Effects of Musical Training on Key and Harmony Perception

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Even adults with no formal music lessons have implicit musical knowledge acquired through exposure to the music of their culture. Two of these abilities are knowledge of key membership (which notes belong in a key) and harmony (chord progressions). Studies to date suggest that perception of harmony emerges around 5–6 years of age. Using simple tasks, we found that formal music training influences key and harmony perception in 3- to 6-year-olds, and that even nonmusicians as young as 3 years have some knowledge of key membership and harmony.

Key words: **music; key membership; harmony; tonality; pitch; musical education**

Sensitivity to some musical aspects appears in infancy,[1] suggesting constraints of the auditory system or information-processing biases. However, other aspects depend on exposure to a particular musical system. Notable experience-dependent aspects are key membership (which notes do and do not belong in a key) and perception of harmony (likelihood of sequential and simultaneous note combinations). Even adults with no musical training have implicit knowledge of key and harmony,[2,3] suggesting that these skills develop through mere exposure.

Key membership and harmony perception are acquired relatively late.[4] Trehub and colleagues[5] found that 4- and 5-year-olds could more easily detect a change in a melody if its notes belonged to a key than when they did not, in contrast to infants, who could detect both changes with equal ease. Similarly, Trainor and Trehub[2,3] found that 5-year-olds, 7-year-olds, and adults detected a deviant out-of-key note better than a deviant in-key note, while infants detected these equally well. Thus, it appears that sensitivity to key membership develops by 4 or 5 years of age.

Harmony perception appears to develop later than key membership. Schellenberg *et al.*[6] primed 6- to 11-year-olds with chord progressions and asked them to make an unrelated, speeded judgment about the last chord (e.g., whether it was in a piano or trumpet tone). All children responded faster to the last chord when it followed Western harmonic rules than when it did not. Similarly, Koelsch *et al.*[7] recorded 5- and 9-year-olds' event-related brain potentials to chord sequences that occasionally contained weak and strong harmonic violations. Adults showed an early right anterior negativity (ERAN) and a late negativity to both weak and strong harmonic violations.[8] In children, both of these components were elicited by strong but not weak harmonic violations.[7] This suggests that young children possess some, although incomplete, implicit knowledge of Western harmonic structure.

Musical training may accelerate the development of harmony perception. Jentschke, Koelsch, and Friederici[9] found that the ERAN was elicited by strong harmonic violations in both 11-year-old musicians and nonmusicians, but that it was stronger in musicians. The

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ERAN may have been stronger in the musicians because of their musical training, but it is also possible that there were pre-existing differences between children who began music lessons and those who did not.

The goal of the present study was to investigate whether musical training accelerates the development of key membership and harmony perception in younger children. We tested 3- to 6-year-old beginner musicians and nonmusicians on their detection of a deviant chord in two versions of "Twinkle Twinkle Little Star." Children were tested initially and again 8–12 months later, after the beginner musicians had participated in music lessons. Since sensitivity to key membership and harmony are emerging around this time,[3,5–7] we hypothesized that children who had participated in music lessons would show better detection of out-of-key and out-of-harmony deviant notes than would children who had not received any formal music lessons.

Method

Participants

Time 1

Forty children participated. Nineteen had no formal musical training (nonmusicians: mean [M] = 4.9 years; SD = 0.8 years) and 21 were just beginning music lessons at time 1 (beginner musicians: M = 4.9 years; SD = 0.8).

Time 2

Thirty-one also participated at time 2, 8–12 months after time 1. In the nonmusician group, 10 remained in the study at time 2 (M = 6.1 years; SD = 0.9 years). All 21 in the beginner musician group remained in the study at time 2 (M = 5.6 years; SD = 0.9 years), and their musical training ranged from 5 to 14 months (M = 7.8 months; SD = 2.1 months).

