Effect of Music Training on Promoting Preliteracy Skills: Preliminary Causal Evidence

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THE PRESENT STUDY INVESTIGATED WHETHER MUSIC TRAINING fosters children's preliteracy skills. Sixty children were randomly assigned to participate in a 20-day training program in either music or visual art. Before and after training, children's phonological awareness and their ability to map visual symbols onto words (i.e., visual-auditory learning) were assessed. Equivalent improvement after training was observed for both groups on the phonological awareness measure, but the children with music training improved significantly more than the art-trained children on the visual-auditory learning measure. Music training appears to benefit certain skills necessary for reading.

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IN THE PAST 10 YEARS SEVERAL STUDIES HAVE INVESTIGATED the impact that life experiences have on cognitive processing (for review, see Draganski & May, 2008). In particular, music experience is one domain that has begun to receive substantial attention. For example, neuroimaging studies have found significant anatomical and functional differences between musicians and nonmusicians in brain regions that are known to be important for music processing (Jäncke, 2009; Schlaug, Norton, Overy, & Winner, 2005). However, because most of these studies used correlational designs to compare professional musicians to nonmusicians, it has not been possible to eliminate preexisting differences between the two groups as a possible causal explanation.

There are, nonetheless, a few studies that have strongly implicated the role of music training in the observed differences in the anatomo-functional organization of the brain. Schneider et al. (2002) found that degree of music expertise correlated significantly with both anatomical structure (i.e., gray matter volume) and neurophysiological data (i.e., the amplitude of early auditory evoked neural activity; see also Gaser & Schlaug, 2003). These findings indicate that the functional differences reported in many studies may be directly associated with anatomical differences and that these functional differences are proportional to the amount of music training received. Furthermore, Hyde et al. (2009) showed structural brain changes after only 15 months of music training in children. Importantly, these changes were correlated with improvements in musically relevant motor and auditory skills. Norton et al. (2005) investigated whether biological predispositions were a possible source of observed differences in MRI and fMRI results for musicians and nonmusicians by comparing children who had recently begun music lessons and those who were not planning to take lessons. Having observed no differences, the authors concluded that any differences between musicians and nonmusicians should be attributed to their training. Taken together, these findings suggest that structural and functional brain differences in adult musicians are the result of training induced brain plasticity rather than biological brain predispositions.

If music training induces structural and functional changes in the brain, then such training may also affect nonmusical cognitive functioning such as language processing and reading skills. The rationale for this prediction is twofold. First, both music and language processing require similar cognitive processes, such as the ability to segment sounds into perceptual units (Norton et al., 2005; Patel, 2008) and to attend to pitch patterns (Foxton et al., 2003; Norton et al., 2005). Second, brain regions recruited during music processing overlap with those recruited during language processing (Koelsch, 2006; Patel, 2003). Thus, if music training modifies brain regions that are associated not only with music processing but also with language

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processing, benefits gained from music training may transfer to language skills.

Recent neuroimaging work using Event Related Potentials (ERPs) supports the idea of a causal link between music training and improved language processing. Moreno and Besson (2006) investigated pitch processing in 8-year-old children who listened to sentences that either contained final words whose pitch was prosodically congruous, weakly incongruous, or strongly incongruous. They found reduced ERP amplitudes in the strongly incongruous condition for children who had been randomly assigned to a music training program compared to children who had been randomly assigned to a visual art training program. These results suggest that music training facilitates pitch processing in language (see also Moreno et al., 2009, for similar findings). Similarly, Jentschke and Koelsch (2009) found that musically trained 10- to 11-year-old children exhibited a more strongly developed ELAN (early left anterior negativity) than did untrained children in response to syntactic violations during sentence processing, although the children in their study were not randomly assigned to groups. Together, these results support the tentative conclusion that music training influences language perception.

