.

*Descriptive Statistics (Means and Standard Deviations) of the attempts needed of the Missing Scan Task*

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Time 1</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$M = .89$</td>
<td>$M = .96$</td>
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<tr>
<td></td>
<td>$(SD = 0.17)$</td>
<td>$(SD = 0.08)$</td>
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<td>Non-Curriculum</td>
<td>$M = .84$</td>
<td>$M = .98$</td>
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<td></td>
<td>$(SD = 0.16)$</td>
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Table 3.

*Descriptive Statistics (Means and Standard Deviations) of the Total Scores of the DCCS Task.*

<table>
<thead>
<tr>
<th></th>
<th>Time 1</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Switch</td>
<td>Post-Switch</td>
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<td>DCCS Color</td>
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<tr>
<td>Total</td>
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<td>$M = 5.64$</td>
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<tr>
<td>Curriculum</td>
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<td>$(SD = 0.63)$</td>
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<td>Non-Curriculum</td>
<td>$(SD = 0.00)$</td>
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Table 4.

Descriptive Statistics (Means and Standard Deviations) of the Initial Switch Trial Score of the DCCS Task. Asterisk denotes significant group difference.

<table>
<thead>
<tr>
<th></th>
<th>Time 1</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Switch Trial</td>
<td>Switch Trial</td>
</tr>
<tr>
<td>DCCS Shape</td>
<td>M = 0.86</td>
<td>M = 1.00</td>
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<tr>
<td></td>
<td>(SD = 0.36)</td>
<td>(SD = 0.00) *</td>
</tr>
<tr>
<td>Curriculum</td>
<td>M = 0.81</td>
<td>M = 0.75</td>
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<tr>
<td></td>
<td>(SD = 0.40)</td>
<td>(SD = 0.45)</td>
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</table>
Table 5.
*Descriptive Statistics (Means and Standard Deviations) of the Hit Reaction Time of the KCPT-2 task.*

<table>
<thead>
<tr>
<th>Time 1</th>
<th>HRT Block</th>
<th>HRT Block</th>
<th>HRT Block</th>
<th>HRT Block</th>
<th>HRT Block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td></td>
<td>$SD = 226.28$</td>
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<td></td>
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<td>$M = 920.00$</td>
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<table>
<thead>
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<th>HRT Block</th>
<th>HRT Block</th>
<th>HRT Block</th>
<th>HRT Block</th>
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<td>1</td>
<td>2</td>
<td>3</td>
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<td>Curriculum</td>
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Table 6.

*Descriptive Statistics (Means and Standard Deviations) of the Percent Omission Errors of the KCPT-2 task.*

<table>
<thead>
<tr>
<th>Time 1</th>
<th>O Block 1</th>
<th>O Block 2</th>
<th>O Block 3</th>
<th>O Block 4</th>
<th>O Block 5</th>
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</thead>
<tbody>
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<td>$SD = 19.69$</td>
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Table 7.

*Descriptive Statistics (Means and Standard Deviations) of the Percent Commission Errors of the KCPT-2 task.*

<table>
<thead>
<tr>
<th>Time 1</th>
<th>C Block 1</th>
<th>C Block 2</th>
<th>C Block 3</th>
<th>C Block 4</th>
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Figure 1. *Time 1 Pre-Switch and Post Switch trials of DCCS Task (Means and Standard Error Bars).*
Figure 2. Time 2 Pre-Switch and Post Switch trials of DCCS Task (Means and Standard Error Bars).
Figure 3. *Time 1 and Time 2 Initial Post-Switch trial of DCCS Task (Means and Standard Error Bars). Asterisk denotes significant group difference.*
Figure 4. Hit Reaction Time (milliseconds) of KCPT-2 Task at Time 1 (Means and Standard Error Bars).
Figure 5. Hit Reaction Time (milliseconds) of KCPT-2 Task at Time 2 (Means and Standard Error Bars).
Figure 6. Percent Omission Errors of KCPT-2 Task at Time 1 (Means and Standard Error Bars). Asterisk denotes significant group difference.
Figure 7. Percent Omission Errors of KCPT-2 Task at Time 2 (Means and Standard Error Bars).
Figure 8. Percent Commission Errors of KCPT-2 Task at Time 1 (Means and Standard Error Bars).
Figure 9. Percent Commission Errors of KCPT-2 Task at Time 2 (Means and Standard Error Bars). Asterisk denotes significant group difference.
Appendix A
Informed Consent Form One – Group Lessons

