Musical Enculturation in Preschool Children: Acquisition of Key and Harmonic Knowledge

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Even adults without formal music training have implicit musical knowledge that they have acquired through day-to-day exposure to the music of their culture. Two of the more sophisticated musical abilities to develop in childhood are knowledge of key membership (which notes belong in a key) and harmony (chords and chord progressions). Previous research suggests sensitivity to key membership by 4 or 5 years, but provides no behavioral evidence of harmony perception until 6 or 7. Thus, we examined knowledge of key membership and harmony in 4- and 5-year-old children using a simple task and a familiar song. In line with previous research, we found that even the youngest children had acquired key membership. Furthermore, even 4-year-olds demonstrated some knowledge of Western harmony, which continued to develop between 4 and 5 years of age. In sum, our results indicate that harmony perception begins to develop earlier than has been previously suggested.

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Key words: key membership, harmony, tonality, musical enculturation, pitch

As music is a form of communication and expression that is both unique to humans and universal across human cultures, musical acquisition is a significant component of normal development. As with language, it takes many years to acquire full musical receptive and productive competence. Similarly, music perception and production become specialized for the structure of the music in the environment even without formal instruction in, or explicit knowledge of, that structure. The process by which children acquire this knowledge is referred to as musical enculturation because it requires experience with the particular musical system of a given culture. In this paper, we examine the acquisition of knowledge about key membership and harmonic syntax in preschool children who are naturally exposed to Western music in everyday life, but who have not received formal music instruction.

The most common scale (or key type) in Western music is the major scale (or key), a seven-note subset of the chromatic scale, an equal division of the octave into 12 intervals called semitones. Acquisition of key membership is manifested as knowledge of whether or not a note belongs to the seven notes of the key in which a piece is written. The unequal spacing of the tones in the major scale (2, 2, 1, 2, 2, 2, 1 semitones) allows each note to take on a different function, and chords based on each note have different meanings. For example, the tonic chord, based on the first note of the scale, is the most stable, and the dominant, based on the fifth note, is the next most stable. The dominant-to-tonic progression is very common at the end of musical phrases, and creates a sense of expectancy: if the harmonies implied by these progressions are not realized, the "wrong" chord may sound surprising or even unpleasant (Huron, 2006; Meyer, 1956). Acquisition of harmonic knowledge includes knowledge about the probabilities by which different chords follow each other, and the hierarchy of stability engendered by the different chords. Even adults with no music training have implicit knowledge of this tonal hierarchy (e.g., Cuddy & Badertscher, 1987; Krumhansl & Keil, 1982), suggesting that it develops in childhood through mere exposure to Western music.

Research suggests that 8-month-old infants are not yet sensitive to key membership, but that sensitivity develops between infancy and 4 or 5 years of age. Trainor and Trehub (1994) found that 5-year-olds', 7-year-olds', and adults' detection of a wrong note was facilitated when the changed note went outside the key. However, infants detected in-key and out-of key changes equally well (Trainor & Trehub, 1992). The acquisition of key membership knowledge also appears to enhance processing of tonal music. Trehub, Cohen, Thorpe, and Morrongiello (1986) found that 4- and 5-year-olds could only detect a change in a tonal melody; in contrast, infants could also detect a change in an atonal melody.

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Harmony perception appears to be one of the last musical skills to develop (e.g., Costa-Giomi, 2003). However, using an implicit task, Schellenberg, Bigand, Poulin-Charronnat, Garnier, and Stevens (2005) showed that 6- to 11-year-olds have some sensitivity to harmony. Children were primed with chord progressions, and made an unrelated, speeded judgment about the last chord (e.g., whether it was a piano or a trumpet tone). All children responded faster to the last chord when it followed Western harmony rules than when it did not, suggesting that even 6-year-olds have implicit knowledge of realized Western harmonic progressions. Furthermore, studies examining children's brain responses to harmonically appropriate and inappropriate chords in a musical context suggest that two event-related potential (ERP) components that are elicited by harmonic violations in adults, the early right anterior negativity (ERAN) and the N5, can also be elicited in children as young as 5 years old (Koelsch et al., 2003; Jentschke, Koelsch, Sallat, & Friederici, 2008). However, whereas both the ERAN and the N5 were elicited even to weak harmonic violations in adults (Koelsch et al., 2001), Koelsch et al. (2003) found that these components were only elicited to strong harmonic violations in children. These results suggest that implicit knowledge of Western harmonic structure is emerging in the preschool and early school years, and continuing to develop throughout childhood.

