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PAPER

Active music classes in infancy enhance musical, communicative and social development

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Abstract

Previous studies suggest that musical training in children can positively affect various aspects of development. However, it remains unknown as to how early in development musical experience can have an effect, the nature of any such effects, and whether different types of music experience affect development differently. We found that random assignment to 6 months of active participatory musical experience beginning at 6 months of age accelerates acquisition of culture-specific knowledge of Western tonality in comparison to a similar amount of passive exposure to music. Furthermore, infants assigned to the active musical experience showed superior development of prelinguistic communicative gestures and social behaviour compared to infants assigned to the passive musical experience. These results indicate that (1) infants can engage in meaningful musical training when appropriate pedagogical approaches are used, (2) active musical participation in infancy enhances culture-specific musical acquisition, and (3) active musical participation in infancy impacts social and communication development.

Introduction

Every society appears to have special songs for infants (Trehub, 2003, 2007) and long before infants understand words, their caregivers communicate with them through music, calming them with lullabies and arousing them with playsongs (Rock, Trainor & Addison, 1999; Shenfield, Trehub & Nakata, 2003; Trehub & Trainor, 1998). Little is known about the effects of this early interactive music-making on development, but in Western societies in recent years caregivers have the option to replace it, at least in part, with passive listening to recorded music. In the present study we randomly assigned 6-month-old infants to 6 months of either active participatory music classes for infants and parents or to passive music classes where recorded music was played in the background while infants and parents engaged in various other activities. After the 6 months of passive versus active music classes, we compared infants in the two groups on their acquisition of knowledge about Western musical tonality, their social behaviours, and their use of communicative gestures.

A number of studies with older children suggest that participation in music lessons positively affects musical, linguistic and cognitive development (Corrigall & Trainor, 2009; Jentschke & Koelsch, 2009; Moreno, Marques, Santos, Santos, Castro & Besson, 2009; Schellenberg, 2011; Schlaug, Forgeard, Zhu, Norton, Norton & Winner, 2009; Trainor & Corrigall, 2010). Fujioka, Ross, Kakigi, Pantev and Trainor (2006) found that over the course of a year of music lessons, 4- to 5-year-old children showed more change in event-related potential brain responses related to attention and memory, in comparison to children engaged in other activities. Shahin, Roberts, Chau, Trainor and Miller (2008) showed that induced gamma band responses from electroencephalogram (EEG) recordings – which are related to attention, feature-binding and top-down processing – emerged after one year of musical training between 4 and 5 years of age, but remained undetectable in children not taking music lessons. Using MRI, Schlaug *et al*. (2009) found that the corpus collosum, which reflects inter-hemispheric communication, develops differently in 5- to 7-year-old children taking music lessons compared to children not taking music lessons. However, these studies did not use random assignment so it is difficult to be sure that the musical training caused the differences. Two studies using random assignment found that participation in one year of music lessons at age 6 years led to a greater increase in IQ compared to one year of participation in drama lessons (Schellenberg, 2004), and that participation in 6 months of music training at age 8 years resulted in enhanced reading and pitch discrimination skills compared to 6 months of painting training (Moreno *et al*., 2009).

Although the brain is likely most plastic early in development, controlled studies of musical training in infants have not been conducted previously. Young