*How the Thinking in Music Curriculum Impacts Preschool-Aged Individuals’ Cognitive Development*

You and your child are invited to participate in a research study being conducted by Shoshanah Singer, an undergraduate honors student at Brandeis University. The study is being conducted under the supervision of Dr. Teresa Mitchell, Lecturer of Psychology at Brandeis University.

Please read this form carefully. We encourage you to ask questions if you want more information about any part of the form or the study.

If you decide that you and your child will participate in this study, you will be asked to sign this form. A copy of the signed form will be given to you to keep for your records – it has important information, including whom to contact if you have questions in the future.

**What is this study about?**

We are conducting this research study because we are trying to learn more about the impact of a new preschool music curriculum, *Thinking in Music*, on students’ development.

This is a two part study. Part one involves videotaping and audiotaping group lessons of the *Thinking in Music* Curriculum conducted at Lemberg Children’s Center and examining them later for how well the teacher follows the curriculum and how the children respond to the lesson.

*Signing this consent form gives us permission to include your child in the group lessons and to record and code his or her participation.*

The second part of the study involves working one-on-one with the researchers on simple tabletop tasks at Lemberg Children’s Center. Signing the second consent form gives us permission to include your child in that part of the study.

**Why have we asked you to participate?**

We are asking you and your child to take part in this research study because your child is a preschool aged student at Lemberg Children’s Center, our partner in this research project.
What will you be asked to do if you participate?

If you and your child decide to participate in this study, you will be asked to complete a questionnaire about your child and your family’s background. Your child will then be asked to participate in group lessons of the Thinking in Music Curriculum during his or her regular time at Lemberg Children’s Center. These lessons will be videotaped and audiotaped for later examination of the teacher’s adherence to the curriculum and for the students’ responses. Therefore, signing this consent form gives us permission to record your child. Up to six lessons will be recorded. Your child’s participation in the lessons may take place either during the Fall of 2017 or the Spring of 2018.

Are there any possible risks to you?

Your child may not wish to participate in individual lessons and is free to sit out if he or she wishes. You and your child can also withdraw from the study completely at any time. There is always the risk that your information could be accidently disclosed to people not connected with this study, but we will do our utmost to secure your information so this does not happen.

Will you benefit from participating in the study?

You will not benefit directly by participating in this study, however we hope the study will result in data regarding the efficacy of the Thinking in Music Curriculum.

Will it cost you anything to participate in the study?

The only cost to you will be your child’s time.

Will you be compensated or receive anything for participating in the study?

There is no compensation for participation in the study.

How will your information be kept private?

Any information that is obtained in connection with this study and that can be identified with you will remain confidential to the extent permitted by law. Your name will be coded using a random combination of letters and numbers (for example b4h86). The list that connects your name with
your code number will be kept separate from the data we collect in a locked file cabinet in the researcher’s office.

The video and audio recordings of the lesson will be coded without any information that could identify your child. The video and audio recordings and the coded data we derive from the recordings will be stored electronically in a password protected encrypted file. The researchers will be the only ones who have access to your information.

When the data from the study is reported (in publications and presentations), it will be in aggregate form – your child’s information will not be identifiable from the findings as a whole. (If in the future we wish to present any video clips including your child, we will provide you with another consent form specifying the exact clip by which you may provide your permission.)

What if you don’t want to participate or change your mind partway through?

