Developmental Psychology
2010, Vol. 46, No. 6, 1799–1803

© 2010 American Psychological Association
0012-1649/10/$12.00 DOI: 10.1037/a0020658

Shifting Perceptions: Developmental Changes in Judgments of Melodic Similarity

Stephanie M. Stalinski and E. Glenn Schellenberg
University of Toronto Mississauga

Musical melodies are recognized on the basis of pitch and temporal relations between consecutive tones. Although some previous evidence (e.g., Saffran & Griepentrog, 2001) points to an absolute-to-relative developmental shift in listeners' perception of pitch, other evidence (e.g., Plantinga & Trainor, 2005; Schellenberg & Trehub, 2003) suggests that both absolute- and relative-pitch processing are evident among listeners of all ages (infants, children, and adults). We attempted to resolve this apparent discrepancy by testing adults as well as children 5–12 years of age. On each trial, listeners rated how similar or how different 2 melodies sounded. The melodies were identical, transposed (all tones shifted in pitch by the same amount), different (same tones reordered, changing pitch relations between successive tones), or transposed and different. Listeners of all ages were sensitive to both changes, but younger listeners attended selectively to transpositions as a source of perceived differences. With increasing age, melodic differences played an increasingly important role, whereas transpositions became less relevant.

Keywords: pitch perception, music and development, musical pitch, relative pitch, absolute pitch

Imagine hearing the song "Happy Birthday to You" played quickly on a piccolo or played slowly on a tuba. These imagery tasks (Halpern, 1992) are relatively easy because adults know—usually implicitly—that melodies are abstractions defined on the basis of pitch and temporal relations between consecutive tones. However, when in development are melodies processed primarily as abstractions? This question motivated us in the present investigation, and we focused specifically on pitch perception.

Relative pitch, the ability to process pitch in terms of *intervals* (i.e., distances in pitch between tones), is fundamental to music cognition. Virtually all adults perceive and represent pitch relatively (except amusics; Peretz, 2008), either explicitly or implicitly. Whereas musicians' explicit knowledge of musical intervals (e.g., "perfect fifth" or seven semitones) allows them to identify the exact pitch distance between two tones, nonmusicians' implicit knowledge allows them to identify a familiar melody presented at a novel pitch level and when a performer plays or sings a wrong note. In the former case, pitch relations between consecutive tones remain constant. In the latter case, a note sung sharp or flat changes these relations.

One view holds that an initial bias for processing pitch absolutely is typically lost over development as relative processing takes precedence (e.g., Takeuchi & Hulse, 1993). Some ontogenetic and phylogenetic evidence corroborates this notion. For example, the rare ability to identify a specific musical tone without reference to an external pitch (i.e., *absolute pitch proper*) is evident primarily among individuals with early music training (i.e., before 7 years of age; Takeuchi & Hulse, 1993), particularly those who are native speakers of tone languages (e.g., Deutsch, Dooley, Henthorn, & Head, 2009; Deutsch, Henthorn, Marvin, & Xu, 2006). These findings are suggestive of a critical period (Trainor, 2005) for associating labels with pitches to maintain an absolute processing style. Absolute-pitch processing has also been linked to atypical human development (autism spectrum disorders or Williams syndrome; Brown et al., 2003; Heaton, Hermelin, & Pring, 1998; Lenhoff, Perales, & Hickok, 2001), whereas comparative psychology has revealed that nonhumans (e.g., birds, monkeys) are more likely than humans to perceive pitch absolutely rather than relatively (e.g., D'Amato, 1988; Friedrich, Zentall, & Weisman, 2007).

Nevertheless, convincing evidence documenting the proposed absolute-to-relative developmental shift among humans is notably absent from the literature. In one apparent exception, Saffran and Griepentrog (Saffran, 2003; Saffran & Griepentrog, 2001) reported that infants performed at above-chance levels in statistical-learning tasks when absolute-pitch cues were available but not when relative-pitch cues were available; musically untrained adults exhibited the opposite pattern. These results are inconclusive for at least four reasons. First, 50% or more of the infants failed to complete the relative-pitch task, which suggests that the task was not age appropriate. Second, levels of performance for the infants were higher when either type of cue was present (but were significant only for absolute cues), yet the interaction between the

This article was published Online First September 6, 2010.

Stephanie M. Stalinski and E. Glenn Schellenberg, Department of Psychology, University of Toronto Mississauga, Mississauga, Ontario, Canada.