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infants are sensitive to some aspects of music (Hannon & Trainor, 2007; Perani, Saccuman, Scifo, Spada, Andreolli, Rovelli, Baldoli & Koelsch, 2010; Trainor, 2005; Trainor & Corrigall, 2010; Trehub, 2003). Without formal training, young infants prefer consonant over dissonant musical intervals (Trainor, Tsang & Cheung, 2002), remember simple melodies for periods of weeks (Saffran, Loman & Robertson, 2000; Trainor, Wu & Tsang, 2004), distinguish metrical structures (Hannon & Trehub, 2005a) and integrate movement and auditory information in extracting the meter of ambiguous rhythms (Phillips-Silver & Trainor, 2005). Importantly, acquisition of musical skills continues throughout development with or without musical training. Many studies in Western adults show that even those without formal musical training have developed brain circuits that are specialized for processing Western musical structure through passive everyday exposure (Bigand & Pineau, 1997; Bigand & Poulin-Charronat, 2006; Janata, Birk, Van Horn, Leman, Tillmann & Bharucha, 2002; Koelsch, Gunter, Schröger & Friederici, 2003; Peretz, 2006; Tillman, Bigand, Escoffier & Lalitte, 2006; Tillman, Bigand & Madurell, 1998; Trainor, McDonald & Alain, 2002). Just as infants learn the particular language spoken in their environment, they also acquire sensitivity to the tonal (musical scales and harmonies) and rhythmic structure of the musical system of their culture (Hannon & Trainor, 2007; Hannon & Trehub, 2005a; Trainor, 2005; Trainor & Corrigall, 2010; Trainor & Trehub, 1992) and exposure to music and movement appears to accelerate acquisition of culture-specific rhythms (Gerry, Faux & Trainor, 2010). Such environmentally driven perceptual specialization is also found for auditory discrimination of native compared to foreign speech contrasts (Kuhl, Tsao & Liu, 2003; Werker & Tees, 1984) and visual discrimination of faces from one's own compared to a foreign race (Kelly, Quinn, Slater, Lee, Ge & Pascalis, 2007) and one's own compared to a foreign species (Pascalis, de Haan & Nelson, 2002). Thus, the natural exposure infants receive to specific faces, languages and music in their environment appears to drive perceptual skill development.

Although it is clear that infant perception becomes specialized through exposure to a particular environment, few studies have investigated the nature of learning early in development in a controlled manner by studying the effects of specific training on skill acquisition in infants using random assignment to different experiences. In the music domain, Gerry *et al*. (2010) did find that infants attending Kindermusik classes showed earlier enculturation to Western rhythms in comparison to infants not attending classes. A study of preschool children also suggests that musical training accelerates acquisition of musical harmony (Corrigall & Trainor, 2009), but neither of these studies used random assignment. A few studies suggest that specific training can affect skill acquisition in infants. Hannon and Trehub (2005b) demonstrated that 12-month-old infants exposed to music with complex metrical structures (uncommon in Western cultures) at home could distinguish rhythmic variations in other metrically complex music at test, whereas 12-month-old infants without such exposure could not. Kuhl *et al*. (2003) showed that 9-month-old English-learning infants exposed interactively to Mandarin speech, but not those with passive exposure, were able to discern phonemic differences in Mandarin. Pascalis, Scott, Kelly, Shannon, Nicholson, Coleman and Nelson (2005) found that 6- to 9-month-old infants who received training on the faces of Barbary macaque monkeys could discriminate monkey faces, whereas those who did not receive this training could not.

In the present study, infants and their parents were randomly assigned to participate in one of two types of music classes. The *active* music class employed a Suzuki-philosophy early childhood education approach in which teachers work with parents and infants using a curriculum that emphasizes movement, singing, playing percussion instruments, and building a repertoire of lullabies and action songs (Jones, 2004). Infants and parents are required to remember songs and to pay attention in order to sing, move, or play a percussion instrument at the appropriate time. Parents are active participants in the learning process; developing an awareness of their infants' progress is considered an essential component of this approach. Parents in the active music classes were encouraged to use a CD of songs from class at home and to repeat the activities on a daily basis. In the *passive* music classes, parents and infants listened to a rotating selection of music from the popular Baby Einstein™ series, the name of which implies educational benefits, featuring popular classical repertoire performed on synthesized musical instruments and without musical expression. While listening to the music, parents and infants in the passive music classes were free to interact at art, books, balls, blocks and stacking cup play stations. Participants chose a different Baby Einstein™ CD each week to play at home.

One goal of the present paper was to test whether active musical experience in infancy enhances sensitivity to Western tonality more than passive experience. To test this, we used a head-turn preference procedure in which infants controlled how long they listened to two different versions of a Sonatina by Thomas Atwood. In its original form (*tonal* version), the Sonatina conformed to the rules of Western musical structure. This tonal version was contrasted with an *atonal* version that changed key every beat. Acquisition of sensitivity to Western tonal structure was expected to lead to a preference for the tonal version. We measured amount and type of at-home musical exposure using a parent questionnaire.