Participating in this study is completely voluntary. You and your child have the right to refuse to participate in all or a part of this study. Even if you decide to participate now, you may change your mind and withdraw from the study at any time without penalty.

Who can you call if you have more questions?

If you have any questions about the research being conducted or your participation in the research, feel free to contact the researchers at 781-736-5333 or tmitch@brandeis.edu.

If you have any questions about your rights as a subject in this research, would like to speak with someone other than the researchers about concerns you have about the study, or in the event the researchers cannot be reached, please contact the Brandeis University IRB (the University’s Committee for the Protection of Human Subjects) at 781-736-8133 or irb@brandeis.edu.

Subject Consent

I have read the contents of this consent form, have been encouraged to ask questions, and have received satisfactory answers to my questions. I understand that my and my child’s participation is voluntary and that I and my child may withdraw our participation at any time without penalty. I voluntarily agree for my child to participate in this study.

Child’s Name _________________________________________________________________
Appendix B
Informed Consent Form Two – Individual Sessions

How the Thinking in Music Curriculum Impacts Preschool-Aged Individuals’ Cognitive Development

You and your child are invited to participate in a research study being conducted by Shoshanah Singer, an undergraduate honors student at Brandeis University. The study is being conducted under the supervision of Dr. Teresa Mitchell, Lecturer of Psychology at Brandeis University.

Please read this form carefully. We encourage you to ask questions if you want more information about any part of the form or the study.

If you decide that you and your child will participate in this study, you will be asked to sign this form. A copy of the signed form will be given to you to keep for your records – it has important information, including whom to contact if you have questions in the future.

What is this study about?

We are conducting this research study because we are trying to learn more about the impact of a new preschool music curriculum, Thinking in Music, on students’ development.

This is a two part study. Part one involves videotaping and audiotaping group lessons of the Thinking in Music Curriculum conducted at Lemberg Children’s Center and examining them later for how well the teacher follows the curriculum and how the children respond to the lesson. Signing the first consent form gives us permission to include your child in that part of the study.

The second part of the study involves individual one-on-one sessions with the researchers on simple tabletop tasks at Lemberg Children’s Center. These tasks are designed to examine memory, executive functions, and categorization in preschoolers. These individual sessions will take place during the school day at Lemberg Children’s Center. We will video and audio record these sessions for later coding of the child’s behavior, such as the number and type of responses made. Your child will participate in sessions at the beginning and the end of the Fall of 2017 as well as at the beginning and end of the Spring 2018. Signing this second consent form gives us permission to include your child in the individual sessions and to record them for later coding.

Why have we asked you to participate?
We are asking you and your child to take part in this research study because your child is a preschool aged student at Lemberg Children’s Center, our partner in this research project.

**What will you be asked to do if you participate?**

Your child will be asked to participate in individual one-on-one sessions with the experimenter during his or her regular time at Lemberg Children’s Center. Each session will last no longer than 15 minutes. These sessions will be videotaped and audiotaped for later examination of your child’s responses, such as the number of items remembered. Therefore signing this consent form gives us permission to record your child’s individual sessions. Your child’s participation in the sessions will take place in the Fall of 2017 as well as the Spring of 2018, with roughly three sessions per season. Please note that if you choose to sign this consent form on your child’s behalf, we will still attain verbal assent or confirmation from your child to confirm that they wish to participate in the individual sessions.

**Are there any possible risks to you?**

Your child may not wish to participate in individual sessions and is free to refuse if he or she wishes. You and your child can also withdraw from the study completely at any time. There is always the risk that your information could be accidently disclosed to people not connected with this study, but we will do our utmost to secure your information so this does not happen.

**Will you benefit from participating in the study?**

You will not benefit directly by participating in this study, however we hope the study will result in data regarding the efficacy of the Thinking in Music Curriculum.

**Will it cost you anything to participate in the study?**

The only cost to you will be your child’s time.

**Will you be compensated or receive anything for participating in the study?**

There is no compensation for participation in the study.

