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Development of the Perception of Musical Relations: Semitone and Diatonic Structure

Sandra E. Trehub, Annabel J. Cohen, Leigh A. Thorpe, and Barbara A. Morrongiello
University of Toronto, Mississauga, Ontario, Canada

In the present research we examined the development of sensitivity to two musical relations significant in Western tonal music, the semitone and diatonic structure. Infants and preschool children were tested for their detection of a semitone change in any position of a five-note melody. Two standard melodies were used, one composed of diatonic tones only and the other containing a nondiatonic tone. In Experiment 1, children from 4 to 6 years of age were superior in detecting the semitone change in the diatonic context compared with the nondiatonic context. In Experiment 2, infants 9 to 11 months of age detected the semitone change in all positions, but their performance was not influenced by diatonic context. These findings indicate that infants and children can discriminate a semitone in a musical context and that the priority of diatonic structure emerges by 4 to 6 years of age.

In the present research we examined the development of sensitivity to two musical relations significant in Western tonal music: the semitone, a musical unit, and diatonic structure, a more complex musical configuration. In Western tonal music, the semitone is the smallest interval between two notes. It represents the frequency ratio of $2^{1/12}$ (i.e., 1:1.059) and divides the octave into 12 equal intervals. Thus, Western tonal music is composed from 12 notes separated by semitones and replicated in successive octaves. Musical compositions differ in their specific selection of these notes, but, nevertheless, the subsets of tones comprising musical compositions share many characteristics. In particular, music is written in a key that specifies a tonic note, which functions psychologically as a reference note (Krumhansl, 1979), and a set of six other tones related as the major or minor mode. The set of relations specified among these seven tones is known as diatonic structure.

The ability of adults to discriminate the smallest musical interval, a semitone, in short melodies has been shown in a variety of recognition tasks (e.g., Cohen, 1982; Cuddy, Cohen, & Mewhort, 1981). In these studies, listeners are better able to detect semitone changes in melodies that conform to diatonic structure, and they make more errors in melodies with increasing violations of diatonic structure. Further evidence for the psychological significance of diatonic structure has been revealed by the probe-tone technique (Krumhansl & Kessler, 1982; Krumhansl & Shepard, 1979). Here a diatonic context is established on each trial by presentation of a diatonic scale, a major triad, or chord progression. Subsequently, a probe tone from the chromatic scale is presented, and subjects rate how well the probe "fits in" with the preceding tonal context. Typically, listeners rate nondiatonic tones as least similar to the context, diatonic tones as more similar to the context, and tones of the major triad as most similar to the context. Comparisons of musically trained and untrained listeners have revealed greater sensitivity to diatonic structure for trained listeners (Krumhansl & Shepard, 1979). Indeed, sensitivity to diatonic structure is not always apparent for untrained listeners (Krumhansl & Shepard, 1979).

Recent developmental research has revealed that infants can discriminate frequency differences smaller than a semitone between isolated tones (Olsho, 1984; Olsho, Schoon, Sakai, Turpin, & Sperduto, 1982), but it is unclear whether such differences are discriminable in the context of multitone sequences or melodies. Similarly, preschool children's resolution of small frequency differences has been documented for isolated tones (Maxon & Hochberg, 1982) but not for tones embedded in melodic sequences. If young listeners cannot resolve such frequency differences in complex contexts, this would limit their ability to represent certain higher order musical relations. For example, the last two notes of the musical scale (ti-do) are separated by an interval of a semitone, and this relation in the context of other larger intervals of the scale helps the listener to define the key (Green, 1965, p. 9). The abstraction of key is fundamental to the appreciation of music, and, in part, it depends upon sensitivity to semitone intervals. Thus, it is of particular interest to determine whether infants and preschool children can detect in a musical context the smallest musically relevant frequency change in Western European music, the semitone.

In contrast to the paucity of research on semitone discrimination in infancy and early childhood, there has been considerable interest in the development of other auditory relations in a melodic context. As a result, we know that infants perceive the invariance of melodic contour (successive directional changes

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Correspondence concerning this article should be addressed to Sandra E. Trehub, Centre for Research in Human Development, Erindale College, University of Toronto, Mississauga, Ontario, Canada L5L 1C6.

in frequency) across transformations of absolute frequency and interval size (Chang & Trehub, 1977; Trehub, 1984; Trehub, Bull, & Thorpe, 1984). They also perceive the invariance of rhythmic patterning across variations in tempo (Washburn & Cohen, 1984). Furthermore, there is evidence to suggest that infants perceive the similarity of tones separated by an octave (Demany & Armand, 1984).