A second goal of the present paper was to test whether engaging in active music-making between parents and infants promotes social, emotional and communicative development. Music is essentially a social activity and good caregiver–child interaction is essential for healthy cognitive and social development during infancy (Singer, Golinkoff & Hirsh-Pasek, 2006). Parents use singing to engage infants in social interaction and infants prefer to listen to infant-directed singing compared to singing of other types (Rock *et al*., 1999; Trainor, 1996; Trehub & Trainor, 1998). In linguistic communication, infants whose interactions with parents involve more speech and diverse vocabulary show better language outcomes later in childhood (e.g., Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991) and this environmental specificity extends to families with different socioeconomic backgrounds (Hoff, 2003). Furthermore, recent studies in children suggest that making music with other people leads to greater social cooperation. For example, Kirschner and Tomasello (2010) found that active music-making amongst 4-year-old children led to spontaneous helpful and cooperative behaviour. We measured social-emotional development with four subscales of the standardized Infant Behavior Questionnaire (IBQ): Distress to Limitations, Distress/Latency to Approach Novel Stimuli, Smiling and Laughter, and Soothability. We measured early communicative development with the standardized MacArthur-Bates Communicative Development Inventories.

Materials and methods

Participants

Infants and parents assigned to the Active Training and Passive Training groups were recruited through Ontario Early Years Centres, which are government-sponsored drop-in centres for preschool children and their families. Programmes in these centres are run in collaboration with Wesley Urban Ministries. Fifty-two infants and their parents signed up to participate for 6 months in an hour-long weekly class held at two different Ontario Early Years Centres located in areas of contrasting socioeconomic vulnerability. Music classes at each centre were offered on two different days of the week, and the class day parents were assigned dictated the type of training they and their infants received. When classes began, 49 families were attending regularly (25 in the Active Training group, and 24 in the Passive Training group). By the end of the 6 months, 38 families were still attending classes regularly (where regularly was defined as attending more than 75% of classes; 21 Active and 17 Passive) and they were asked to participate in the final round of testing at 12 months of age. Of those, 34 families (20 Active and 14 Passive) participated in all initial and final tests. The infants were 19 girls and 15 boys. In our final sample, 16 families (10 Active, 6 Passive) lived in neighbourhoods considered highly socioeconomically vulnerable for young children, according to the Neighbourhood Social Index risk factors provided by Human Resources Development Canada (Connor, 2001). The average age at the commencement of the classes was 6.49 months (SD = 0.99) and at the time of final testing in the last weeks of classes was 11.56 months (SD = 0.85). An additional control group (n = 31) of infants was recruited from the Developmental Studies Database at McMaster. Five of these infants were eliminated because they had participated in more than 4 months of parent-infant music classes, leaving 26 infants in this condition. This group received no training and completed a subset of the final tests (Measure of sensitivity to Western tonality and musical exposure questionnaire) at 12 months (average age at test was 11.41 months, SD = 0.54). All experimental procedures were approved by the McMaster Research Ethics Board (MREB), and informed consent was obtained from all parents.

Musical experience protocol

In the two active music classes, infants and their parents engaged in active music-making in Suzuki Early Childhood Education classes developed by Dorothy Jones (Jones, 2004). Parents and children participated in a weekly one-hour interactive music class. Two teachers worked with the parents and infants to build a repertoire of lullabies, action songs and nursery rhymes. Parents were encouraged to use the curriculum CD at home and to repeat the songs and rhymes daily. These participants learned a repertoire of songs and musical activities designed to develop their musical abilities through participation and observation. The class emphasized developing good singing skills and listening to acoustic music. Repetition is central to this approach, and parents were encouraged to be active participants in the learning. The curriculum emphasized singing, movement, infant/parent bonding as well as awareness of infant development.

In order to ensure that any effects were due to the Suzuki (active) music classes and not just as a result of participation in any class where parents can talk to other adults and get positive reinforcement for being with their child and listening to music, the other two groups of infants were assigned to the passive music classes (one at each centre). In these classes, infants and parents received passive exposure to recorded music in the form of a rotating series of recordings from the popular Baby Einstein™ series. This series of recordings features popular classical repertoire performed entirely on synthesized musical instruments and without musical expression. Participants chose a different CD each week for use at home. During the classes, the music played in the background, while infants and parents were free to play at five play stations including art, books, balls, building blocks and stacking cups. The curriculum did not include movement, a repertoire of memorized songs and action games, paying attention, or active parental involvement in music-making. The class was taught by a university-trained elementary education specialist, assisted by a university-trained music student.