This article was supported by the Natural Sciences and Engineering Research Council of Canada. We thank the staff at the Ontario Science Centre (Toronto, Ontario, Canada) for their cooperation, the families who participated, Joanna Dudek and Kristina Neuman for assistance with testing, and Sandra Trehub for helpful comments on a draft of this article.

Correspondence concerning this article should be addressed to E. Glenn Schellenberg, Department of Psychology, University of Toronto Mississauga, Mississauga, Ontario L5L 1C6, Canada. E-mail: g.schellenberg@utoronto.ca

presence of a cue and the type of cue was far from statistically significant. Third, if infants were encoding pairwise statistics (rather than statistics calculated over triplets of tones), their performance was consistent with relative-pitch processing (Trainor, 2005). Finally, even if the observed response patterns could be interpreted unequivocally, a difference between the starting and end points of development (infants and adults, respectively) provides no information about when in development an absolute-to-relative shift occurs.

Moreover, other researchers have found that young infants perceive and remember pitch relations, either on a short-term basis using discrimination tasks (e.g., Trainor & Trehub, 1992; Trehub, Schellenberg, & Kamenetsky, 1999; Trehub, Thorpe, & Morrongiello, 1987) or on a long-term basis using preferential looking (Plantinga & Trainor, 2005). For example, when infants hear a melody presented repeatedly in transposition (at different pitch levels), they recognize when its component intervals change (e.g., Trainor & Trehub, 1992; Trehub et al., 1999, 1987). When infants are exposed to a specific melody for a week, they subsequently show a preference for a novel melody, even when the pitch level of the familiar melody is changed (Plantinga & Trainor, 2005). Also in conflict with the proposed absolute-to-relative shift are findings indicating that adults remember the pitch level of auditory stimuli with remarkable accuracy. For example, adults sing well-known pop songs at close to the original recorded pitch (Levitin, 1994), and they remember the pitch of the dial tone (Smith & Schmuckler, 2008). They also identify the pitch level of familiar recordings at above-chance levels, even when comparison recordings are shifted in pitch by only one or two semitones (Schellenberg & Trehub, 2003). Similar results have been evident when children (Schellenberg & Trehub, 2008; Trehub, Schellenberg, & Nakata, 2008) and infants (Volkova, Trehub, & Schellenberg, 2006) have been tested with age-appropriate music. These findings point to developmental consistency rather than to change in listeners' mental representations of musical pitch.

We sought to reconcile evidence of an absolute-to-relative shift with other evidence that listeners process pitch both absolutely and relatively across the lifespan. We used a melody comparison task to examine age-related changes in the use of absolute and relative cues by varying these cues orthogonally. All of our stimulus melodies were isochronous such that temporal cues were irrelevant. The absolute-pitch change involved a transposition, which maintained consecutive pitch relations and, hence, the melody's identity. The relative-pitch manipulation involved two different melodies, with the same set of tones simply reordered to change pitch relations between successive tones. Both manipulations were repeated measures, which allowed us to compare them within different age groups. To the best of our knowledge, in this experimental study we are the first to examine the use of both absolute and relative cues in a musical context simultaneously within the same groups of participants.

We had three main predictions: (a) Listeners of all ages would be sensitive to both changes, (b) younger children would find the transposition to be more salient than the melodic change, and (c) the salience of the melodic change would increase with increasing age. The latter two predictions were based on the premise that older listeners have more experience hearing the same melodies at a variety of pitch levels (e.g., in a different key, by a singer of a different gender). For them, the actual pitch level of any tune is more or less meaningless because a melody is defined and identified solely on the basis of relational information.

Method

Participants

A large sample (N = 116) of 5- to 12-year-old children was recruited and tested at the Ontario Science Centre (Toronto, Ontario, Canada), which is a popular, interactive children's museum that attracts an ethnically and socioeconomically diverse population of visitors. The children were categorized into three age groups: 5- to 7-year-olds (n = 39; 20 girls, 19 boys; mean years of music training = 0.21; range = 0–2 years), 8- and 9-year-olds (n = 39; 22 girls, 17 boys; mean years of music training = 0.92; range = 0–4 years), and 10- to 12-year-olds (n = 38; 19 girls, 19 boys; mean years of music training = 1.32; range = 0–8 years). One additional boy from the youngest group was tested but was excluded from the sample for responding identically on all trials. We also recruited a comparison group of 19 adults (i.e., undergraduate students; 11 women, eight men; age range = 17–25 years; mean years of music training = 3.00; range = 0–12 years) who were tested in the laboratory.