**How will your information be kept private?**
Any information that is obtained in connection with this study and that can be identified with you will remain confidential to the extent permitted by law. Your name will be coded using a random combination of letters and numbers (for example b4h86). The list that connects your name with your code number will be kept separate from the data we collect in a locked file cabinet in the researcher’s office.

The video and audio recordings of the individual sessions will be coded without any information that could identify your child. The video and audio recordings and the coded data we derive from the recordings will be stored electronically in a password protected encrypted file. The researchers will be the only ones who have access to your information.

When the data from the study is reported (in publications and presentations), it will be in aggregate form – your child’s information will not be identifiable from the findings as a whole. (If in the future we wish to present any video clips including your child, we will provide you with another consent form specifying the exact clip by which you may provide your permission.)

What if you don’t want to participate or change your mind partway through?

Participating in this study is completely voluntary. You and your child have the right to refuse to participate in all or a part of this study. Even if you decide to participate now, you may change your mind and withdraw from the study at any time without penalty.

Who can you call if you have more questions?

If you have any questions about the research being conducted or your participation in the research, feel free to contact the researchers at 781-736-5333 or tmitch@brandeis.edu.

If you have any questions about your rights as a subject in this research, would like to speak with someone other than the researchers about concerns you have about the study, or in the event the researchers cannot be reached, please contact the Brandeis University IRB (the University’s Committee for the Protection of Human Subjects) at 781-736-8133 or irb@brandeis.edu.

Subject Consent

I have read the contents of this consent form, have been encouraged to ask questions, and have received satisfactory answers to my questions. I understand that my and my child’s participation is voluntary and that I and my child may withdraw our participation at any time without penalty. I voluntarily agree for my child to participate in this study.
Child’s Name


Participant’s Signature

Date

Investigator’s Signature

Date
Appendix C
Demographic Questionnaire

We will use the information you provide in this questionnaire to characterize our sample of participants. If there is information that you do not wish to provide, you are free to refrain from answering that question.

1. Child’s Name:
________________________________________________________________________

2. Child’s Date of Birth (mm/dd/yyyy): (      /      /20     )

3. Child’s Gender:
   a. ( ) Female
   b. ( ) Male
   c. ( ) Other

4. Household Address:
________________________________________________________________________
________________________________________________________________________

If two addresses, second address:
________________________________________________________________________

5. Individuals in the household including relation & age (e.g. sister, 8 years):
   a. Adults:
________________________________________________________________________

   b. Children:
________________________________________________________________________

If there is a second household, please list members of that household as well:
________________________________________________________________________

6. Languages in Household:
   a. Primary language:
________________________________________________________________________

   i. Which individuals in the home speak this language?
________________________________________________________________________
ii. Which individuals in the home read this language?


b. Second language:


i. Which individuals in the home speak this language?


ii. Which individuals in the home read this language?


c. If there is a third language, please list it here.


7. With which ethnicities does your family identify:
   a. ( ) White
   b. ( ) Hispanic or Latino
   c. ( ) Black or African American
   d. ( ) Native American
   e. ( ) Asian/Pacific Islander
   f. ( ) Other

8. Parents/Guardians Marital Status:
   a. ( ) Single
   b. ( ) Married
   c. ( ) Separated
   d. ( ) Widowed
   e. ( ) Other

9. Range of Household Income Per Year:
   a. 0-50,000
   b. 50-75,000
   c. 75-100,000
   d. 100-125,000
   e. 125,000 +

10. If second household, range of 2nd Household Income Per Year:
    a. 0-50,000
    b. 50-75,000
    c. 75-100,000
    d. 100-125,000
    e. 125,000 +
11. Level of Education, Parent/Guardian 1:
   a. Some high school
   b. High school diploma
   c. Some college
   d. College diploma
   e. Master’s Degree
   f. Professional Degree (e.g. PhD, MD, JD)

12. Current job title and employer, Parent/Guardian 1:
   ____________________________________________

13. Level of Education, Parent/Guardian 2:
   a. Some high school
   b. High school diploma
   c. Some college
   d. College diploma
   e. Master’s Degree
   f. Professional Degree (e.g. PhD, MD, JD)

14. Current job title and employer, Parent/Guardian 2:
   ____________________________________________
Appendix D
Missing Scan Task Script

The child sits across from the experimenter and a small cardboard house is placed on the table facing the child. Out of the child’s line of sight, a backpack is placed under the table that contains 65 animal-shaped Beanie Babies.