Recent research has extended this possibility by investigating whether music training also influences the cognitive and linguistic processes associated with reading. Although reading ability may appear to be distally related to music ability (as compared to speech perception), points of similarity between music and reading suggest that skills learned in music training may transfer to skills needed for reading. First, reading an alphabetic language requires an awareness of its phonological structure and necessitates an ability to differentiate between its phonemes (National Institute of Child Health and Human Development, 2000). Importantly, there is considerable variability in children's degree of phonological awareness, and individuals who exhibit poor phonological awareness also tend to be poor readers (e.g., Bradley & Bryant, 1983; Werker & Tees, 1987). Music expertise also requires an awareness of sound structure such as an ability to differentiate between tones. Because research has found that there are strong correlations between phonological awareness and pitch discrimination ability (Anvari, Trainor, Woodside, & Levy, 2002; Lamb & Gregory, 1993) and that music training affects speech perception (Moreno & Besson, 2006; Moreno et al., 2009), music training may lead to improvements in general auditory sensitivity that would then lead to an improved ability to perceive phonological structure (Butzlaff, 2000; Patel, 2008). A recent study by Degé and Schwarzer (2011) implicated a causal association between music training and enhanced phonological awareness but the sample size was small (i.e., 13 children per condition) so this result should be interpreted cautiously. A second parallel is that both reading and music have formal structure in which a written code is mapped directly onto sounds (phonemes and notes, respectively). Experience mapping a symbol onto a sound in music training may benefit learning the grapheme-phoneme correspondences needed for reading (Butzlaff, 2000; Forgeard, Schlaug, Norton, Rosam, & Iyengar, 2008).

Despite their underlying similarities, research on the association between music training and reading skills has produced mixed results (Črnčec, Wilson, & Prior, 2006). In a meta-analysis that included 25 correlational studies and 6 experimental studies, Butzlaff (2000) compared reading performance on standardized tests for students with music experience and those with no music experience. Although a robust positive association was observed between music training and reading performance in the correlational studies, only half the experimental studies found evidence of positive transfer from music training to reading performance. Butzlaff determined that no clear conclusion about the causal role of music training on reading skills could be drawn from this group of studies (see also Črnčec et al., 2006, for a similar conclusion).

Nevertheless, recent research has investigated the nature of this association by examining associations between specific properties of both music ability and reading ability. For example, Foxton et al. (2003) correlated adult readers' ability to detect differences in pitch contours with performance on exception-word reading (i.e., words that do not follow spelling-sound correspondences, e.g., "ache"), orthographic processing (i.e., identifying correct spellings from incorrect spelling when all words sound like real words, e.g., "rain" vs. "rane"), and phonological decoding (i.e., reading nonwords, e.g., "tegwop"). Performance on the pitch task accounted for a significant portion of the variance in both the exception-word reading task and the phonological decoding task, but not the orthographic processing task. The authors concluded that the association between pitch processing and reading component skills are limited to the phonological domain. Results from a longitudinal study by Forgeard et al. (2008, Study 2) are consistent with this finding. They found that 6-year-old children with 14 months of music training improved significantly more on a phonological decoding task (reading nonwords) than did children with no music training, but no differences were observed on a word identification task (reading real words). Similarly, in Study 1 a stronger association between pitch processing and phonological skills was observed in children with music training. These correlational findings clearly intimate a causal association between music training, phonological awareness, and reading ability.

Phonological processing is not the only component of reading that may be influenced by music training. Anvari et al. (2002) found that preschool children's music perception skills (note, not their music training) predicted reading ability even after variance from phonological awareness ability was held constant. And in a quasi-experimental design, Piro and Ortiz (2009) found that musically trained students had significantly higher scores on a vocabulary test and on a receptive grammar test than untrained students, despite there being no group differences at pretest. Similarly, Ho, Cheung, and Chan (2003) found that musically trained children exhibited superior verbal but not visual memory performance compared to children without music training. Both vocabulary knowledge and grammatical ability are predictive of skilled reading (Jared, Cormier, Levy, & Wade-Woolley, 2010; Muter, Hulme, Snowling, & Stevenson, 2004).

Although results of correlational studies are suggestive of a causal relationship between music training and cognitive processes associated with reading, as noted above, few studies have found evidence to support the interpretation of a causal association (Butzlaff, 2000; Črnčec et al., 2006). This is partly because few studies have used a design in which participants were randomly assigned to training conditions. A notable exception is a recent study by Moreno et al. (2009), who randomly assigned 8-year-old children to six months of either music or visual art training. Participants performed a word reading task before and after training. This reading task included words with simple and consistent spelling-sound correspondences (i.e., 1 grapheme to 1 phoneme mappings), words with complex and consistent spelling-sound correspondences (i.e., 2 grapheme to 1 phoneme mappings), and words with complex and inconsistent mappings (i.e., exception words whose pronunciation cannot be derived from the rules). The only significant improvement following training was observed for the musically trained children in the inconsistent mapping condition. This result suggests a direct effect of music training on reading skill, at least for the most difficult reading condition.

