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PAPER

Effects of Kindermusik training on infants' rhythmic enculturation

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Abstract

Phillips-Silver and Trainor (2005) demonstrated a link between movement and the metrical interpretation of rhythm patterns in 7-month-old infants. Infants bounced on every second beat of a rhythmic pattern with no auditory accents later preferred to listen to an accented version of the pattern with accents every second beat (duple or march meter), whereas infants bounced on every third beat of the same rhythmic pattern preferred to listen to a version with accents every third beat (triple or waltz meter). The present study compared infants participating in Kindermusik classes with infants not participating in music classes. In Kindermusik classes infants receive enriched experience moving to music. Following Western musical norms, the majority of the music samples in the classes are in duple meter. During the preference test, Kindermusik infants listened longer overall, indicating heightened interest in musical rhythms. Both groups listened longer to the accented version that matched how they had been bounced, but only the Kindermusik group showed a stronger preference in the case of duple bouncing than in the case of triple bouncing. We conclude that musical classes for infants can accelerate the development of culture-specific metrical perception.

Introduction

In many domains infants are initially open to a wide variety of perceptual organizations, but through exposure to the forms of a particular culture, their perceptual organization narrows to become specialized for the forms of their culture. We refer to this process as enculturation. For example, young infants readily discriminate phonemes from categories found in any language, but before the end of the first year preferentially process the categories of the language of their culture (Werker & Tees, 2005). In the visual domain, face processing becomes better for human over animal faces, and for faces of one's own race over foreign faces (Pascalis, de Haan & Nelson, 2002; Kelly, Quinn, Slater, Lee, Ge & Pascalis, 2008).

In the musical domain, some aspects of infants' early perception are quite sophisticated (Trehub & Hannon, 2006). Infants, like adults, prefer consonant intervals over dissonant intervals (Trainor & Heinmiller, 1998; Trainor, Tsang & Cheung, 2002), remember simple melodies over days or weeks (Saffran, Loman & Robertson, 2000; Plantinga & Trainor, 2005), discriminate rhythm patterns (Demany, McKenzie & Vurpillot, 1977), recognize rhythmic patterns across variation in tempo (Trehub & Thorpe, 1989; Baruch & Drake, 1997), distinguish metrical structures (Hannon & Trehub, 2005a), and extract the meter of ambiguous rhythms through the integration of movement and auditory information (Phillips-Silver & Trainor, 2005). On the other hand, it takes considerable exposure to a musical system before enculturation occurs to the pitch structure of its scales and harmony (Trainor, 2005; Trainor & Trehub, 1992, 1994). In the present paper we investigate enculturation in rhythmic acquisition, asking whether enriched multisensory experience with Western music and movement, as found in Kindermusik training, accelerates infants' bias for preferential processing of common rhythms in Western music.

Rhythm has two components: the *rhythm pattern* itself, that is, the sequence of sound events and silences, and the *metrical structure*, or underlying beat (Lerdahl & Jackendoff, 1983; London, 2004). Metrical structure is not directly present in the stimulus, but is extracted perceptually from the rhythm pattern. Metrical structure is hierarchically organized, with accented beats typically occurring at regular intervals. For example, at one level of the hierarchy every second beat might be accented; at the next level, every fourth beat might be accented. Intuitively, the metrical structure is what you would tap your foot to and it continues in a regular way whether or not there are sound events on every beat.

A number of researchers have noted close connections between musical rhythm and movement (Brown & Parsons, 2008; Cross, 2003; Phillips-Silver & Trainor,

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2005, 2007, 2008; Todd, Cousins & Lee, 2007; Trainor, 2008; Zatorre, Chen & Penhune, 2007). Several pedagogical approaches to teaching musical rhythm are based on the belief that metrical structure must first be felt in terms of rhythmic body movements, which can then be transferred to sound perception and production. The Swiss educator Jacques Dalcroze believed that sensitivity to rhythm and beat in music could be developed by structured and improvised movement to music (Dalcroze, 1967). He developed Eurhythmics ('good rhythm') training, which promotes multisensory musical processing and an emphasis on physical awareness while experiencing music.