Apparatus and Stimuli

The stimuli comprised 500-ms piano tones presented over headphones. Tones were combined into four sequences (see Figure 1): two different seven-tone melodies with both melodies presented at two different pitch levels. The two lower pitch melodies (A and B) were composed from the same set of six tones, with the first and last tones fixed at middle C but with the other tones reordered, thus changing the pitch relations between consecutive tones. The two higher pitch melodies (C and D) were identical to the lower

Figure 1. The four stimulus melodies. A and B comprise the same set of tones presented at the same pitch level. A and B start and end on the same tone, but the middle tones are reordered, thereby changing the intervals (pitch relations) between consecutive tones. C is the same as A except for its pitch level; C is transposed upward in pitch by four semitones. Likewise, D is the same as B except that it is transposed upward in pitch by four semitones.

versions except that they were transposed upward by four semitones.

We elected to pit a rather large transposition against an obvious change in relative pitch to preclude floor effects that might emerge when testing children. The transposition included a pitch shift much greater than the smallest pitch difference that infants can detect (i.e., one third of a semitone; Olsho, Schoon, Sakai, Turpin, & Sperduto, 1982), whereas the melodic change included a difference in *contour* (i.e., upward or downward changes between successive tones). Contour is the most obvious dimension of relative pitch, which even young infants perceive and remember (e.g., Trehub, Bull, & Thorpe, 1984). Moreover, young children can identify the direction of pitch changes even when such changes are smaller than one semitone (Stalinski, Schellenberg, & Trehub, 2008).

Procedure

Participants were tested individually. They were told that on each trial they would hear two tunes. Their task was to use a 5-point rating scale and to decide whether the tunes sounded *exactly the same* (1), *almost the same* (2), *a little bit different* (3), *quite different* (4), or *very different* (5). In addition to the written labels, the rating scale included pictorial analogs for the benefit of children who could not read and to make the task more engaging. Specifically, a pair of colored circles appeared above each of the five options. One circle was the same color (blue) for each option. The other circle differed in hue along a gradient ranging from blue (*exactly the same* or 1) to white (*very different* or 5).

On each trial, the two melodies were separated by 1 s of silence. Each of the four melodies occurred as the first and second melody in all possible combinations (including repetitions) such that there were 16 trials (presented in random order) and four trials for each type of change. Compared with the first melody, the second melody was (a) exactly the same, (b) the same melody transposed, (c) a different melody, or (d) a different melody transposed. Two practice trials were completed before beginning the test session. The entire procedure lasted approximately 10 min.

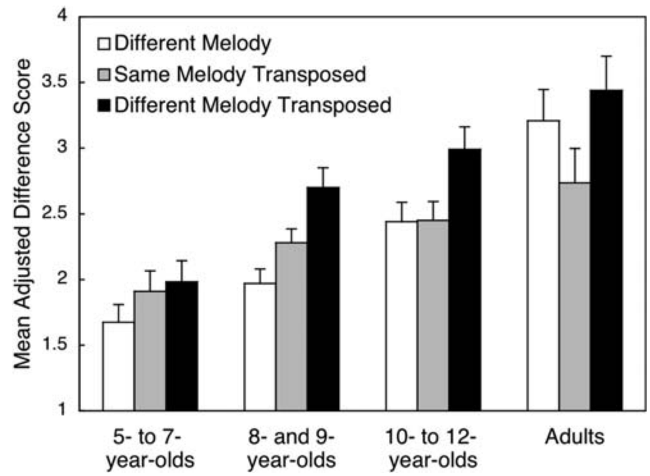

Figure 2. Means and standard errors for adjusted difference scores for each age group and for each type of melodic change. Scores were adjusted by dividing each listener's original scores by his or her score in the no-change condition. Higher scores correspond to greater perceived differences between melodies.

Results

Each listener had four scores, one for each condition, with each score averaged over four original ratings. All four age groups provided higher ratings in each of the three change conditions compared with the no-change condition (ps $< .0001$), which confirmed that each age group attended to absolute-pitch changes (transpositions) and to relative-pitch changes (melodic changes). Subsequent analyses focused primarily on differences among the other three conditions separately for each age group. Because the youngest children tended to provide higher ratings ($M = 1.94$) than the other three groups (Ms < 1.38) in the no-change condition, $F(3, 131) = 6.78$, $p < .0005$, $\eta^2 = .13$, we adjusted for this bias in subsequent analyses by dividing each listener's three change scores by his or her score in the no-change condition. Figure 2 illustrates descriptive statistics for adjusted scores separately for each age group and for each change.