The purpose of the present study was to extend this research by comparing the effects of intensive training in music or visual art on two preliteracy skills: phonological awareness and symbolic mapping of arbitrary visual forms onto familiar words. Phonological awareness is a necessary prerequisite for learning grapheme-phoneme mappings (Bradley & Bryant, 1983; Goswami, 1990), and music training may increase general auditory sensitivity that transfers to the ability to perceive phonological structure (Butzlaff, 2000; Degé & Schwarzer, 2011; Patel, 2008). We assessed this skill using a rhyming test, predicting that music training would improve phonological awareness.

The learning of grapheme-phoneme mappings underlies word decoding (Anvari et al., 2002), and this kind of learning is similar to the learning of notation-note mappings in music. Both processes involve mapping an arbitrary visual symbol onto an auditory stimulus. Although this component of reading has received less attention in the reading literature than has phonological awareness, this skill is not a trivial one. First, children must develop "concepts of print" — that is, they must grasp the concept that symbols represent sounds (Bialystok, 1997; Bialystok, Shenfield, & Codd, 2000). Additionally, to read English, children must learn to map approximately 40 phonemes onto graphemes where there is often not a one to one correspondence between a letter and a sound, and where identifying a phoneme depends on the letters that surround it. Children's ability to do this was tested with a visual-auditory learning test in which children had to learn to associate unfamiliar symbols with known words and then combine these symbols into sentences. Because music training involves a parallel mapping of notes to sounds, the hypothesis was that musically trained children would improve more than art-trained children on this test.

Method

Participants

Seventy-two children between 4 and 6 years of age were recruited from various neighborhoods in the Greater Toronto Area to participate in a "summer camp." These children participated in a concurrent project investigating the effect of music and art training on intelligence and executive functioning (see Moreno et al., 2011). Data from 12 participants were discarded: three dropped out of the summer camp after two weeks, two children became ill, two did not speak English fluently, two exhibited floor performance on the visual-auditory learning test (VAL) at pretest, and three exhibited ceiling performance on the VAL at pretest. The final sample consisted of 60 children with 30 in each training group (14 boys/16 girls in the visual art group and 12 boys/18 girls in the music group). According to a background questionnaire given to the parents, none of the participants had more than one year of private music or art lessons.

Training

Over a period of four weeks, the children participated in either a music or visual art training program. There were two sessions of one hour each day (15 minutes for organization and 45 minutes of training) for 20 days, all led by trained teachers. The material was projected on the classroom wall and involved groups of students interacting with the materials. Teachers began the training session with a 1 hr lesson, followed by a 1 hr break, followed by another 1 hr lesson. Breaks consisted of outdoor games and snacks. Children were pseudorandomly assigned to training in either morning or afternoon sessions based on parental constraints.

Two computerized training programs (both created by the first author) were administered. The curriculum in music listening (U.S. Patent App. No. 61/325,918, 2010) included training on rhythm, melody, pitch, voice, and basic music concepts such as the musical staff. The training in visual art emphasized the development of visuospatial skills relating to concepts such as light and color, line, perspective, material, and texture. The interactive feature of the program involved animated characters that engaged the children after each response: repeating instructions, giving feedback, and asking questions based on the user's performance. The computer implementations allowed us to control the pace of each lesson for each group. The training programs were matched on learning goals, graphics and design, duration, number of breaks, and number of teaching staff. They only differed on the nature of the training.

Each training program was administered to the classes in separate rooms with one computer in each class (i.e., group lessons). Each lesson was conducted by a teacher, three teaching assistants, and one research assistant. In total, six teachers (three art, three music) were recruited who each met the following criteria: prior experience with preschool children and a Master's degree in music or art. In both groups, one teacher conducted the class for two weeks and two other teachers taught for one week each. For both groups, teachers directed the computerized training as a group activity and adhered closely to the software curriculum. The role of the research assistant was to ensure that the teachers were adhering to the curriculum. During the training, the research assistants were seated in a corner of the room as observers.

At the end of the training, the music and art teachers evaluated each child on a scale from 0 to 7 on several skills taught during the training. A minimum average score of 5 was required to consider the training successful. Teachers were not aware of this threshold. All children completed the training with a minimum average grade of 5.