Western music typically uses simple metrical structures, with accents occurring either every second beat (duple rhythm), as in a march, or every third beat (triple rhythm), as in a waltz. Other traditions, including much folk music from Africa and Eastern Europe, use more complicated metrical structures consisting of 5-, 7-, or 11-beat patterns. The rhythmic structures of many musical styles including American jazz and traditional music in South America are also rich with syncopation, or accented sound events that occur between the beats of the metrical structure.

Metrical sequences with ratios of simple integers, such as 1:2 and 1:3, are more easily reproduced and remembered by Western listeners than patterns with more complex ratios, as shown in perceptual (Drake & Gerard, 1989) and in brain imaging (Janata & Grafton, 2003) studies. Within the relatively simple metrical structures of Western music, duple subdivisions are much more common than triple. Duple rhythms are also easier for Western children and adults to reproduce than triple rhythms (Drake, 1993).

In the absence of strong beat accents, perception of meter can be ambiguous and thus depend on context and individual interpretation, such that the same rhythm can be perceived in multiple ways (Repp, 2006). Regardless of the ambiguity, Western adults will impose a metrical interpretation even when a series of identical isochronous beats is presented. However, listeners are more likely to impose a binary than a ternary interpretation, as evidenced by ERP responses on subjectively, but not physically, accented beats (Brochard, Abecasis, Potter, Ragot & Drake, 2003).

There is evidence that metrical perception is affected by enculturation (Hannon & Trainor, 2007). Hannon and Trehub (2005a) showed that Bulgarian and Macedonian adults, who grew up listening to complex metrical structures in the music of their folk traditions, were able to discriminate timing alterations in music with either simple (4-beat) or complex (7-beat) metrical patterns, whereas North American adults were able to detect changes only in the simple metrical patterns. Furthermore, 6-month-old North American infants performed like Bulgarian and Macedonian adults, but by 11 months, infants only detected changes to the simple metrical structure (Hannon & Trehub, 2005b). These results suggest that enculturation plays an important role in the development of musical skills during the infancy period and that young infants appear to show greater flexibility than older infants in the organization of auditory-temporal input.

These findings raise questions about whether formal musical training at this age might accelerate the process of enculturation. Most popular pedagogical approaches are not aimed at young infants; indeed, the motor and language skill requirements of many methods preclude musical training in infancy. For example, the Orff Method integrates movement, singing and instrumental skills, but the instruments used such as xylophones and glockenspiels require fine motor control and are not suitable for use with young infants. Although some educators use the Orff approach with children as young as 3 to 4 years of age, the importance of speech-syllable pattern production to Orff precludes use of the method with pre-verbal infants. In fact, in the field of music pedagogy, most research on the acquisition of rhythmic skills is concerned with teaching methods directed toward school-aged children. For example, one of the most prominent theorists in this field, Edwin Gordon, developed a rhythm-syllabic system that only older children can use.

Recent trends, however, have been towards introducing formal musical training at increasingly younger ages (e.g. *Suzuki*, *Kindermusik*, *Musikgarten*, and *Music Together* have added programs for infants). For example, the Suzuki method, one of the most popular forms of music education today, traditionally advocates that children as young as 3 can learn to play the violin when there is an experienced teacher and a parent committed to working with the child involved in the process (Suzuki, 1983). Canadian Suzuki teacher-trainer Dorothy Jones has adapted this philosophical approach for infants with emphasis on singing, the use of rhythm instruments, as well as development of the parents' observational skills (Jones, 2004).