Harmonic structure affects melodic structure in Western music in that the different notes of a melody imply particular harmonies, and these harmonic implications color how a melody is perceived, even when the melody is presented without chordal accompaniment. Adults are sensitive to implied harmony in that they are faster to detect a note change in a melody if the change goes to a within-key note that is not in the implied chord expected at that point (i.e., the note sounds wrong or jarring as it doesn't fit the implied harmony) in comparison to another within-key note that is in the implied chord at that point (Trainor & Trehub, 1994). Seven-year-olds but not 5-year-olds appear to be like adults in their sensitivity to implied harmony (Trainor & Trehub, 1994). Similar results have been found using the probe-tone paradigm in which a musical context is given followed by a probe tone, which can be out-of-key, or consist of one of the seven notes in the context key. Krumhansl and Keil (1982) found that 6- and 7-year-olds preferred in-key notes to out-of-key notes, but they did not differentiate between different kinds of in-key notes, thereby not showing sensitivity to implied harmony. However, 8- to 11-year-olds additionally preferred notes that belonged to the tonic triad over notes that did not. Later probe-tone studies found that children as young as 6 years old could show sensitivity to the full tonal hierarchy if the task was simplified (Cuddy & Badertscher, 1987; Speer & Meeks, 1985). In sum, this research has provided evidence that children as young as 6 years are sensitive to harmonic structure.

Taken together, the available evidence suggests that children are sensitive to key membership at 4 or 5 years (e.g., Trainor & Trehub, 1994; Trehub et al., 1986), perhaps younger, but little is known about their harmonic sensitivity before 6 years of age (e.g., Cuddy & Badertscher, 1987; Schellenberg et al., 2005; Speer & Meeks, 1985; Trainor & Trehub, 1994). Thus, our goal was to examine the developmental acquisition of knowledge of key membership and harmony in younger children between 4 and 5 years of age. We expected that both age groups would show sensitivity to key membership, but that 5-year-olds would show greater sensitivity to harmonic violations than 4-year-olds.

Method

PARTICIPANTS

Twenty-seven 4-year-olds (20 girls, 7 boys; $M = 4.0$ years; $SD = 0.3$ years) and 25 5-year-olds (17 girls, 8 boys; $M = 5.0$ years; $SD = 0.3$ years) were tested individually at home, at school, or in a psychology laboratory. An additional four children were tested but excluded for failing to complete the task. Most children came from upper-middle-class families, and none had participated in formal music training.

DESIGN

The task was designed to assess children's perception of key membership and harmony using a simple task and a familiar song (i.e., the first line of *Twinkle Twinkle Little Star*). Children received a sticker book and stickers for participating. In each condition, we asked children to use handheld happy and sad face signs to judge whether a frog puppet played each excerpt (or each trial) correctly or incorrectly, or whether it sounded good or bad (see the descriptions of each condition below). All stimuli were presented in a synthesized piano timbre from GarageBand over portable speakers connected to a computer. In each of three conditions, children were first presented with example and practice trials. Half of the 12 test trials were presented in the standard form in the key of D major, and half ended on one of three types of deviants: (1) out-of-key, (2) in key but out-of-harmony, and (3) in key and within-harmony. Figures 1A-C show the full set of stimuli in each condition. We created two pseudorandom orders for each condition such that there were no more than three consecutive standard or three consecutive deviant trials. The three conditions were administered as part of a larger study, which included various nonmusical tasks that are not reported here. The three conditions were always presented in the same order, listed below, although there were intervening tasks between each of them. The three conditions were:

1. Melody Alone (Figure 1A). Only the melody was presented and the deviants occurred on the final note. In this condition, out-of-key deviants ended on the note D#, which does not belong to the key of D major. Out-of-harmony deviants ended on C#, a note that belongs to the key of D major but that does not belong to the tonic chord (D, F#, A), which is strongly implied at the end of the sequence. Within-harmony deviants ended on F#, which belongs to the tonic chord but nevertheless deviates from the standard ending (the note D). Children judged whether each trial ended correctly or incorrectly. This condition was administered to ensure that children were familiar with the song and performance was expected to be high.
2. Melody Accompanied by Chords (Figure 1B). Both the melody and the chords were presented, and the deviants occurred on the final chord (the melody was not changed). In this condition, out-of-key deviants ended on a D minor chord, which contains one note (F natural) that does not belong to the key of D major, and is one step away from D Major in key space, according to Krumhansl and Kessler's (1982) spatial representation of all 24 major and minor keys. Out-of-harmony deviants ended on a G major chord, which contains notes that all belong to the key of D major but violate the strong expectation of a dominant-to-tonic chord progression at the end of the sequence. Within-harmony deviants simply ended on

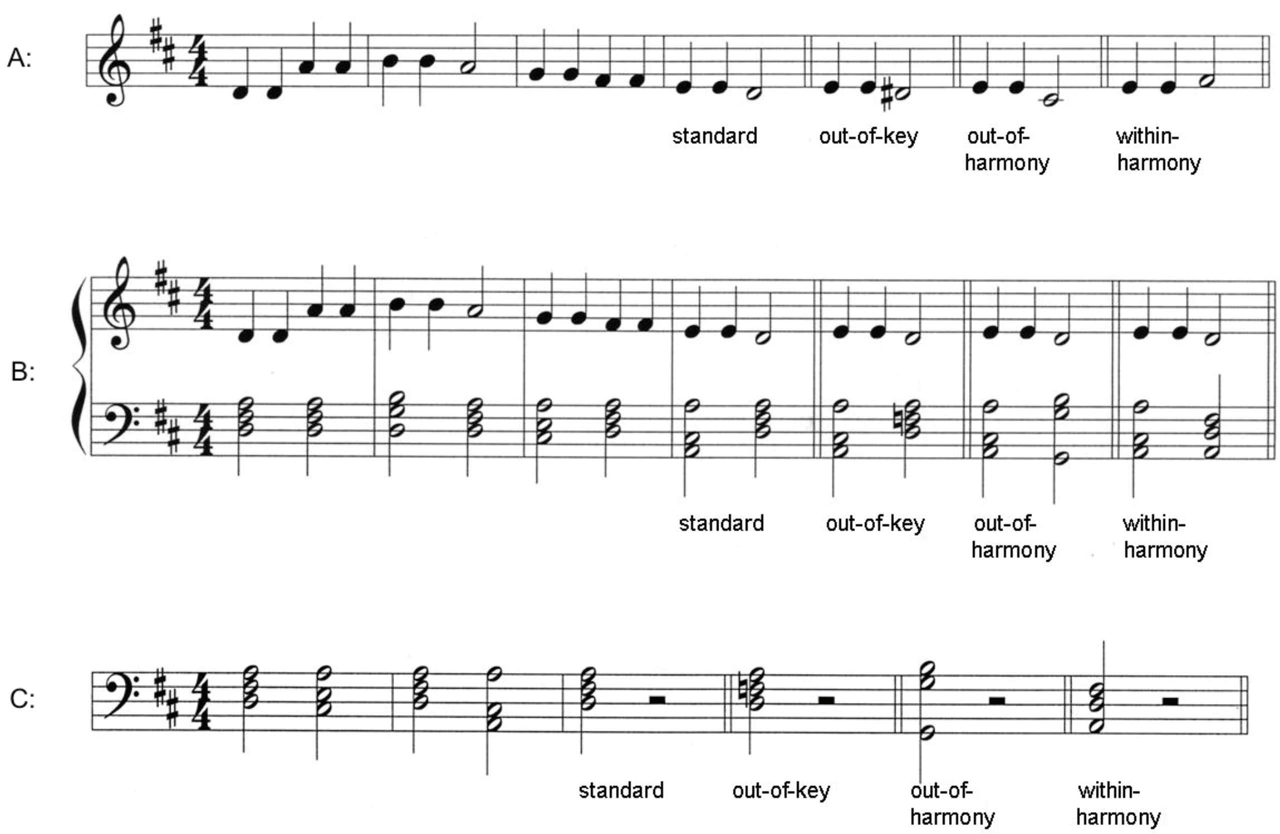

FIGURE 1. Note and chord sequences of the key membership and harmony perception test. (A) Melody Alone condition. All trials began with the first three measures; the four subsequent measures represent the fourth measure and end of the sequence for each trial type (standard, out-of-key, out-of-harmony, and within-harmony). Deviant notes occurred on the last note of the sequence. (B) Melody Accompanied by Chords condition. All trials began with the first three measures; the four subsequent measures represent the fourth measure and end of the sequence for each trial type (standard, out-of-key, out-of-harmony, and within-harmony). Deviant chords occurred on the last chord of the sequence. (C) Chords Alone condition. All trials began with the first two measures; the four subsequent measures represent the fourth measure and end of the sequence for each trial type (standard, out-of-key, out-of-harmony, and within-harmony). Deviant chords occurred on the last chord of the sequence.