In both types of music class, two trained teachers were present at all times and interacted with the parent–child dyads throughout the class. Parents were aware that there were multiple music classes operating over the six-month time period, but they were not told the details of the experimental manipulations. It is unlikely that there was more parent/child interaction in the active as compared to the passive music class; however, there were likely different types of interaction given the emphasis on activities involving play, creativity and discovering new objects in the passive music class, and an emphasis on active participatory music-making in the active music class. We did not measure other variables such as the amount of talking, diversity in vocabulary, smiling, or physical contact between parents and infants, but we had no reason to believe that these differed substantially between groups.

Infants in the Active Training, Passive Training, and No Training groups heard a similar amount of music per week in the classes and at home as reported by parents (Active Training average 17.9 hours/week, SE = 3.1; Passive Training average 14.8 hours/week, SE = 4.9; No Training 14.5 hours/week, SE = 3.6). The groups did not differ significantly by a one-way ANOVA, p = .75.

Measure of sensitivity to Western tonality

Two versions of an excerpt from a Sonatina by Thomas Atwood (1765–1838) were created (Figure 1). One version presented the music in its original form in the key of G major (tonal version). The other version alternated every beat between G major and G-flat major (atonal version). Both versions can be heard at http://www.psychology.mcmaster.ca/ljt/stimuli.htm. The effect of this manipulation was that the feeling of a tonal centre was lost (all 12 chromatic notes were represented) without additional sensory dissonance (each chord in isolation was equally consonant in tonal and atonal versions). Additionally, both versions had the same rhythms and phrasing.

A head-turn preference procedure was conducted with each infant individually. The infant was seated on his or her parent's lap across from the experimenter in a large sound attenuating chamber (Industrial Acoustics Co.), with a cabinet and audiological GSI speaker set up on each side of the infant. Sounds were presented at approximately 55 dB(A) over a background of 25 dB(A). To begin each trial, the experimenter attracted the infant's attention forward; when this was accomplished, the experimenter pushed a button that triggered the computer to begin flashing a light in the cabinet on one side of the infant, illuminating a toy inside. When the experimenter judged that the infant was looking toward the toy, as indicated by a head-turn of at least 45^o in the direction of the cabinet, the experimenter pushed another button that triggered one of the two versions of the music to begin playing. The experimenter continued pressing the button until the infant looked away. The music played for as long as the infant continued to look in the direction of the speaker, and stopped when the

Figure 1 *A. The original tonal version of the excerpt from the Sonatina by Thomas Atwood in G major. B. The atonal version of the same piece, created by lowering every note of the original version by a semitone on the second and fourth beats of every bar while not altering the notes on the first and third beats of every bar. This atonal version has the same rhythm and phrasing as the original, but is no longer in any particular key. Both versions contain the same amount of sensory consonance and dissonance as the intervals on every beat are identical between the two versions (just transposed down a semitone in the case of the second and fourth beats).*

infant looked away for 2 consecutive seconds, at which point the light in the cabinet was also extinguished. When the experimenter attracted the infant's attention forward again, the next trial was initiated, this time with a flashing light on the other side of the infant. When the infant looked in this direction the other version played in the same manner as the first. Trials of the tonal and atonal versions alternated, so that the speaker on one side of the infant always played the original tonal version, and the speaker on the opposite side always played the atonal version. The experiment continued in this fashion for a total of 20 trials. Side and version of first presentation were counterbalanced across infants. Neither the experimenter nor the parent was aware of which speaker would be playing which song, and both adults listened to masking music over headphones in order to prevent either party from hearing the sound stimuli and potentially influencing the infant's responses. The computer recorded listening times on tonal and atonal trials as a measure of preference.

In total, 60 infants were tested on this measure of tonality preference (20 Active Training, 14 Passive Training, 26 No Training). Seven infants did not complete the procedure due to fussing and crying (two Passive Training, two No Training) or parental interference (three No Training). It is potentially worth noting that all infants from the Active Training group completed the preference tests without fussing or crying. The No Training group tended to have higher looking times than the other two groups, likely because the training groups had been to the lab previously so the situation was less novel, and they had also completed multiple tests the same day. Outlier analyses were therefore completed separately for the No Training group. Data from three additional infants (two Passive Training, one No Training) were excluded for producing overall looking times that were more than 2 standard deviations from the mean resulting in a final sample of 20 Active Training, 10 Passive Training, and 20 No Training infants.