The *Kindermusik* program is another popular approach to music education for young children with more than one million families currently participating in 66 countries (Kindermusik, 2007). Kindermusik was initially developed for young school-aged children in Germany during the 1960s, but now includes a curriculum for newborns through to children aged 7 years. The Kindermusik approach is based on participation of the child rather than evaluative performance. One of the hallmarks of Kindermusik is that parents and children take part in activities that combine music and movement, in line with research indicating the importance of movement in learning rhythm (Phillips-Silver & Trainor, 2005) and the approach of Dalcroze. At the same time, the rhythmic character of the musical materials used in Kindermusik reflects that of Western music generally, making it a good choice with which to examine the effects of enriched musical experience on enculturation to Western rhythmic structures. We analyzed the rhythmic structures of the eight units of the infant curriculum (birth to 18 months) and found that, in line with the general bias for duple meters in Western musical structure, 71% of the 239 songs or spoken rhythms (i.e. poems, chants) in the Kindermusik repertoire were in duple meter while 29% were in triple meter, and none were in more complex meters.

In order to evaluate whether formal musical training in infancy affects the development of rhythmic enculturation, we examined the metrical processing of infants enrolled in Kindermusik in comparison to previous data on infants not enrolled in formal musical classes. Due to the emphasis on combining movement and auditory rhythm in the Kindermusik approach, we focused our testing on movement–auditory interactions.

It is generally acknowledged that music makes us want to move to the beat. A series of studies conducted by Phillips-Silver, Trainor and their colleagues (Phillips-Silver & Trainor, 2005, 2007, 2008; Trainor, Gao, Lei, Lehtovarara & Harris, 2009) show that body movement also shapes how we hear rhythm, particularly in disambiguating rhythm patterns with more than one possible metrical interpretation. Phillips-Silver and Trainor (2005) familiarized infants for 2 minutes to a repeating ambiguous (without accented beats) 6-beat rhythm pattern. During familiarization, half of the infants were bounced (moved up and down) on every second beat and the other half on every third beat. Adding intensity accents to the ambiguous auditory rhythmic pattern can create very different metrical interpretations. Accenting every second beat (duple meter) results in the perception of a march, whereas accenting every third beat (triple meter) results in the perception of a waltz. After training, infants' listening preferences were tested for these two auditory versions of the rhythm pattern. Infants chose to listen longer to the version with the accented beat pattern that matched the beats on which they were bounced, even though all infants heard the same ambiguous rhythm pattern during familiarization. This suggests that infants who were bounced on every second beat encoded the pattern in a duple meter whereas those who were bounced on every third beat encoded the pattern in a triple meter. Subsequent experiments ruled out visual cues to movement as necessary for the movement–auditory interaction, but showed that body movement was necessary. Specifically, infants who were blindfolded during familiarization were influenced by the bouncing experience whereas infants who watched the experimenter bounce, but did not participate in movement, showed no preference for either pattern. Further experiments showed that movement also affects adults' interpretation of an ambiguous rhythm pattern (Phillips-Silver & Trainor, 2007) and that the vestibular system plays a crucial role in the movement effect (Phillips-Silver & Trainor, 2008; Trainor *et al.*, 2009).

In the present study, infants enrolled in Kindermusik classes were tested on the procedure of Phillips-Silver and Trainor (2005), and the results of the infants in the present study were compared to those of the infants in the 2005 study who were not undergoing any formal musical training. We had two main hypotheses. First, because of their enriched experience with movement–auditory interactions, infants participating in Kindermusik were expected to show stronger effects of movement on auditory rhythm encoding than infants not taking formal training. Second, because of the predominance of duple meters in the Kindermusik corpus, it was hypothesized that infants in the Kindermusik group would show stronger enculturation, that is, a stronger bias for duple meters.

Method

Participants

The participants were eight infants (four males, four females), aged 6.7 to 8.2 months (average age 7.4 months) with no known hearing deficits. All were currently participating in infant Kindermusik classes in the Hamilton, Ontario area. They were compared to the 16 infants from Phillips-Silver and Trainor (2005), who were aged 6.9 to 8.2 months (average age 7.5 months), who had no formal musical training. Procedures were approved by the McMaster University Research Ethics Board, and parents gave written permission for the infants to participate.