Both types of training were described by teachers and parents as challenging, interesting, and rewarding experiences for the children. Thus, none of the parents complained that their child followed one type of training and not the other. When speaking to the parents, there was general consensus in their gratitude for free music or visual art lessons. At the end of the 20 day training session there was a children's art exhibition and a concert showcasing the skills they had learned. Many parents took it upon themselves to engage their child in music or art programs as a result of our summer camp. A few months after the training program was complete, a ceremony was organized in which children received a certificate of participation and a DVD showing their participation in the camp. Children were also given small toys and stickers at the pre-test and posttest stages.

Assessment Measures

Background questionnaire. A questionnaire to be completed by the parents was developed to ascertain both the children's and parents' demographic, language, and music/art background. Included on the questionnaire was a Likert scale measuring parents' level of education where "1" was "no high school diploma," "2" was "high school graduate," "3" was "some college or college diploma," "4" was "bachelor's degree," and "5" was " graduate or professional degree." The questionnaire was also used to confirm that the children had minimal experience in music or art programs.

Intelligence measures. To estimate overall IQ, we administered the Vocabulary and Block Design subtests of the WPPSI-III (Wechsler Preschool and Primary Scale of Intelligence), an intelligence test designed for children aged 2 years 6 months to 7 years 3 months (Wechsler, 2002). This test provides subtest and composite scores that represent intellectual functioning in verbal and spatial domains (see Sattler, 2008, for conversion tables).

The Vocabulary subtest contains 25 words arranged in order of increasing difficulty. The child is asked to explain orally the meaning of each word (for example, "What is a ___?" or "What does ___ mean?"). The Block Design subtest contains 20 items, consisting of two-dimensional, red and white pictures of abstract designs. Children use red and white blocks to assemble a design identical to that in the picture.

Preliteracy Measures

Phonological awareness - Rhyming test. Rhyming is one of the subtests in the Sound Awareness section of the Woodcock-Johnson III Tests of Cognitive Abilities (Woodcock, Mather & McGrew, 2001). Rhyming was tested by having the child name a word that rhymed with a given word and by asking the child if two or more spoken words rhymed. Performance was scored as the number of correct responses out of a possible total score of 17.

Visual-Auditory Learning test. The Visual-Auditory Learning test (VAL) is a standardized measure ($M = 100$, $SD = 15$; Woodcock & Johnson, 1977) that assesses the ability of a child to associate unfamiliar visual symbols (rebuses) with familiar words from the child's oral vocabulary, and to translate sequences of rebuses into sentences. In this test, children are initially taught arbitrary mappings between unfamiliar visual symbols and known words. They are subsequently shown a series of these symbols and asked to identify the symbols by using the associated words. As the test progresses, more symbols are added to the children's repertoire and the sentences denoted by the symbols become more complicated. Performance was assessed using the children's standard score on this measure.

Procedure

Children were tested using a pretest/training/posttest design. The pre and posttest stages involved the same tests (i.e., the WPPSI and Woodcock-Johnson subtests). The tests were presented to children in a randomized order. The testing took place in our laboratory and lasted 60 min for each session. Children were assessed individually by a research assistant blind to training type received. Four female research assistants took part in both the pre and posttest phases. After the pretest, children were pseudo-randomly assigned to music training or to visual art training to ensure that there were no pretraining differences between groups on age, intelligence scores, and mother's education level (an estimate of socioeconomic status). Because this study was part of a larger project with a battery of tests (see Moreno et al., 2011), groups were matched on background measures that, if not controlled, could conceivably serve as explanations for group differences. After training, children returned to our laboratory to be retested on the assessment measures.

Results

There were no differences at pretest between groups on WPPSI scores, age, or mother's education, all Fs < 1 (see Table 1). Mean scores (maximum score of 17) for the rhyming test are reported in Table 2. A two-way ANOVA using training group and testing session as independent variables produced a significant main effect of session, $F(1, 58) = 15.21$, $p < .001$, $MSE = 4.84$, in which there were significantly higher scores on the post-test ($M = 10.5$) than on the pretest ($M = 8.9$). However, there was no main effect of group or interaction between group and session, both Fs < 1.