Experimenter: We are going to play a memory game. The first round will be practice!

The experimenter brings out two randomly selected Beanie Babies and places them on the table in front of the child. The two animals represent a memory set size of two and are used as the training and practice set for each child.

Experimenter: Please name these two animals out loud. Try to remember the animals because they are going inside the house and you will not be able to see them anymore. When they come back out of the house, one of the animals will be missing.

Give the child approximately 10 seconds to look at the animals in the memory set and name them out loud before putting inside the house.

Two-to-three seconds later, bring one Beanie Baby back out (chosen at random).

Experimenter: Which one is missing?

The child has to display understanding of the instructions before proceeding with the MST. If the child is unable to demonstrate an understanding, he/she will not continue with the MST.

Experimenter: Good, I think you understand this game. Are you ready to play?

OR

Experimenter: Let’s try the practice again. I will pull out two new animals. Please name these two animals out loud. Try to remember the animals because they are going inside the house and you will not be able to see them anymore. When they come back out of the house, one of the animals will be missing.

3 ANIMALS

For younger children (3- to 4-year-olds), the memory set size begins with three animals and increases in length by one animal each time the child correctly reports the missing item.

Experimenter: Good! I will now show you three new animals. Please name these three animals out loud. Try to remember the animals because they are going inside the house and you will not be able to see them anymore. When they come back out of the house, one of the animals will be missing.
Give the child approximately 10 seconds to look at the animals in the memory set and name them out loud before putting inside the house.

Two-to-three seconds later, bring two Beanie Babies back out (chosen at random).

Experimenter: Which one is missing?

Experimenter: Nice job! Are you ready for the next level?

OR

Experimenter: Let’s try this round again! I will pull out three new animals. Please name these three animals out loud. Try to remember the animals because they are going inside the house and you will not be able to see them anymore. When they come back out of the house, one of the animals will be missing.

Give the child approximately 10 seconds to look at the animals in the memory set and name them out loud before putting inside the house.

Two-to-three seconds later, bring two Beanie Babies back out (chosen at random).

Experimenter: Which one is missing?

This pattern will continue on until the child maxes out of a round with two trials or accomplishes a memory set of 10.
We are going to play a sorting game! This is the COLOR game. Are you ready?

Here’s a purple plane and here’s a yellow bus.

In the color game all the purple ones go here *(pointing to the box on the left w/ the purple plane on it)* And all the yellow ones go here *(pointing to the box on the right w/ the yellow bus on it)*.

See, here’s a purple one. So it goes here *(place it in box on the left)*. If it’s purple it goes here, but if it’s yellow it goes here *(pointing to boxes to identify them)*.

See, here’s a yellow one. So it goes here *(place it in box on the right)*. If it’s purple it goes here, but if it’s yellow it goes here *(pointing to boxes to identify them)*.

Now it’s your turn. So remember, if it’s purple it goes here, but if it’s yellow it goes here *(pointing to boxes)*.
Rule Check: Can you show me where the purple ones go in the color game?

If Correct: Very good, that’s right.

If Incorrect: Uh oh. Remember, in the color game, all the purple ones go here, and all the yellow ones go here. (Point to appropriate boxes. Repeat question and reminder 1 more time, only then mark as incorrect & move on.)

1st attempt
Circle Response: Correct (1) Incorrect (0)

2nd attempt (if 1st incorrect)
Circle Response: Correct (1) Incorrect (0)

Can you show me where the yellow ones go in the color game?