Music perception in young children extends beyond the perception of contour and rhythm. By 6 or 7 years of age, their internalization of diatonic scale structure is evident in their preference for scale (diatonic) over nonscale (nondiatonic) tones (Badertscher, 1985; Krumhansl & Keil, 1982; Speer & Adams, 1985). Krumhansl and Keil (1982) required children to judge whether two-note completions of a sequence that began with C E C G sounded "good" or "bad" on a 7-point scale, with the extremes defined by frowning and smiling faces. Speer and Adams (1985) and Badertscher (1985) used a similar rating procedure to determine how well each single tone of the chromatic scale completed an initial musical presentation.

By 8 or 9 years of age, children show increased awareness of Western tonal structure, as revealed by a preference for specific diatonic tones, namely the tones of the tonic triad in the two-tone probe task (Krumhansl & Keil, 1982). Older children show superior retention of tonal over atonal melodies (Zenatti, 1969) and can differentiate appropriate from inappropriate completions of melodies (Reimers, in Winner, 1982).

Although such changes in music listening skills are not dependent on formal musical training, there is evidence that training accelerates the development of sensitivity to musical relations. For example, Dowling and Goedecke (in Dowling, 1982) found that 6-year-old trained listeners detected contour changes more readily than did untrained age-mates and equivalently to untrained 8-year-olds. Similarly, Speer and Adams (1985) found sensitivity to major triad structure in those 6-year-olds who had experienced extracurricular music training.

It may be the case that, regardless of the degree of exposure, the encoding of some aspects of musical structure is limited by maturation or the development of appropriate cognitive skills. For example, Dowling and Goedecke (in Dowling, 1982) found that musical training contributed little to 6-year-olds' detection of reordered pitches in a melody but did enhance performance for 8-year-olds. In the case of infants as opposed to children, it is likely that their listening skills reflect general propensities or predispositions for structuring complex auditory patterns, for example, grouping on the basis of similar frequency (Thorpe, 1985; Trehub, 1985). It is possible, although unlikely, that such propensities could include favored status for tones related by diatonic scale structure.

As noted, evidence for the internalization of scale structure has been obtained with first and second graders, but there is no indication that this represents the initial age of acquisition of such knowledge. In one case in which younger children were assessed (Zenatti, 1969), the task demands seemed to preclude reasonable performance. Zenatti (1969) required children to identify the position of one changed note in three-note sequences, half of which belonged to one major scale (called tonal) and half of which did not (called atonal). Because 5-year-olds performed at chance levels in both cases, it was obviously impossible to find an effect of tonality. It is doubtful that the three-note sequences used by Zenatti were classifiable as tonal or atonal, even by adults. When tested on similar tasks, adults did not show the expected superiority for diatonic sequences, except in the case of sequences longer than three notes, which were not used with the youngest children. By the age at which children could achieve performance exceeding chance levels on the longer sequences (i.e., approximately 9 years), an effect of tonality was evident. Because Badertscher (1985), Krumhansl and Keil (1982), and Speer and Adams (1985; J. R. Speer, personal communication, December 10, 1985) did not test children younger than 6 years, it is unclear whether their tasks would be suitable for younger children.

In the past few years, several investigators have devised music perception tasks that are clearly within the capabilities of infants and preschool children (e.g., Trehub et al., 1984; Morrongiello, Trehub, Thorpe, & Capodilupo, 1985). The infant version of the procedure involves exposure to repetitions of a background melody presented from a laterally positioned loudspeaker. Infants are trained to turn toward the loudspeaker when changes in the melody occur, and turns to such changes are reinforced by the illumination and activation of an animated toy. The number of turns on such change trials are compared to turns on an equivalent number of no-change trials. For any given discrimination between a standard and comparison melody, the degree of difficulty can be varied by manipulating the duration between familiarization and test melody or by filling this intermelody interval with an interpolated or distractor sequence. With this procedure, it has been established that information about absolute frequency is available over very brief retention intervals (e.g., 800 ms: Trehub et al., 1984, Experiment 1). With longer retention intervals (e.g., 2.6 s), infants can discriminate changes in contour and frequency range but not interval size (Trehub et al., 1984, Experiment 2). In addition, changes in contour signaled by the change of even a single tone of a six-tone melody are detectable by infant listeners (Trehub, Thorpe, & Morrongiello, 1985).