The youngest children attended more to changes in pitch level than to changes in melodic structure. Specifically, for 5- to 7-year-olds, adjusted scores were higher for transposed melodies than for different melodies, $t(38) = 2.23$, $p < .05$. Although scores were also higher for different melodies transposed than for different melodies, $t(38) = 3.09$, $p < .005$, scores for melodies that were different and transposed were no different from scores for the same melody transposed ($p > .2$). The 8- and 9-year-olds were similar to the youngest children in two respects: The transposition was more salient than the melodic change, $t(38) = 3.78$, $p < .001$, and a different melody transposed was more noticeable than a melodic change alone, $t(38) = 7.09$, $p < .0001$. In contrast to the youngest group, they also found the different melody transposed to be more salient than a transposition alone, $t(38) = 4.30$, $p < .0005$. The 10- to 12-year-olds differed from the two younger groups by providing virtually identical ratings in the different-melody and transposition conditions ($p > .9$). As with the 8- and 9-year-olds, the oldest group of children found a different melody transposed to be more noticeable than a simple transposition, $t(37) = 5.43$, $p < .0001$, and a different melody presented at the same pitch level, $t(37) = 5.72$, $p < .0001$. Finally, the adults attended more to the relative-pitch change than to the change in pitch level. For them, the transposition was less salient than the melodic change, $t(18) = 2.12$, $p < .05$. Moreover, although the change in both dimensions was more salient than a simple transposition, $t(18) = 3.34$, $p < .005$, a different melody transposed was no more salient than a different melody presented at the same pitch level ($p > .2$).

A mixed-design analysis of variance with the three changes as a within-subjects factor and with age as a between-subjects factor revealed a significant interaction between change and age, $F(6, 262) = 5.48$, $p < .0001$, partial $\eta^2 = .11$. In short, the salience of the absolute-pitch change compared with the relative-pitch change differed across age groups. This pattern was unaffected when music training was included as a covariate in the analysis. Specifically, music training had no main effect ($p > .1$) and did not interact with the melodic change ($F < 1$).

Discussion

There are two conflicting perspectives about pitch perception and development. One claims that absolute cues eventually lose precedence to relative cues. The other claims that pitch is processed both absolutely and relatively across development. Our data are the first to provide support for both perspectives. Compared with a melody that was simply repeated, a melody that was transposed sounded more different to listeners of all ages, as did two different melodies composed from the same set of tones. We also observed age-related differences in the salience of the transposition and the melodic change, with the melodic change becoming progressively more important for older listeners. Five- to 7-year-olds found the transposition to be more salient than the melodic change, and they were oblivious to the melodic change when it was also transposed. By contrast, adults found the melodic change to be more salient than the transposition, and a transposition was irrelevant if a melodic change was also involved. An orderly developmental trend between these two points was evident for the two older groups of children. Eight- and 9-year-olds also found the transposition to be more salient than the melodic change, but unlike the youngest group, they were sensitive to the melodic change even in the context of a transposition. Finally, 10- to 12-year-olds also provided higher ratings for a different melody transposed than for a simple transposition, but they found the transposition and melodic changes to be equally salient. In short, adult-like judgments of melodic similarity appear to be achieved relatively late in development, after 12 years of age.

It is important to note that our present focus was not on discriminability—whether listeners could notice changes in pitch level or in melodic structure. Indeed, listeners of all ages rated transpositions and melodic changes as sounding more different than two identical melodies, which confirms that discriminability was not an issue, whether the change involved a transposition or a different melody. Rather, our focus was on whether listeners attended more to relative or absolute cues and how these attentional inclinations changed over development. The results reveal that as listeners develop from early childhood to adulthood, a melodic change eventually becomes more important than a transposition in the context of a task that requires them to focus on the similarity between two tunes. Differences in how the experimental task is worded may yield different results. Future research could shed light on whether the response patterns and the developmental changes that we observed vary as a function of the particular experimental task. It is also important to confirm that the present findings would extend to a larger set of stimulus melodies and to determine more precisely when in development adult-like response patterns become evident.