Standard scores on the visual-auditory learning test are also reported in Table 2. The two-way ANOVA for group and session revealed a main effect of session, $F(1, 58) = 35.44$, $p < .001$, $MSE = 27.67$, showing improvement from the pretest ($M = 109.3$) to the posttest ($M = 115.0$). A main effect of group was also observed, $F(1, 58) = 8.10$, $p < .01$, $MSE = 138.65$, in which children in the music group ($M = 115.2$) outperformed children in the visual art group ($M = 109.1$), with no significant interaction of group and session, $F(1, 58) = 1.79$, $p > .10$, $MSE = 27.67$. However, the main effect of group suggested that the groups may not have been matched at pretest on visual-auditory learning, making it difficult to compare differences in improvement following training. In other words, improvement due to training may have been confounded with the visual art group having more room for improvement than the music group. The difference in initial ability was confirmed by a one-way ANOVA for the pretest session, $F(1, 58) = 4.40$, $p < .05$, $MSE = 79.72$. Therefore, an analysis of covariance on posttest scores using pretest scores as a covariate was conducted to evaluate performance following training. The ANCOVA revealed that the music group significantly outperformed the visual art group $F(1, 57) = 4.65$, $p < .05$, $MSE = 24.41$, indicating that, when group differences at pretest were equated, greater improvement following training was observed in the music group. These data (using the adjusted mean scores) are presented in Figure 1.

TABLE 1. Group Means (and Standard Deviations) for Background Measures at PreTest.

Background Measures	Training Type	
	Visual Art	Music
Age (in Months)	63.7 (6.5)	62.7 (4.5)
Mother's Education	3.8 (0.9)	3.8 (1.0)
WPPSI Estimated I.Q.	105.9 (10.9)	106.7 (12.2)

Discussion

The goal of the current study was to investigate whether short-term intensive music training improves performance on preliteracy skills in children. After only 20 days of training, both the visual art and music

TABLE 2. Mean Scores (and Standard Deviations) on Preliteracy Measures for the Visual Art and Music Training Groups at Pre and Posttest.

	Training Type			
	Pre-test		Post-test	
Preliteracy Measures	Visual Art	Music	Visual Art	Music
Rhyming (top score = 17)	8.6 (3.9)	9.2 (2.9)	10.0 (4.3)	11.0 (3.7)
Visual-Auditory Learning	106.9 (9.5)	111.7 (8.4)	111.3 (9.2)	118.7 (9.4)

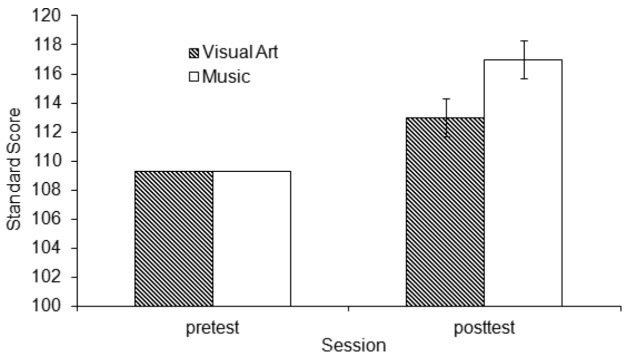

FIGURE 1. Estimated mean scores on the visual-auditory learning test for the visual art and music training groups at pre and posttest when pretest performance is statistically equated.

groups exhibited comparable improvement in rhyme awareness. Similarly, both groups' ability to map unfamiliar symbols to known words improved significantly from pretest to posttest. However, when the two training groups were statistically equated at pretest, the magnitude of improvement was found to be larger for the musically trained group than for the visual art group. It is important to note that this group difference was subtle and emerged only after pretest scores were equated in an ANCOVA. Consequently, the effect of music training on preliteracy skills should be considered preliminary and suggestive.

One possible explanation for the differential improvement of the two groups is that there was a qualitative difference between the groups at pretest that enabled the children assigned to the music group to exhibit greater improvement. However, given that the two groups were matched on two IQ subtests and SES at pre-test, and in the absence of another obvious variable, this possibility seems unlikely. Our interpretation is that when pre-literate children were trained on "note to sound" mappings in music, they gained experience with the use of symbolic representations. Consequently, their ability to understand that a symbol is an arbitrary representation of a concept was enhanced. This is the symbolic skill assessed in the visual-auditory learning test and is an essential preparatory skill in learning to read. It may also be that music training helps improve children's general ability to learn arbitrary mappings between symbols and concepts by enhancing general memory ability. However, our study does not allow us to differentiate between these possibilities.