In the preschool version of this procedure, children are presented with three, four, or five repetitions of the standard melody followed by an altered melody (change trial) or a further repetition (no-change trial). Children are trained to make a response (e.g., clapping hands, jumping, pressing a button) on change trials for visual reinforcement. With this procedure, it has been established that preschool children can detect changes that alter the contour of a melody as well as those that preserve the contour of a melody, but performance is superior on the former task (Morrongiello et al., 1985). Moreover, changes in the rate of presentation have a greater effect on the detection of changes that preserve contour than on those that violate contour (Morrongiello et al., 1985).

Experiment 1

The purpose of the present experiment was to examine preschool children's semitone discrimination in the context of two five-tone melodies, one with diatonic tones only, the other of which included a nondiatonic tone. On the basis of previous evidence of preference for diatonic over nondiatonic tones with first- and second-grade children (e.g., Krumhansl & Keil, 1982), the sensitivity of first-grade children to the diatonic/nondiatonic distinction (Speer & Adams, 1985), and the use of a task that has been successful with preschool children (Morrongiello et al., 1985), we expected detection of a semitone change to be easier in the diatonic context than in the nondiatonic context.

The diatonic context selected was a melody based on the major triad, C E G E C. The tones of the major triad are effective in establishing diatonic context in probe-tone tasks (Badertscher, 1985; Cuddy, 1985; Krumhansl & Kessler, 1982) as well as in a task in which listeners judge similarities between pairs of tones presented in a tonal context (Krumhansl, 1979, Experiment 1). Moreover, the major triad is considered in music theory to be a prototype of tonal structure (Schenker, 1906/1954). The nondiatonic context of the present investigation differed from the major triad by raising G to G#, thus producing an augmented triad not found in the major scale. Despite this difference, both melodies were similar in contour and general size of intervals. If the perceptual system of preschoolers gives priority to diatonic structure, this would result in more difficulty encoding the augmented triad melody than the major triad melody and, consequently, more difficulty in detecting deviations from the augmented triad melody.

Method

Subjects. The participants were 34 children from 4.2 to 5.9 years of age. Children were excluded from the final sample for failure to meet the training criterion ($N = 1$) and failure to complete the test session ($N = 3$). The final sample of 30 children comprised 12 females and 18 males, approximately 4.8 years of age.

Apparatus. The stimuli were generated on line by a synthesizer/function generator (Hewlett-Packard 3325A) and were presented via one channel of a stereo amplifier (Marantz, Model 1010) over a loudspeaker (Radio Shack, Nova-6). Intensity of the stimulus was controlled by the synthesizer, and calibrated with a General Radio 1551-C sound-level meter. Testing was carried out inside a sound-attenuating chamber (Industrial Acoustics Co.). A microcomputer (Commodore PET, Model 2001-16N) connected to a custom-built interface controlled the synthesizer, the activation of the toys, and lighting in each of the four chambers of the smoked Plexiglas box. The microcomputer also monitored the two keys of a small control box (two push buttons mounted on a Hammond chassis) by which the experimenter initiated trials and recorded responses from inside the testing booth.

Stimuli. The two standard sequences of five notes, as shown in Figure 1, were the ascending–descending major triad (C_4, E_4, G_4, E_4, C_4) and augmented triad (C_4, E_4, $G\#_4$, E_4, C_4), with frequencies specified for the tempered scale (Backus, 1969, p. 134). For the training phase, one contrasting melody was generated for each standard by raising both the first and last note (C_4) by two semitones (to D_4). For the test phase, five contrasting melodies were formed for each standard by increasing the frequency of one of the notes of the standard by one semitone.

The tones were sinusoidal waveforms, 200 ms in duration, linearly ramped at onset and offset, with a 30-ms rise and decay time. The intertone intervals were 200 ms; thus each sequence was 1.8 s. The intermelody interval was 800 ms. The ambient noise level, measured at the approximate location of the listener's head, was 42 dB C (27 dB A). Stimulus intensity, measured at this location, averaged about 70 dB C.

Procedure. Throughout the session, the child sat across from an experimenter. A loudspeaker and four-chambered Plexiglas box containing four different toys were to the side of the child at an angle of 45°. Each trial consisted of three, four, or five presentations (randomly determined) of the standard melody, followed by one presentation of the test melody. The child was allowed 4.0 s in which to respond, beginning at the start of the test melody. Responses occurring before the presentation of the test melody or after the end of the response interval were not recorded by the computer. The standard melody was either the major triad or augmented triad sequence. The test melody was one of the five contrasting melodies (i.e., change trial) or another presentation of the standard melody (i.e., no-change trial). No-change trials provided a measure of guessing or false alarms.