If Correct: Very good, that’s right.

If Incorrect: Uh oh. Remember, in the color game, all the purple ones go here, and all the yellow ones go here. (Point to appropriate boxes. Repeat question and reminder 1 more time, only then mark as incorrect & move on.)

1st attempt
Circle Response: Correct (1) Incorrect (0)

2nd attempt (if 1st incorrect)
Circle Response: Correct (1) Incorrect (0)

LET’S TRY THIS GAME!

On each trial, say: If it is a purple one, then put it here, but if it is a yellow one, put it here.

1. (yellow plane) Here’s a yellow one. Purple _____ Yellow _____

2. (purple bus) Here’s a purple one. Purple _____ Yellow _____

3. (purple bus) Here’s a purple one. Purple _____ Yellow _____

4. (yellow plane) Here’s a yellow one. Purple _____ Yellow _____

5. (yellow plane) Here’s a yellow one. Purple _____ Yellow _____

6. (purple bus) Here’s a purple one. Purple _____ Yellow _____

Total Color (0-6):______
Pass/Fail Color (0-1):______
(0 if < 5 correct, 1 if ≥ 5)
Now we’re going to play a new game. We’re not going to play the color game anymore (Shake head no). We’re going to play the shape game. In the SHAPE game, all of the buses go here (pointing to box on the right w/ yellow bus) and all of the planes go here (pointing to box on the left w/ purple plane).

Rule Check: Can you show me where the buses go in the shape game?

1st attempt
Circle Response: Correct (1) Incorrect (0)

If Correct: Very good, that’s right.
If Incorrect: Uh oh. Remember, in the shape game, all the buses go here (right), and all the planes go here (left). (Point to appropriate boxes. Repeat question and reminder 1 more time, only then mark as incorrect & move on.)

Rule Check: Can you show me where the planes go in the shape game?

1st attempt
Circle Response: Correct (1) Incorrect (0)

If Correct: Very good, that’s right.
If Incorrect: Uh oh. Remember, in the shape game, all the buses go here (right), and all the planes go here (left). (Point to appropriate boxes. Repeat question and reminder 1 more time, only then mark as incorrect & move on.)

LET’S TRY THIS GAME!

On each trial, say: If it is a bus, then put it here, but if it is a plane, put it here.

Shape Test Trials:

1. (purple bus) Here’s a bus.
   Plane _____ Bus _____

2. (yellow plane) Here’s a plane.
   Plane _____ Bus _____

3. (purple bus) Here’s a bus.
   Plane _____ Bus _____

4. (purple bus) Here’s a bus.
   Plane _____ Bus _____

5. (yellow plane) Here’s a plane.
   Plane _____ Bus _____

6. (yellow plane) Here’s a plane.
   Plane _____ Bus _____

Total Shape (0-6):______
Pass/Fail Shape (0-1):______
(0 if < 5 correct, 1 if ≥ 5)
Appendix F
DCCS Shape Script

We are going to play a sorting game! This is the SHAPE game. Are you ready?

Here’s a green car and here’s an orange boat.

In the shape game all the boats go here (pointing to the box on the left w/ the green boats on it) And all the cars go here (pointing to the box on the right w/ the orange car on it).

See, here’s a boat. So it goes here (place it in box on the left). If it’s car it goes here, but if it’s boat it goes here (pointing to boxes to identify them).

See, here’s an car. So it goes here (place it in box on the right). If it’s boat it goes here, but if it’s car it goes here (pointing to boxes to identify them).

Now it’s your turn. So remember, if it’s car it goes here, but if it’s boat it goes here (pointing to boxes).
Rule Check: Can you show me where the cars go in the shape game?

1st attempt
Circle Response: Correct (1) Incorrect (0)
2nd attempt (if 1st incorrect)
Circle Response: Correct (1) Incorrect (0)

If Correct: Very good, that’s right.
If Incorrect: Uh oh. Remember, in the shape game, all the boats go here (left), and all the cars go here (right). (Point to appropriate boxes. Repeat question and reminder 1 more time, only then mark as incorrect & move on.)