Although it has long been hypothesized that there is an absolute-to-relative developmental shift in pitch processing, ours is the first study to provide evidence of this purported shift in a single, cross-sectional experiment. Our findings confirm that melodic processing becomes more abstract and less dependent on surface features as listeners get older. Indeed, for young listeners, a melody's actual identity may often be irrelevant when other, less abstract changes are present simultaneously, including a change in pitch level. This result has particular relevance for the appreciation of virtually all Western musical styles, which often have themes repeated and varied at different pitch levels and on different instruments. Generalizing across such changes (i.e., recognizing that a particular theme has been repeated or varied) may be beyond the mental capacity of a typical young child in many instances. Future research could examine whether simultaneous changes in dimensions other than pitch level (e.g., tempo, timbre, intensity) also overwhelm the perception of pitch relations among young children.

Why do listeners appear to be sensitive to absolute-pitch cues in some studies but to relative-pitch cues in others? Differences in methods and theoretical objectives undoubtedly play a role. For example, relational cues are salient for infants when stimuli are transposed constantly in an operant head-turn procedure and when noticing shifts in pitch is not reinforced. In these instances, infants learn rapidly to ignore pitch-level changes and to attend to intervals between tones (e.g., Trehub et al., 1999; see also Saffran, Reeck, Niebuhr, & Wilson, 2005). Children also focus on pitch relations when they are required to identify whether a comparison melody is an exact transposition of a standard melody (Schellenberg & Trehub, 1996) or when the first and last tones of three-tone sequences are fixed across trials and they are asked to determine whether the middle tone went up or down (Stalinski et al., 2008). Other tasks encourage the use of absolute-pitch information, such as (a) when relative cues are fixed by pitch-shifting recordings electronically (Schellenberg & Trehub, 2003, 2008; Trehub et al., 2008) or (b) when mental representations are similarly fixed for stimuli that are always heard at the same pitch level (Levitin, 1994; Smith & Schmuckler, 2008). Even when similar methods are used, discrepancies can emerge because of stimulus differences. For example, when stimuli are computer-generated melodies, infants exhibit long-term memory for a melody but not for its specific pitch level (Plantinga & Trainor, 2005). By contrast, infants remember the pitch level of expressively sung lullabies (Volkova et al., 2006).

Absolute-to-relative developmental shifts are evident in domains other than pitch perception. For example, when younger children are asked to interpret metaphors, they base their interpretations on shared physical attributes, whereas older children base their interpretations on shared relational structures (e.g., Gentner, 1988; Rattermann & Gentner, 1998). Similarly, understanding absolute number precedes understanding of relations between numbers (e.g., greater than or less than; Michie, 1985). The present findings are consistent with a general tendency to attend selectively to obvious surface-level features and changes early in life but to attend to more abstract, symbolic, and relational properties later in development (e.g., Piaget, 1966; Vygotsky, 1934/1986).

In sum, the current findings help to reconcile apparent discrepancies regarding the use of absolute and relative cues in pitch processing. Although pitch processing undergoes an absolute-to-relative developmental shift from 5 years to adulthood, both absolute and relative cues are available to listeners of all ages. What develops is the salience of relative cues and the attention focused on them, both in comparison with absolute cues and when changes in absolute pitch occur simultaneously.

References

Brown, W. A., Cammuso, K., Sachs, H., Winklosky, B., Mullane, J., Bernier, R., . . . Folstein, S. E. (2003). Autism-related language, personality, and cognition in people with absolute pitch: Results of a prelim-