Materials and Design

Two conditions assessed children's perception of key membership and harmony using a simple task and a familiar song (i.e., "Twinkle Twinkle Little Star") presented in a piano timbre. Each condition had 2 example trials, 2–4 training trials, and 10 test trials: 6 in standard form, 2 with an out-of-key change on the last chord, and 2 with a change that was in key, but out-of-harmony. The melody-plus-chords condition (Fig. 1A) sounded familiar; thus, children judged whether each trial ended correctly or incorrectly. The chords-alone condition (Fig. 1B) sounded unfamiliar; thus, children judged whether each trial sounded good or bad. We computed the proportion of trials

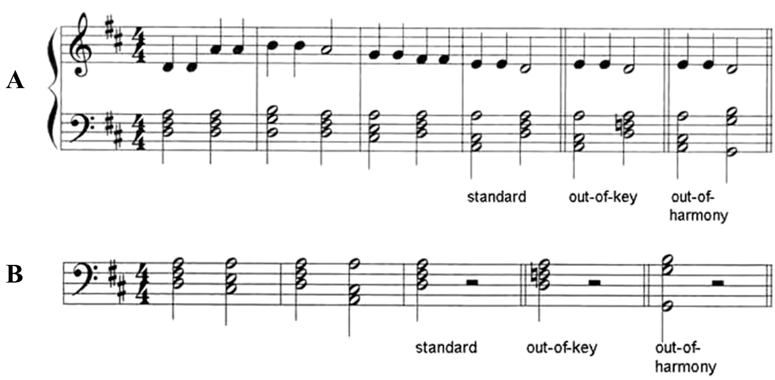

Figure 1. Note and chord sequences. (**A**) Melody-plus-chords condition. All trials began with the first three bars; the last three bars represent the fourth bar and end of the sequence for each trial type (standard, out-of-key, out-of-harmony). (**B**) Chords-alone condition. All trials began with the first two bars; the last three bars represent the third bar and end of the sequence for each trial type (standard, out-of-key, out-of-harmony).

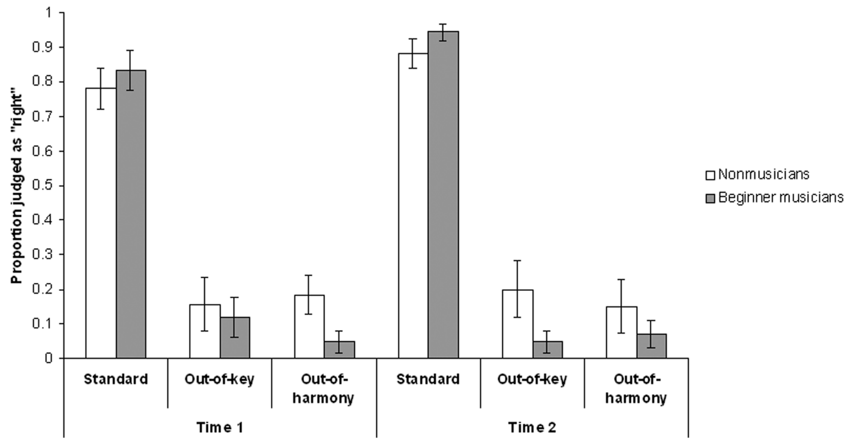

Figure 2. Performance on the melody-plus-chords condition at times 1 and 2. Bars represent standard error.

judged as "right" or "good" for each trial type (standard, out-of-key, and out-of-harmony).

Results

For each condition (melody-plus-chords, chords-alone) at each time (1, 2), we first conducted a 2 × 3 ANOVA with musical training as a between-subjects factor (nonmusicians, beginner musicians) and trial type as a within-subjects factor (standard, out-of-key, out-of-harmony), adjusting degrees of freedom according to the Greenhouse–Geisser correction where appropriate. Each of these revealed a trial-type effect; thus, we compared performance on standard trials to each of the change trials (out-of-key, out-of-harmony). Whenever an effect involving musical training emerged in the overall ANOVA, we included musical training as a between-subjects factor in the follow-up analyses. Finally, if an effect of musical training persisted in these follow-up analyses, we analyzed each trial separately to compare performance between groups.

The results of the melody-plus-chords condition at time 1 are presented in Figure 2. There was an effect of trial type [$F(1.96,74.48) = 98.12$, $P < 0.01$], but no effects involving musical training (both Ps > 0.20). Further ANOVAs revealed significant differences between standard and out-of-key trials [$F(1,39) = 127.00$, $P < 0.01$] and standard and out-of-harmony trials [$F(1,39) = 156.47$, $P < 0.01$].

The results of the melody-plus-chords condition at time 2 are presented in Figure 2. There was an effect of trial type [$F(1.91,55.49) = 178.91$, $P < 0.01$], but no effects involving musical training (both Ps > 0.05). Further ANOVAs revealed significant differences between standard and out-of-key trials [$F(1,30) = 270.11$, $P < 0.01$] and standard and out-of-harmony trials [$F(1,30) = 290.64$, $P < 0.01$]. The results of the melody-plus-chords condition at both time 1 and 2 suggest that even children with no formal musical training are sensitive to key membership and harmony in a familiar song.