Stimuli

All sounds were presented with a Power Macintosh 7300/180 computer, through a Denon PMA-480R amplifier, to two audiological GSI speakers located in a large Industrial Acoustics Co. sound-attenuating booth with a noise floor of 25 dB(A). The stimuli were identical to those of Phillips-Silver and Trainor (2005). For the *training*, a 6-beat metrical structure was established with a slapstick sound every 330 ms (at 50 dB) and a snare drum downbeat (at 60 dB) every 6 of these beats, using a Roland 64-Voice Synthesizer Module. After 12 repetitions of the 6-beat structure, the rhythm pattern of interest was added, consisting of four snare drum beat sounds with SOAs of 660-330-330-660 ms, presented at 60 dB (Figure 1). All sound events of the rhythm pattern were of equal duration and intensity (i.e. there were no accents present). During *testing*, the same rhythm pattern was presented, but in two different accented versions. For the *duple meter* test stimulus, sound events occurring on every second beat were presented at 60 dB, and the intervening sounds at 55 dB, which divided the rhythm into three groups of two beats. In the *triple meter* test stimulus sound events occurring on every third beat were presented at 60 dB, and the intervening sounds at 55 dB, which subdivided the rhythm pattern into two groups of three beats.

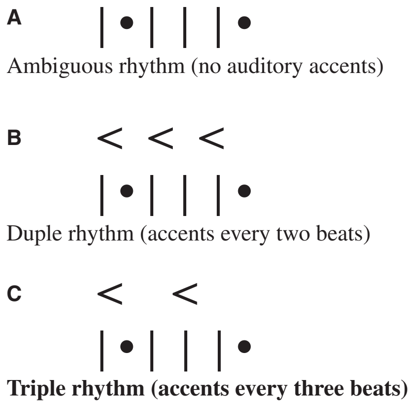

Figure 1 *Representation of the rhythmic stimuli. A. The metrically ambiguous rhythm pattern. B. The duple metrical version. C. The triple metrical version. Vertical lines represent snare drum onsets, dots represent silent beats, and arrows represent accented beats. This rhythm pattern was superimposed on a background that established the metrical structure, with a slapstick sound every beat and a snaredrum every sixth beat.*

Procedure

Prior to testing, parents were given a questionnaire to evaluate the musical background of the parents (formal musical training, years of lessons, participation in musical ensembles) as well as the number of hours music was played in the home and the styles of music listened to. Following this, the identical *training* and *testing* phases as in Phillips-Silver and Trainor (2005) were conducted.

Training

The experimenter stood between the two speakers holding the infant. The experimenter bounced up and down from the knees throughout the 2-min training phase, consisting of 60 repetitions of the training rhythm stimulus. During training, all subjects heard the same ambiguous rhythm pattern with no accents (Figure 1A), but were randomly assigned to one of two movement conditions. In the duple movement condition, infants were bounced on every second beat (beats 1, 3 and 5) and in the triple movement condition, on every third beat (beats 1 and 4).

Testing

Immediately following the training phase the parent was seated between the two loudspeakers facing the experimenter with the infant on his or her lap and a head-turn looking-time preference procedure was conducted. The experimenter and the parent wore headphones and listened to masking music for the duration of the test. Trials were presented to the infant such that the rhythm pattern was played from either the loudspeaker on the left or on the right (alternating between trials). A custom-written program running on the Power Macintosh 7300/180 computer controlled the experiment. The experimenter initiated a trial when the infant was looking forward, by pressing a button on a custom-built button box connected to the computer through a custom-built interface. On each trial, a light initially flashed on one side of the infant illuminating a toy. When the infant looked at the toy, the experimenter pressed a second button, which caused the computer to keep the light on and to play either the duple meter test stimulus (Figure 1B) or the triple meter test stimulus (Figure 1C), with trials alternating between these two. For as long as the infant looked at the light and toy, the rhythm continued to play. When the infant looked away the experimenter lifted the button, which caused the sound and light to stop, thus signaling the end of the trial. The computer kept track of how long the infant listened on each trial so that looking times, or preferences for the duple versus triple accented patterns, could be analyzed. Whether the duple or triple metrical pattern was heard on the first trial, and whether the first trial was on the right or on the left, were counterbalanced so that within each bouncing condition half of the infants heard the duple rhythm first, and half heard the triple rhythm first; as well, half heard the duple rhythm on the right and half heard it on the left. Each infant completed 20 test trials.