Measure of social-emotional development

In order to examine social development, both before and after the 6 months of classes, parents of infants in the two training conditions completed four subscales of the Infant Behavior Questionnaire (IBQ): Distress to Limitations, Distress/Latency to Novel Situations, Smiling and Laughter, and Soothability. The IBQ has been shown to reliably measure individual differences in infant social reactivity and regulation (Gartstein & Rothbart, 2003; Parade & Leerkes, 2008; see Rothbart, 1981, for example questions). Because the IBQ is a parent report questionnaire, we interpret IBQ data as indicating the health of the relationship between infant and parent, and were primarily interested in differences pre and post music classes. Data from 33 infants who participated in the 6 months of training (20 Active Training, 13 Passive Training) were included in the IBQ analyses. One infant from the Passive Training group was excluded for parent's failure to complete the IBQ form while the infant was still 12 months of age.

Measure of early communicative development

Parents of infants in the two training conditions completed the MacArthur-Bates Communicative Development Inventories before and after the 6 months of classes. The MacArthur-Bates is a parent report that tracks current and emerging communicative behaviours (Fenson, Dale, Reznick, Bates, Thal & Pethick, 1994); before 1 year of age, these consist primarily of the use of gestures (Bates, Benigni, Bretherton, Camaioni & Volterra, 1979). Data from 33 infants who participated in the 6 months of training (20 Active Training, 13 Passive Training) were included in the MacArthur-Bates analyses. One infant from the Passive Training group was excluded for parent's failure to complete the MacArthur-Bates form while the infant was still 12 months of age.

Results

Sensitivity to Western tonality

The preferences of each infant in each of the groups (Active Training, Passive Training, and No Training) for the tonal compared to atonal versions of the Atwood Sonatina were tested at 12 months of age (Figure 2). Preliminary analyses including Socioeconomic vulnerability (high, low) and SEX (female, male) as factors yielded no significant effects, and data were collapsed across these categories for further analyses. An ANOVA with Version (tonal, atonal) as a within-subject factor and TrainingGroup (Active, Passive, No) as a between-subjects factor revealed no main effect of Version, $F(1, 47)$

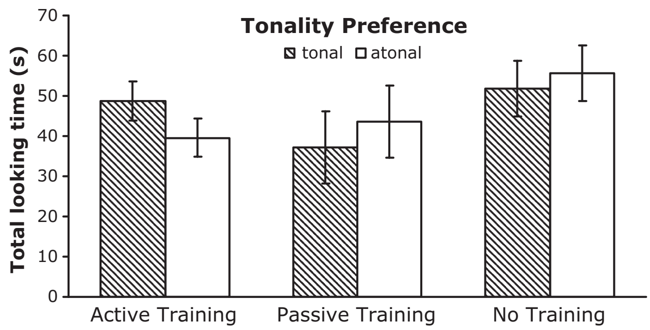

Figure 2 *Listening preferences for tonal compared to atonal versions of an excerpt from the Sonatina in G major by Atwood for infants in the Active, Passive, and No Training groups. Infants in the Active Training group prefer the tonal version, whereas infants in the Passive Training and No Training groups show no preference. Error bars represent standard error of the difference.*

< 1, $p = .90$, but did reveal an interaction between Version and TrainingGroup and a main effect of TrainingGroup which both approached significance, $F(2, 47) = 2.55$, $p = .09$ and $F(2, 47) = 3.05$, $p = .06$. The Active Training group looked longer to hear the tonal version, $F(1, 19) = 5.61$, $p = .03$, but the Passive Training group did not, $F(1, 9) = .65$, $p = .44$, nor did the No Training group, $F(1, 19) = .56$, $p = .46$. The marginal main effect of TrainingGroup was driven by higher overall looking times in the No Training compared to Passive and Active Training groups ($p = .03$ and $p = .06$, respectively by post-hoc LSD tests) for reasons discussed in the Methods section. Because there were differences in overall looking times across groups, and because overall looking times within groups were quite variable (Active Training $M = 88.3$s, $SE = 5.6$, Passive Training $M = 80.8$s, $SE = 9.8$, No Training $M = 107.4$s, $SE = 8.2$), proportion of total looking time to the tonal version is likely a more robust measure of preference than raw looking time. A one-way ANOVA on proportion of time spent looking to hear the tonal version revealed a significant difference between the three groups, $F(2, 47) = 3.17$, $p = .05$. Looking proportions were significantly different from chance (proportion of .5) for the Active Training group, $M = .55$, $SE = .02$, $p = .02$, but not for the Passive Training group, $M = .46$, $SE = .05$, $p = .69$ or the No Training group, $M = .48$, $SE = .02$, $p = .41$. By both measures, only infants in the Active Training group showed a preference for the tonal version. Thus, only infants who participated in the active music classes demonstrated knowledge of Western tonality.