the same D major chord in inversion instead of in root position. Thus, our deviants were constructed such that physical deviance from the standard ending chord was pitted against the degree of musical violation: out-of-key deviants only slightly differed physically from the standard ending chord (i.e., one semitone in one note), whereas out-of-harmony and within-harmony deviants differed physically from the standard ending by a greater degree (see Figure 1). Therefore, if children based their judgments on the degree of physical deviance from the standard ending, they should actually be worst at detecting out-of-key deviants. However, if children based their judgments on the degree of key and harmony violation as we predicted, the opposite pattern should be observed. Thus, our stimuli were designed to be a strong test of our prediction that children's judgments would be based on degree of musical violation rather than degree of physical deviance. Because the melody was present, the song sounded familiar and we therefore asked children to judge whether each trial ended correctly or incorrectly.

3. Chords Alone (Figure 1C). Only the last five chords of the song clip were presented. The very same deviants occurred on the final chord as in the Melody Accompanied by Chords condition. Because the melody was absent, the music sounded unfamiliar. Therefore, we asked children to judge whether each trial sounded good or bad rather than judge whether each trial ended correctly or incorrectly.

We then calculated the mean proportion of trials judged as "right" (in the Melody Alone and Melody Accompanied by Chords conditions) or "good" (in the Chords Alone condition).

Results

Each condition was analyzed separately. A Greenhouse-Geisser correction for degrees of freedom was used whenever the sphericity assumption was violated. For each, an initial omnibus ANOVA was conducted with Age Group (4-year-olds, 5-year-olds) as the between-subjects factor and Trial Type (standard, out-of-key, out-of-harmony, within-harmony) as the within-subjects factor. For the Melody Alone condition (see Figure 2), the only significant effect was that of Trial Type, $F(3, 150) = 112.51$, $\varepsilon = 0.87$, $p_{adj} < .001$. We then conducted three ANOVAs comparing standard trials to each of the three types of deviant trials, which revealed significant differences between standard trials and each of the deviant trials (all *p*s < .01). This suggests that all children were familiar with the melody and could detect any type of change to it. Finally, we compared the three types of deviant trials to each other. The lack of a significant effect indicates that children detected each type of change equally well.