Results

The eight Kindermusik infants of the present study were compared to the 16 infants from Phillips-Silver and Trainor (2005), who had no formal musical training (see Figures 2 and 3).[1] An ANOVA was conducted with looking time as the dependent measure. The main variable of interest, Metrical Match, took on the value *familiar* when the bouncing experience matched the metrical accents of the test rhythm (i.e. either both duple or both triple), and *novel* when these were mismatched (i.e. one was duple and the other triple). We examined the first half of the trials separately from the last half of the trials because preferences often change from familiar to no preference to a novel

[1] These analyses were repeated comparing the eight Kindermusik infants to a randomly chosen eight infants tested in Phillips-Silver and Trainor (2005) in order to make sure that the results did not reflect the unequal sample sizes. (The infants were chosen randomly within the constraint that the following were counterbalanced: type of movement experience, whether the first stimulus in the preference test was presented on the left or on the right, and whether the first stimulus did or did not metrically match the bouncing experience.) The results of all ANOVAs were essentially the same. The only two differences across all of these analyses were that (1) the main effect of Background approached but was no longer statistically significant in the first overall ANOVA (p = .14). This effect is not crucial for the interpretation in any case as it is the interactions that tell the main story. Second, the effect of Metrical Match in the no-Kindermusik group alone for the second half only approached but did not reach significance (p = .09).

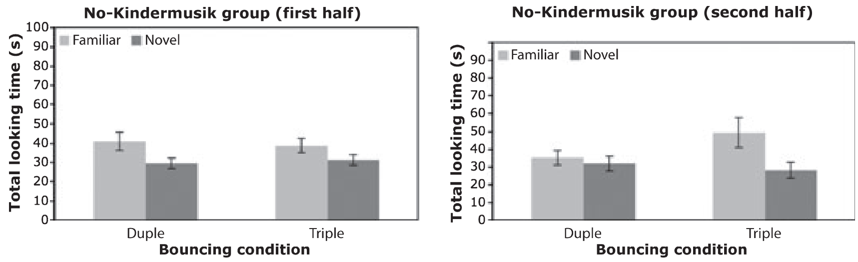

Figure 2 *Looking times for the no-Kindermusik group for the first 10 trials (left panel) and second 10 trials (right panel) for the familiar and novel rhythms across the duple and triple movement training (bouncing) conditions. Error bars reflect the standard error of the mean.*

preference with increased exposure to a stimulus (Rose, Gottfried, Melloy-Carminar & Bridger, 1982). The rate at which this change occurs can be thought of as measure of encoding efficiency. The ANOVA had Metrical Match (novel, familiar) and Half (1st 10 trials, 2nd 10 trials) as within-subjects factors and Background (Kindermusik, no-Kindermusik) and Movement Type (duple, triple) as between-subjects factors. There was a main effect of Background, $F(1, 20) = 4.80$, $p = .04$, $\eta^2 = .194$, reflecting overall longer looking times in Kindermusik than in no-Kindermusik infants. There was a main effect of Metrical Match, $F(1, 20) = 6.98$, $p = .016$, $\eta^2 = .259$, with longer looking times on familiar than on novel trials. There were interactions between Metrical Match and Test Half, $F(1, 20) = 9.01$, $p = .007$, $\eta^2 = .310$, between Metrical Match, Test Half and Movement Type, $F(1, 20) = 8.90$, $p = .007$, $\eta^2 = .308$, and between Metrical Match, Test Half and Background, $F(1, 20) = 12.57$, $p = .002$, $\eta^2 = .386$. In addition there was a trend for an interaction between Background and Movement Type, $F(1, 20) = 2.90$, $p = .10$. Because of this trend, our a priori hypothesis for group differences in enculturation, and the interaction involving background, we conducted separate analyses for the Kindermusik and no-Kindermusik groups.