Social-emotional development

Using scores from the four subtests of the IBQ as the dependent measures, separate ANOVAs were conducted with PrePost (6 months, 12 months) as a within-subjects factor and TrainingGroup (Active, Passive) as a between-subjects factor. Preliminary analyses including Socioeconomic vulnerability (high, low) and SEX (female, male) as factors yielded no significant effects, and data were collapsed across these categories for further analyses. For Distress to Limitations, distress generally increased between 6 and 12 months, main effect of PrePost $F(1, 31) = 7.7$, $p = .009$, but more so for infants in the Passive Training group, interaction between Pre-Post and TrainingGroup, $F(1, 31) = 23.1$, $p < .001$. In other words, after participation in active music classes, infants showed much lower levels of distress than after participation in passive music classes (Figure 3A). When confronted with Novel Stimuli, distress generally increased between 6 and 12 months, main effect of PrePost $F(1, 31) = 36.0$, $p < .001$, but more so for infants in the Passive Training group, interaction between PrePost and TrainingGroup, $F(1, 31) = 19.4$, $p < .001$ (Figure 3B). In other words, after participation in active music classes, infants showed much lower levels of distress when confronted with novel stimuli than after participation in passive music classes. There was an overall decrease in Smiling and Laughter between 6 and 12 months, $F(1, 31) = 4.7$, $p = .04$, but the decrease was greater for those participating in the passive compared to active music classes, $F(1, 31) = 13.3$, $p = .001$ (Figure 3C). For Soothability, infants

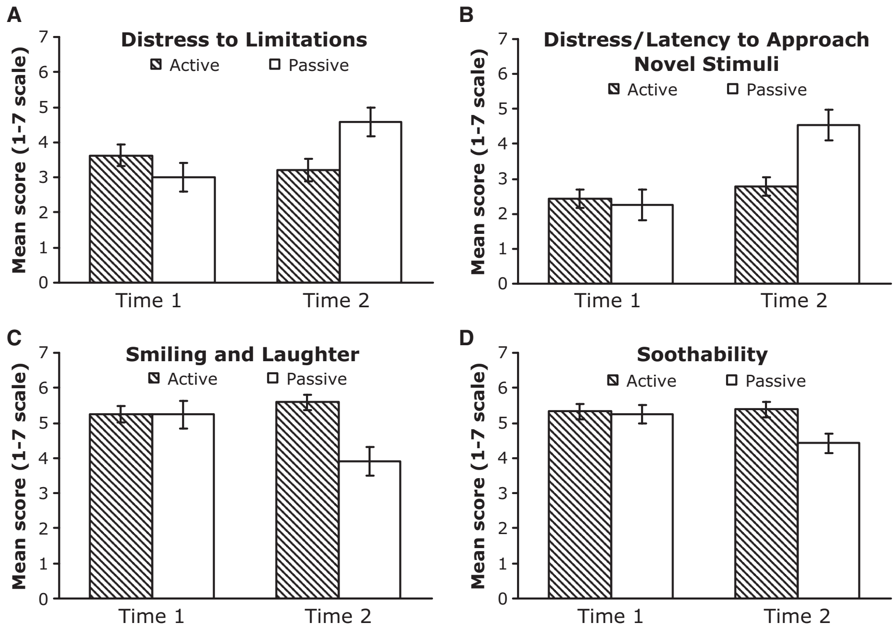

Figure 3 *IBQ scores before and after musical training. There are no differences between the Active and Passive Training groups at Time 1 before the music classes began ($p > .05$ in all cases), but 6 months later, compared to infants in the passive music classes, infants in the active music classes show less distress to limitations [$t(31) = 3.51$, $p = .001$] (A) and less distress/lower approach latency with novel objects [$t(31) = 4.64$, $p < .001$] (B). Infants in the active music classes also show more smiling and laughter [$t(31) = -.562$, $p < .001$] (C) and are more easily soothed [$t(31) = -4.24$, $p < .001$] (D). Error bars represent standard error of the difference.*

generally became more difficult to soothe, $F(1, 31) = 7.0$, $p = .01$, but less so for those in the active compared to passive music classes, $F(1, 31) = 9.3$, $p = .005$ (Figure 3D).