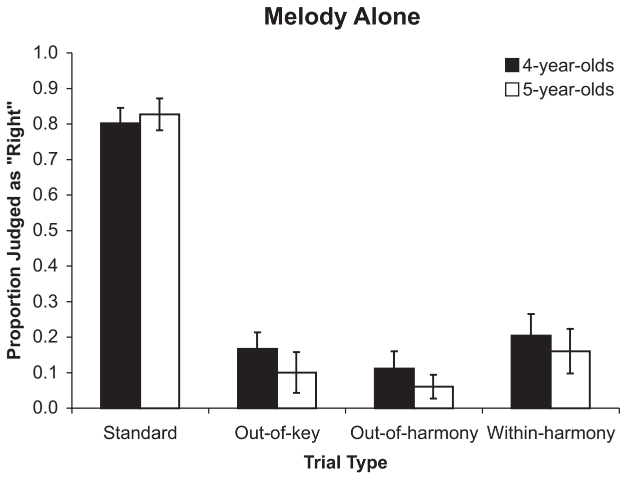

FIGURE 2. Performance on the Melody Alone condition. Bars represent standard error.

For the Melody Accompanied by Chords condition (Figure 3), the omnibus ANOVA revealed only a significant effect of Trial Type, $F(3, 150) = 45.57$, $\varepsilon = 0.77$, $p_{adj} < .001$. Standard trials differed significantly from each of the deviant trials (all *p*s < .05), suggesting that all children were sensitive to both key membership and harmony in a familiar context. Finally, comparing the three types of change trials to each other revealed that out-of-key and

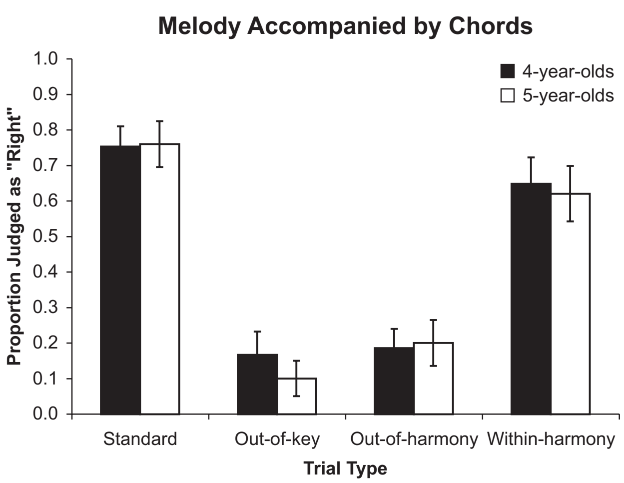

FIGURE 3. Performance on the Melody Accompanied by Chords condition. Bars represent standard error.

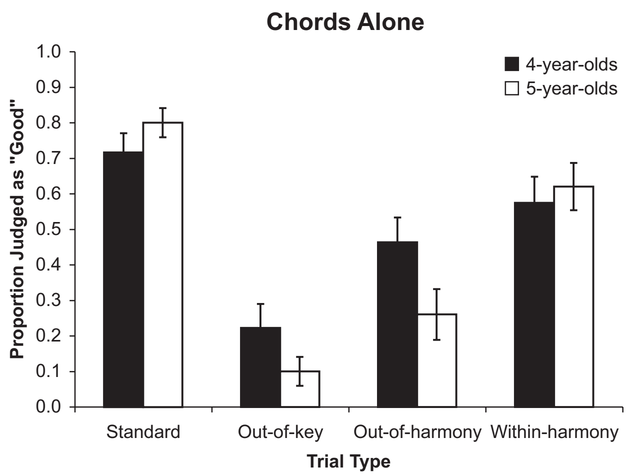

FIGURE 4. Performance on the Chords Alone condition. Bars represent standard error.

out-of-harmony trials did not differ significantly from each other ($p > .2$), but both of these differed from within-harmony trials (both ps < .01). Thus, children found out-of-key and out-of-harmony changes easier to detect than within-harmony changes.