For the no-Kindermusik infants, an ANOVA was conducted with Metrical Match (familiar, novel) and Test Half (1st 10 trials, 2nd 10 trials) as within-subject factors and Movement Type (duple, triple) as a between-subjects factor (see Figure 2). There was a main effect of Metrical Match, $F(1, 14) = 19.76$, $p = .001$, $\eta^2 = .585$, with longer looking times to familiar than to novel overall. There was also an interaction between Metrical Match, Test Half and Movement Type, $F(1, 14) = 4.59$, $p = .05$, $\eta^2 = .247$. To understand this interaction, we conducted separate ANOVAs for each half with Metrical Match (familiar, novel) as a within-subjects factor and Movement Type (duple, triple) as a between-subjects factor. For the first half the only significant effect was a main effect of Metrical Match, $F(1, 14) = 21.2$, $p = .001$, $\eta^2 = .602$, with longer looking times to familiar than to novel trials. For the second half, there was a significant main effect of Metrical Match, $F(1, 14) = 7.14$, $p = .02$, $\eta^2 = .338$, and the interaction between Metrical Match and Movement Type approached significance, $F(1, 14) = 3.76$, $p = .07$, $\eta^2 = .212$. As can be seen in Figure 2, right panel, the familiarity preference remained strong in the second half for infants in the triple Movement Type condition, but disappeared for those in the duple. This suggests that, in addition to effects of movement experience, the triple rhythm maintains infants' interest for longer.

Similar ANOVAs were conducted for the Kindermusik group (see Figure 3). Overall there was no main effect of Metrical Match or Test Half; however, there was an interaction between Test Half and Metrical Match, $F(1, 6) = 10.44$, $p = .018$, $\eta^2 = .635$, so we conducted separate ANOVAs for each half. For the first half, there was a significant main effect of Metrical Match, $F(1, 6) = 30.13$, $p = .002$, $\eta^2 = .834$, indicating that, as with infants with no musical training, movement affected how the Kindermusik infants interpreted the ambiguous rhythm. Also, there was an interaction between Metrical Match and Movement Type, $F(1, 6) = 6.57$, $p = .043$, $\eta^2 = .522$, reflecting a much larger familiarity preference for infants moved in duple than for infants moved in triple. This suggests that the Kindermusik training biases infants for duple meters. For the second half, there were no significant main effects or interactions, suggesting that infants in the Kindermusik group became familiar more quickly with both rhythms after the exposure of the first half.

From the questionnaire data, we extracted the number of hours per week that the Kindermusik infants listened to music at home, the number of years that their mothers had taken music lessons and the number of years that

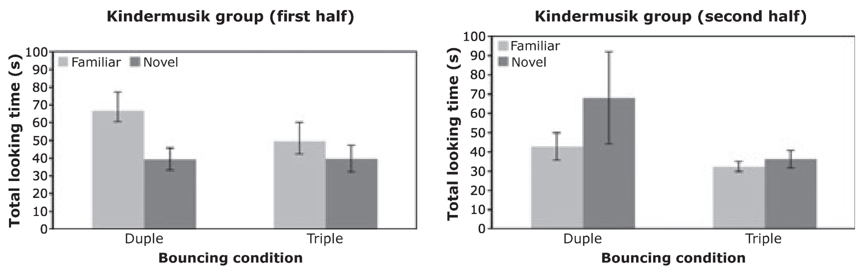

Figure 3 *Looking times for the Kindermusik group for the first 10 trials (left panel) and second 10 trials (right panel) for the familiar and novel rhythms across the duple and triple movement training (bouncing) conditions. Error bars reflect the standard error of the mean.*

their fathers had taken music lessons. None of these variables correlated with proportion of looking time to the metrical structure that matched their movement experience in either the first or second half of the trials. However, future research would need to be conducted with many more infants in order to be more certain about whether or not these environmental variables affect infant performance.