Early communicative development

Using scores from the MacArthur-Bates inventories, an ANOVA was conducted with PrePost (6 months, 12 months) as a within-subjects factor and TrainingGroup (Active, Passive) as a between-subjects factor. Preliminary analyses including Socioeconomic vulnerability (high, low) and SEX (female, male) as factors yielded no significant effects, and data were collapsed across these categories for further analyses. Use of gestures increased greatly between 6 and 12 months of age, $F(1, 31) = 139.0$, $p < .001$, but increased more so for those in the active compared to passive music classes, $F(1, 31) = 7.30$, $p = .01$ (Figure 4). It should be noted that in the case of early gestures, unlike any of the other measures tested, the groups differed initially at 6 months, $t(31) = 2.52$, $p = .007$. However, this questionnaire was designed primarily for infants 8 months and older, as 6-month-olds can only produce a small number of the gestures, so the results at 6 months are likely not reliable.

Discussion

The results indicate that when appropriate pedagogical techniques are used, active music classes for infants and parents can accelerate infants' acquisition of culture-specific musical knowledge and can positively influence communication and social interaction between parents and infants. Despite the focus in the literature on older children, the present findings suggest that the infant brain might be particularly plastic with respect to musical experience. Previous literature suggests that training in infancy with uncommon musical metrical structures, foreign languages, or foreign faces can enhance discrimination for stimuli not normally found in an infants' natural environment (Hannon & Trehub, 2005b; Kuhl *et al*., 2003; Kelly *et al*., 2007; Pascalis *et al*., 2002, 2005). The present findings indicate that enriched active musical experience can accelerate acquisition of knowledge about Western musical tonality in infancy. There is recent evidence that 5-year-olds prefer a tonal melody over an atonal melody (Corrigall & Trainor, 2011) but little was known about the development of this ability prior to 5 years of age. The present findings indicate that it is possible to see the beginnings of sensitivity to Western musical tonality as young as 12 months of age.

Furthermore, interactive musical experience appears to facilitate cognitive development in the form of earlier use of prelinguistic communicative gestures. It was previously found that the amount and nature of maternal speech input can influence later language processing in infants (Hurtado, Marchman & Fernald, 2008). The present results suggest that musical interaction may influence linguistic processing as well. Perhaps most important is that the active musical training facilitated social development. While it remains an open question as to whether the positive changes seen in the group with active musical experience on the IBQ resided exclusively in the infants' behaviour or also reflected how parents perceived their infants' behaviour, it is remarkable that 6 months of active music classes involving infants and parents led to a substantially more positive outcome than 6 months of passive music exposure also involving infants and parents.

It is clear from the present results that different types of musical experience have different effects in infancy. However, the two types of class to which infants were randomly assigned differed in several important ways. The active music class emphasized learning a small, defined repertoire of lullabies, action songs and nursery rhymes. Infants and parents actively engaged in playing percussion instruments. Parents learned to sing and played a CD at home that included versions of the musical repertoire utilized in class, sung and performed on acoustic instruments with expression. Each parent also learned to observe his or her infant's achievements and preferences in class and write a weekly journal documenting his or her infant's progress. In contrast, there was no active music-making in the passive music class and there was little repetition of the synthesized recorded music from week to week. Parents were encouraged to take a different CD home each week. In class, under the supervision of the