For the Chords Alone condition (Figure 4) the omnibus ANOVA revealed a significant effect of Trial Type, $F(3, 150) = 46.58$, $\varepsilon = 0.95$, $p_{adj} < .001$, and an interaction between Age Group and Trial Type, $F(3, 150) = 3.15$, $\varepsilon = 0.95$, $p_{adj} < .05$. Because we found an effect involving Age Group, we kept it as a between-subjects factor in the next analyses comparing standard trials to each of the three types of deviant trials. These analyses revealed significant differences between standard trials and each of the deviant trials (all ps < .01). The only effect involving Age Group was a significant interaction in the analysis comparing standard and out-of-harmony trials ($p < .05$). To follow up, we examined the effect of Age Group on standard and out-of-harmony trials separately, and found a significant effect on out-of-harmony trials only, $t(50) = 2.03$, $p < .05$. Figure 4 shows that 5-year-olds outperformed 4-year-olds on these trials. Finally, we analyzed performance on the three types of change trials in 4- and 5-year-olds separately. In 4-year-olds, out-of-key trials differed significantly from both out-of-harmony and within-harmony trials (both ps < .01), but these did not differ significantly from each other ($p > .20$). This suggests that 4-year-olds found out-of-harmony and within-harmony changes more difficult to detect than out-of-key changes. In 5-year-olds, out-of-key and out-of-harmony trials did not differ ($p > .05$), but both of these differed from within-harmony trials (both ps < .01). These results suggest that 5-year-olds, but not 4-year-olds, show an adult-like pattern.

Discussion

Previous research demonstrated knowledge of key membership by 4 to 5 years of age (Trainor & Trehub, 1994; Trehub et al., 1986), but no previous studies had examined sensitivity to realized harmonic chord progressions in children younger than 6 years, and one study failed to find evidence of harmonic sensitivity to implied harmonies in 5-year-olds (Trainor & Trehub, 1994). We tested 4- and 5-year-olds with an easier task than had been used in previous research and found evidence of key membership knowledge and harmony perception even in our youngest participants who, at 4 years of age, were at least 2 years younger than the youngest age at which harmony perception had been demonstrated behaviorally (Cuddy & Badertscher, 1987; Schellenberg et al., 2005; Speer & Meeks, 1985). These results fit with electrophysiological evidence suggesting some harmonic knowledge in 5-year-olds (Jentschke et al., 2008; Koelsch et al., 2003).

Children of both age groups detected all types of deviant notes at near ceiling levels when only the melody was presented, suggesting that all children were very familiar with *Twinkle Twinkle Little Star*. Furthermore, children of both age groups easily detected out-of-key chord changes in the two conditions involving chords. Interestingly, both 4- and 5-year-olds easily detected out-of-harmony deviants when the song sounded familiar (i.e., when presented with both the melody and the chords), but 5-year-olds outperformed 4-year-olds at detecting these deviants when the song sounded unfamiliar (i.e., when presented with only the chords). Furthermore, while 4-year-olds were better at detecting out-of-key than in-key deviants, 5-year-olds were also better at detecting out-of-harmony than within-harmony deviants. These results suggest that 5-year-olds display a more adult-like pattern than 4-year-olds, and have a greater sensitivity to harmony. Finally, our results showed that even young children can detect within-harmony changes at above chance levels. However, detection of these subtle changes is not as good as detection of either out-of-key or out-of-harmony changes. In sum, the results indicate that 4- and 5-year-old children differ most in sensitivity to harmony.

Our results converge with previous findings suggesting that children develop sensitivity to key membership relatively early (e.g., Trainor & Trehub, 1994; Trehub et al., 1986), and that harmony perception develops later (e.g., Cuddy & Badertscher, 1987; Krumhansl & Keil, 1982; Schellenberg et al., 2005; Speer & Meeks, 1985; Trainor & Trehub, 1994); however, our results suggest that this developmental progression begins earlier than previously suggested (Costa-Giomi, 2003; Krumhansl & Keil, 1982). Because knowledge of key membership simply involves knowing which notes belong in the key and which do not, whereas harmony perception involves more fine-grained knowledge of the subtle relationships between notes and chords within a particular key, it is not surprising that harmony perception develops later than knowledge of key membership. Future research could examine even younger children to specify the developmental course of each of these skills.

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