inary study. *Journal of Autism and Developmental Disorders, 33,* 163–167.
D'Amato, M. R. (1988). A search for tonal pattern perception in cebus monkeys: Why monkeys can't hum a tune. *Music Perception, 5,* 453–480.
Deutsch, D., Dooley, K., Henthorn, T., & Head, B. (2009). Absolute pitch among students at an American music conservatory: Association with tone language fluency. *The Journal of the Acoustical Society of America, 125,* 2398–2403.
Deutsch, D., Henthorn, T., Marvin, E., & Xu, H. S. (2006). Absolute pitch among American and Chinese conservatory students: Prevalence differences, and evidence for a speech-related critical period (L). *The Journal of the Acoustical Society of America, 119,* 719–722.
Friedrich, A., Zentall, T., & Weisman, R. (2007). Absolute pitch: Frequency-range discriminations in pigeons (*columba livia*)—Comparisons with zebra finches (*taeniopygia guttata*) and humans (*homo sapiens*). *Journal of Comparative Psychology, 121,* 95–105.
Gentner, D. (1988). Metaphor as structure mapping: The relational shift. *Child Development, 59,* 47–59.
Halpern, A. R. (1992). Musical aspects of auditory imagery. In D. Reisberg (Ed.), *Auditory imagery* (pp. 1–28). Hillsdale, NJ: Erlbaum.
Heaton, P., Hermelin, B., & Pring, L. (1998). Autism and pitch processing: A precursor for savant musical ability. *Music Perception, 15,* 291–305.
Lenhoff, H. M., Perales, O., & Hickok, G. (2001). Absolute pitch in Williams syndrome. *Music Perception, 18,* 491–503.
Levitin, D. J. (1994). Absolute memory for musical pitch: Evidence from the production of learned melodies. *Perception & Psychophysics, 56,* 414–423.
Michie, S. (1985). Development of absolute and relative concepts of number in preschool children. *Developmental Psychology, 21,* 247–252.
Olsho, L. W., Schoon, C., Sakai, R., Turpin, R., & Sperduto, V. (1982). Auditory frequency discrimination in infancy. *Developmental Psychology, 18,* 721–726.
Peretz, I. (2008). Musical disorders: From behavior to genes. *Current Directions in Psychological Science, 17,* 329–333.
Piaget, J. (1966). *The psychology of the child.* Paris, France: Presses Universitaires de France.
Plantinga, J., & Trainor, L. J. (2005). Memory for melody: Infants use a relative pitch code. *Cognition, 98,* 1–11.
Rattermann, M. J., & Gentner, D. (1998). More evidence for a relational shift in the development of analogy: Children's performance on a causal-mapping task. *Cognitive Development, 13,* 453–478.
Saffran, J. R. (2003). Absolute pitch in infancy and adulthood: The role of tonal structure. *Developmental Science, 6,* 37–49.
Saffran, J. R., & Griepentrog, G. J. (2001). Absolute pitch in infant auditory learning: Evidence for developmental reorganization. *Developmental Psychology, 37,* 74–85.
Saffran, J. R., Reeck, K., Niebuhr, A., & Wilson, D. (2005). Changing the tune: The structure of the input affects infants' use of absolute and relative pitch. *Developmental Science, 8,* 1–7.
Schellenberg, E. G., & Trehub, S. E. (1996). Children's discrimination of melodic intervals. *Developmental Psychology, 32,* 1039–1050.
Schellenberg, E. G., & Trehub, S. E. (2003). Good pitch memory is widespread. *Psychological Science, 14,* 262–266.
Schellenberg, E. G., & Trehub, S. E. (2008). Is there an Asian advantage for pitch memory? *Music Perception, 25,* 241–252.
Smith, N. A., & Schmuckler, M. A. (2008). Dial A440 for absolute pitch: Absolute pitch memory by non-absolute pitch possessors. *The Journal of the Acoustical Society of America, 123,* EL77–EL84.
Stalinski, S. M., Schellenberg, E. G., & Trehub, S. E. (2008). Developmental changes in the perception of pitch contour: Distinguishing up from down. *The Journal of the Acoustical Society of America, 124,* 1759–1763.
Takeuchi, A. H., & Hulse, S. H. (1993). Absolute pitch. *Psychological Bulletin, 113,* 345–361.
Trainor, L. J. (2005). Are there critical periods for musical development? *Developmental Psychobiology, 46,* 262–278.
Trainor, L. J., & Trehub, S. E. (1992). A comparison of infants' and adults' sensitivity to Western musical structure. *Journal of Experimental Psychology: Human Perception ad Performance, 18,* 394–402.
Trehub, S. E., Bull, D., & Thorpe, L. A. (1984). Infants' perception of melodies: The role of melodic contour. *Child Development, 55,* 821–830.
Trehub, S. E., Schellenberg, E. G., & Kamenetsky, S. B. (1999). Infants' and adults' perception of scale structure. *Journal of Experimental Psychology: Human Perception and Performance, 25,* 965–975.
Trehub, S. E., Schellenberg, E. G., & Nakata, T. (2008). Cross-cultural perspectives on pitch memory. *Journal of Experimental Child Psychology, 100,* 40–52.
Trehub, S. E., Thorpe, L. A., & Morrongiello, B. A. (1987). Organizational processes in infants' perception of auditory patterns. *Child Development, 58,* 741–749.
Volkova, A., Trehub, S. E., & Schellenberg, E. G. (2006). Infants' memory for musical performances. *Developmental Science, 9,* 583–589.
Vygotsky, L. (1986). *Thought and language* (A. Kozulin, Trans.). Cambridge, MA: MIT Press. (Original work published 1934)

Received December 11, 2009
Revision received May 1, 2010
Accepted June 11, 2010 ■