The results of the chords-alone condition at time 1 are presented in Figure 3. There was an effect of trial type [$F(1.89,71.98) = 56.42$, $P < 0.01$], but no effects involving musical training (both Ps > 0.50). Further ANOVAs revealed significant differences between standard and out-of-key trials [$F(1,39) = 140.07$, $P < 0.01$] and standard and out-of-harmony trials [$F(1,39) = 32.55$, $P < 0.01$].

The results of the chords-alone condition at time 2 are presented in Figure 3. There was an effect of musical training [$F(1,29) = 18.02$, $P < 0.01$], an effect of trial type [$F(1.86, 53.98) = 107.27$, $P < 0.01$], and the interaction approached significance [$F(1.86,53.98) = 2.95$,

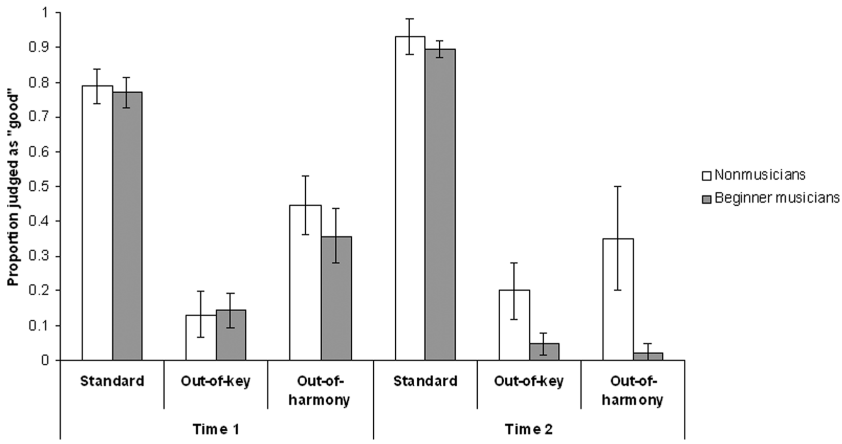

Figure 3. Performance on the chords-alone condition at times 1 and 2. Bars represent standard error.

$P = 0.07$]. Thus, we included musical training as a between-subjects factor in the two subsequent analyses. The first ANOVA revealed a significant difference between standard and out-of-key trials [$F(1,29) = 238.68$, $P < 0.01$], an effect of musical training [$F(1,29) = 6.96$, $P = 0.01$], but no interaction ($P > 0.25$). The second ANOVA revealed a significant difference between standard and out-of-harmony trials [$F(1,29) = 131.22$, $P < 0.01$], an effect of musical training [$F(1,29) = 11.16$, $P < 0.01$], and an interaction [$F(1,29) = 5.19$, $P = 0.03$]. Because effects involving musical training persisted in both of these follow-up analyses, we examined the effect of musical training on each trial type. There was no effect of musical training on standard trials ($P > 0.40$); however, there was on out-of-key trials [$F(1,30) = 4.34$, $P = 0.05$], and on out-of-harmony trials [$F(1,30) = 9.24$, $P < 0.01$]. The results of the chords-alone condition at both time 1 and 2 suggest that while nonmusicians have some knowledge of key membership and harmony in an unfamiliar song, musical training leads to greater sensitivity to both of these structures.

Conclusions

The groups were similar at time 1, but musical training effects emerged on the out-of-key and out-of-harmony trials of the chords-alone condition at time 2, after the musicians had participated in formal music lessons. These results suggest that musical training rather than preexisting differences is the driving force behind musicians' superior performance.

No previous studies have found that children under 5 years are sensitive to harmony. By using simple chord progressions and a highly familiar song, we found that nonmusicians as young as 3 years have some knowledge of appropriate harmonic progressions. Our results converge with previous findings suggesting that children develop sensitivity to key membership earlier than to harmony.[3] Because knowledge of key membership simply involves knowing which notes belong in key and which do not, whereas harmonic perception involves finer-grained knowledge of the subtle relationships between notes and chords within a key, it is not surprising that the former develops before the latter. Finally, our results suggest that children are sensitive to key and harmony in familiar songs before they can generalize that knowledge to unfamiliar songs.

Conflicts of Interest

The authors declare no conflicts of interest.

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