Discussion

For both groups of infants (those with Kindermusik training and those without), movement biased their metrical interpretation of the ambiguous rhythm pattern. However, we found two main differences between infants taking formal Kindermusik classes and infants not engaged in music lessons. First, infants in the Kindermusik classes showed longer looking times overall than infants without musical training. This suggests that those in Kindermusik classes found the rhythmic sequences more engaging, presumably as a result of their musical exposure. Second, those in Kindermusik who were bounced in duple meter showed a large familiarity preference in the first half, whereas those bounced in triple showed only a modest familiarity preference. This is in contrast to infants without formal musical training, who showed similar familiarity preferences whether bounced in duple or in triple. For infants bounced in triple, those not in Kindermusik classes showed larger familiarity effects (i.e. a larger preference for triple meter) than those in Kindermusik, suggesting less sensitivity to triple meter movement–auditory interactions in the Kindermusik group. Finally, there was a non-significant trend in the Kindermusik group in the second half toward a novelty preference, particularly in the case of familiarization with duple movement. In general, infants' preferences change from familiarity to novelty preferences with increased exposure to a stimulus (e.g. Rose *et al*., 1982). The novelty trend in the Kindermusik group in the second half of the trials suggests, then, that the infants in this group quickly encoded the metrical patterns, tiring of the familiar pattern more quickly than those in the no-Kindermusik group.

It is possible that the duple bias arises in the Kindermusik group from the enriched movement experience alone as the natural rhythms of human locomotion are more related to duple than triple forms. However, the measured duple bias is evident in infants' preferences for auditory rhythms, so it appears that any such effect of the movement experience alone is transferring to the auditory domain. Furthermore, previous studies suggest that young infants are readily able to encode complex rhythms and that enculturation has a strong effect on musical development. North American infants are able to detect changes in Western, Bulgarian and Macedonian rhythmic patterns at 6 months, but by 11 months are able to do so only with Western rhythms (Hannon & Trehub, 2005b). Enculturation is also seen in the pitch domain. Sensitivity to consonance emerges early in development, but more system-specific musical knowledge of scale and harmonic structure develops later (Trainor & Trehub, 1992, 1994; Trainor, 2005).

In sum, these results suggest that Kindermusik training has the effect of biasing processing for duple compared to triple rhythms. Although we did not randomly assign infants to Kindermusik classes or not, the results are consistent with an experiential effect of Kindermusik. First, the long looking times of the Kindermusik infants might well reflect a heightened interest in music developed through listening and movement. Second, the Kindermusik curriculum contains music predominantly in duple rhythms. This experience may well accelerate the bias that Western adults develop for duple rhythms. It is unlikely that infants in Kindermusik classes were genetically predisposed to preferentially process duple compared to triple meters, whereas infants not in Kindermusik classes were not. Therefore, it is reasonable to interpret the findings of the present study as evidence that formal musical training in infancy affects metrical processing.

Western music is predominantly in duple meters. The present study is the first to show accelerated culture-specific musical processing through formal training in infancy. However, Western composers in both popular and classical traditions are increasingly incorporating rhythms from around the world in their music (e.g. Ross, 2008). It is therefore essential that musicians today are versatile in their rhythmic competencies. Similarly, music listeners will have better access to the changing music of their culture, and to music from around the world, if they are adept at complex rhythmic processing. The results of the present study suggest that if one goal of musical training is to enable people to be able to both produce and appreciate more complex meters, an ideal musical training program for infants would include a variety of metrical forms.

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