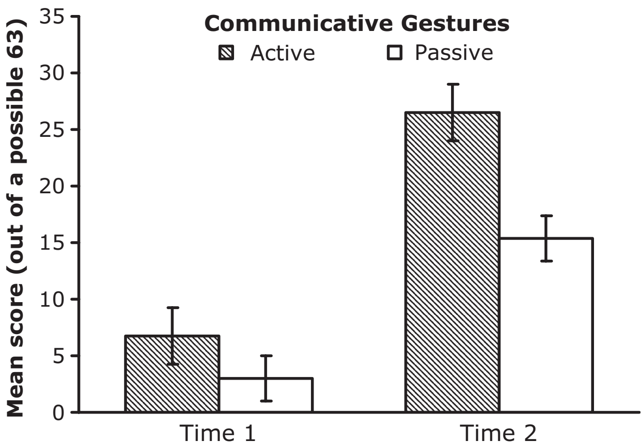

Figure 4 *Communicative gestures before and after musical training. At Time 2, when infants were 12 months of age, differences between the Active and Passive Training groups were highly significant [t(31) = 3.56, p = .001]. Groups also differed statistically at Time 1 [t(31) = 2.52, p = .007] when infants were 6 months of age, so results should be interpreted with caution. However, this questionnaire was designed for use with infants 8 months of age or older so the numbers of gestures reported at Time 1 were very small and unreliable. Furthermore, the improvement between 6 and 12 months of age was significantly greater for the Active compared to the Passive Training group [F(1, 31) = 7.30, p = .01]. Error bars represent standard error of the difference.*

teachers, the infant–parent dyads explored a variety of activities, including building blocks, simple art activities, shapes and textures, and picture books. New activities and play objects were rotated regularly. Parents worked closely with their infants during the activities in class, but they did not receive specific instructions to observe their children and journal the progress. In this first study it is not possible to be sure which factors were most important in driving the effects seen. Given the sample sizes in the training conditions, multiple regression analyses looking at associations between specific factors and outcomes were also not possible. However, differences in the overall pedagogical approach between the classes likely contributed to the differences observed.

Amount of repetition is a good candidate for future studies investigating differences between methods of musical instruction. In the active music classes, the emphasis on repetition of the songs and activities in class, as well as the encouragement to listen to the same music at home may have promoted learning in infants and developed a familiarity with activities that enabled the parents to continue to work on the material from class at home with their infants. Another candidate is the quality of the music. The active music class emphasized good singing skills and musical expression, which may have increased parental motivation and promoted parent–infant bonding, as compared to the passive music class where there was no singing and the recordings featured unexpressive synthesized music. A third candidate for future study is the role of parents' explicit observations of their infants. Such observation might increase parents' sensitivity to subtle cues from the infant, which might be particularly important for the differences observed in the parental questionnaire-based social and language scores. It will remain for future studies to test which of these factors is crucial for realizing the positive outcomes described here.

In all likelihood musical acquisition, cognitive development and social interaction do not operate as isolated systems, but affect each other. For example, positive social interactions between infants and parents likely lead to better communication and earlier acquisition of communicative gestures, which in turn lead to more positive social interactions. Shared musical activities between infants and parents likely lead to positive social interactions, and the mutual enjoyment of musical activities likely leads to earlier acquisition of culture-specific musical knowledge. Thus, for positive outcomes of early musical experience, programmes should likely incorporate stimulating musical activities and positive social interactions between parents and infants.

Music educators debate the age at which it is appropriate to begin musical training and whether there is an optimal order as to when different musical skills should be introduced. The present results suggest that when parents are actively involved and materials appropriate for infants are utilized, musical training can profitably begin early in infancy.

Toy and educational companies have created musical recordings that require virtually no parent–infant interaction and rely for the most part on inexpressive, synthesized musical sounds, sometimes marketed as being beneficial for infant development. However, one study on the effects of the popular Baby Einstein™ videos found that infants did not learn words highlighted in the videos in the absence of parental interaction (Richert, Robb, Fender & Wartella, 2010). Music media aimed at busy parents with young children have sometimes become a substitute for infant–parent interaction involving the singing of lullabies and playsongs. Our results suggest that active participation by parents and infants is likely essential for optimal learning, and our results indicate that aspects of active participation are crucial to fully realizing musical, communicative and social benefits of musical experience in early development.

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Supporting Information Online

Additional supporting information may be found in the online version of this article:

Sound example 1. The tonal original version of the excerpt from the Sonatina by Thomas Atwood.

Sound example 2. The atonal version of the excerpt from the Sonatina by Thomas Atwood (see Figure 1 for information as to how the atonal version was constructed).

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