Rule Check: Can you show me where the boats go in the shape game?

If Correct: Very good, that’s right.
If Incorrect: Uh oh. Remember, in the shape game, all the cars go here (right), and all the boats go here (left). (Point to appropriate boxes. Repeat question and reminder 1 more time, only then mark as incorrect & move on.)

1st attempt
Circle Response: Correct (1) Incorrect (0)
2nd attempt (if 1st incorrect)
Circle Response: Correct (1) Incorrect (0)

LET’S TRY THIS GAME!

On each trial, say: If it is a boat, then put it here, but if it is a car, put it here.

Shape Test Trials:

1. (Green car) Here’s a car. Car _____ Boat _____
2. (Orange boat) Here’s a boat. Car _____ Boat _____
3. (Green car) Here’s a car. Car _____ Boat _____
4. (Green car) Here’s a car. Car _____ Boat _____
5. (Orange boat) Here’s a boat. Car _____ Boat _____
6. (Orange boat) Here’s a boat. Car _____ Boat _____

Total Shape (0-6):_______
Pass/Fail Shape (0-1):_______
(0 if < 5 correct, 1 if ≥ 5)
Good job! Now we’re going to play a new game. We’re not going to play the shape game anymore (Shake head no). We are going to play the COLOR game! In the color game, all the green ones go here, and all the orange ones go here.

Rule Check: Can you show me where the green ones go in the color game?

*If Correct:* Very good, that’s right.

*If Incorrect:* Uh oh. Remember, in the color game, all the green ones go here, and all the orange ones go here. (Point to appropriate boxes. Repeat question and reminder 1 more time, only then mark as incorrect & move on.)

1st attempt
Circle Response: Correct (1) Incorrect (0)

2nd attempt (if 1st incorrect)
Circle Response: Correct (1) Incorrect (0)

Can you show me where the orange ones go in the color game?

If Correct: Very good, that’s right.
If Incorrect: Uh oh. Remember, in the color game, all the green ones go here, and all the orange ones go here. (Point to appropriate boxes. Repeat question and reminder 1 more time, only then mark as incorrect & move on.)

1st attempt
Circle Response: Correct (1) Incorrect (0)

2nd attempt (if 1st incorrect)
Circle Response: Correct (1) Incorrect (0)

LET’S TRY THIS GAME!

On each trial, say: If it is a green one, then put it here, but if it is an orange one, put it here.

1. (Orange boat) Here’s an orange one. Green _____ Orange_____
2. (Green car) Here’s a green one. Green _____ Orange_____
3. (Green car) Here’s a green one. Green _____ Orange_____
4. (Orange boat) Here’s an orange one. Green _____ Orange_____
5. (Orange boat) Here’s an orange one. Green _____ Orange_____
6. (Green car) Here’s a green one. Green _____ Orange_____

Total Color (0-6):_____
Pass/Fail Color (0-1):_____
(0 if < 5 correct, 1 if ≥ 5)
First: put in ID #

In a moment, I am going to press “OK” to start the computer program. When the program starts, some pictures will flash very quickly on the screen, one at a time. You will have to press the spacebar (or click on the mouse) each time you see a picture, except when it is a soccer ball. When you see the soccer ball, DO NOT press anything, just wait for the next picture. If you make a mistake, it is okay. Do not worry about it and just keep going. Respond as fast and as correctly as you can. Let’s practice these rules. Can you show me how to use the spacebar?

Practice Round - give reinforcement

“Press it’s a... _____ (plane/boat/horse etc...)”
Or

“Don’t press, it’s a ball!”

Check if the child understood the rules well enough to play the game.

Play!

Give encouragement every 1.5 minutes (at every block)

If participant asks how much longer… “I’m not sure, but you’re doing great! Let’s keep going!”