Some evidence for improved memory comes from a study of literacy skills in older children. Moreno et al. (2009) found that 8-year-old children's error rates on reading exception words improved significantly after music but not visual art training. No group differences were observed for words that adhered to phoneme-grapheme rules. Reading exception words (also called irregular or inconsistent words) depends more heavily on memory processes since these words must be learned by mapping their orthographies directly onto their meanings and cannot be easily decoded by using phonology. Moreno et al.'s (2009) results may be reinterpreted to suggest that music training improved memory processes, which in turn facilitated learning the mappings between irregular orthographic forms and their meanings.

A few correlational studies also point to an association between music knowledge and memory enhancement. Foxton et al. (2003) found that adults' ability to detect pitch contours was correlated not only with reading consistent words, but also with reading exception words. This finding suggests that at its core, the link between music perception and reading may not be solely based on the overlap between auditory and phonological knowledge as the authors suggested. Likewise, Ho et al. (2003) found that children with music training had better verbal memory for orally presented words than did children with no music training. Vocabulary learning is another example of mapping unfamiliar phonological forms onto meaning. Recall that Piro and Ortiz (2009) found that musically trained children exhibited superior vocabulary knowledge after three years of piano lessons compared to children who did not receive these lessons. Taken together, these findings indicate that music training may ameliorate memory ability, which in turn is important for several cognitive processes including reading.

Despite evidence of an association between music perception and phonological awareness (e.g., Anvari et al., 2002; Lamb & Gregory, 1993), in the current study music training had no differential impact on rhyming ability. Both groups improved from pretest to posttest, possibly because of maturation and test-retest effects. These findings differ from those previously reported in the literature. Degé and Schwarzer (2011), Moritz (2007, as cited in Forgeard et al., 2008), and Overy (2003, Study 1) observed improvement in children's phonological processing following music training. However, in each case the training period was considerably longer – 5, 6, and 10 months, respectively. It may be that 20 days of training is insufficient to improve both the underlying phonological representations of words and children's ability to access these representations explicitly in a phonological awareness test. Using a more sensitive measure such as ERP might reveal implicit effects of music training on phonological representations.

There are two important reasons why the question of whether music training improves phonological awareness remains unsettled. First, studies that observed an effect had a small sample (Degé & Schwarzer, 2011), employed pre-existing groups (e.g., Forgeard et al., 2008), or lacked a control group (e.g., Overy, 2003). Further studies with larger samples and stringently controlled designs should be conducted to replicate findings that music training strengthens phonological awareness skills. Second, it is difficult to compare results across studies because studies have used very different kinds of music training. Our music training is different from typical music lessons because the computerized lessons focused on music theory and perception rather than hands-on instrumental experience. However, a benefit of our approach is that it reduces the variability of content in the lessons. Consequently, future studies could systematically manipulate the proportion of time spent on each music skill to investigate their relative impact on nonmusical abilities. Nevertheless, differences in training programs necessitate that caution be taken in extending our findings to typical music lessons.

To date, there is little evidence that music training directly improves reading ability. Our study provides preliminary evidence that a preliteracy skill that is important for reading is enhanced by music training. However, further research is necessary to determine whether improvement on this skill actually results in improved reading ability. Because direct parallels can be made between the cognitive processes recruited by music processing and these preliteracy skills, it was reasonable to assume that proximal transfer would occur at this level of processing. Likewise, proximal transfer has been observed wherein music training influenced auditory processing (Fujioka et al., 2006) as well as pitch processing during language perception (Moreno & Besson, 2006; Moreno et al., 2009). However, reading is a skill that involves multiple cognitive processes operating in concert (e.g., orthographic processing, phonological decoding, accessing oral language knowledge, working memory, etc.) and thus may not be directly affected by music training. If music training affects only specific subcomponents necessary for reading, then improvement might not be observed on reading performance itself (e.g., Overy, 2003). Consequently, future studies investigating the influence of music training on reading behavior directly should also include measures that have been shown to be good predictors of skilled reading such as vocabulary and naming fluency (National Institute of Child Health and Human Development, 2000). By investigating how these variables may be influenced by music training, as well as examining the association between these variables and skilled reading, a more comprehensive picture of how music training may either directly or indirectly foster reading may emerge.

In conclusion, the current study represents an important step in our understanding of how skills acquired in music training may transfer to other cognitive domains. Our study is one of the few to employ a longitudinal design and randomly assign children to training conditions. Implications of this type of research are twofold. First, observing transfer from one domain to another is suggestive of underlying general cognitive processes that can be recruited for different functions. Second, evidence of such transfer provides promise that music training may eventually be used to facilitate learning in other domains, such as reading.

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