Initially, the experimenter explained that the child would be playing a game with the following rules. The melody would be repeated a few times, followed by another repetition (i.e., same song) or by a different melody (new song). The child was to indicate when a new melody occurred by speaking, clapping, raising a hand, or whatever response was mutually acceptable to experimenter and child. Because there were three, four, or five melodies in each series, it was important to listen carefully to each presentation because it might be the last one. If the child responded to the new melody, a toy near the loudspeaker would be turned on. During the training phase, two change trials were presented, one with each standard melody, with the experimenter assisting the child or demonstrating appropriate responding, as required. The child was then required to meet a training criterion of five consecutive correct responses without assistance within a maximum of 20 trials. The experimenter recorded the child's responses by pressing a button. If a response to change occurred within the 4-s response interval, the computer activated and illuminated one of the four toys for 4 s. All but one of the children in the final sample achieved the training criterion in the minimum of 5 trials; the remaining child required 9 trials.

Once the child met the training criterion, the test phase began immediately. During this phase, the experimenter wore headphones carrying music to mask the nature of the trial. Each child received 10 trials with each standard sequence, including 5 presentations of no-change trials and one presentation of each of 5 change trials (i.e., a one-semitone change at each of the serial positions), for a total of 20 trials. The 20

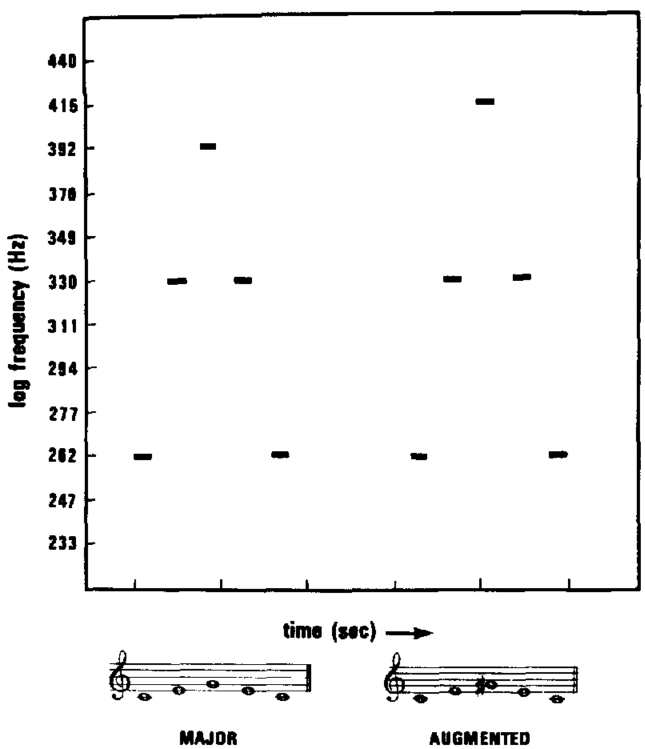

Figure 1. Schematic representation of test melodies.

trials were randomly ordered over the session with the constraint that no more than 2 no-change trials would be presented successively.

Results and Discussion

The data from each child were converted to proportion correct out of five for each of the four different conditions (major triad—no-change and change; augmented triad—no-change and change). Children rarely misjudged the no-change trials (.97 correct for both melodies). They made errors, however, in detecting the incorrect melody, noting fewer changes in the augmented triad melody (.63) than in the major triad melody (.79), $t(29) = 3.88, p < .001$.

The mean proportion correct detection of the different melody as a function of melodic condition and serial position of the incorrect tone is depicted in Figure 2 .The advantage of major triad structure is particularly striking for certain changes. It appears that the G# in the augmented triad is encoded imprecisely and has the effect of weakening the representation of the E on either side, whereas the G in the major triad is encoded more precisely and stabilizes the encoding of the neighboring tones. Tests of significance of the difference between two binomial proportions were performed on the proportion correct for individual serial positions (i.e., five separate tests). Because the proportions were based on a large number of trials ($N = 30$), the normal approximation to the binomial was used. These tests revealed higher performance on the major triad for the change at Serial Position 3 ($z = 3.03, p < .01$) and at Serial Position 4 ($z = 2.2, p < .05$).

For both sequences, comparisons resulting from a change in the final position appeared to be the most difficult to detect. Tests of the significance of the difference between proportion correct on each position, collapsing over both melodies, revealed poorer performance on the last position as compared with all others (all *p*s < .01). When the melodies were analyzed individually, Position 4 was not significantly different from Position 5 for the augmented sequence. This decline in performance at the end of the melody may reflect children's lesser attention to the final notes of the melody or the lesser response time following changes in later serial positions. Experimenters indicated, however, that children responded promptly to perceived changes and that they did not typically respond outside of the response interval.

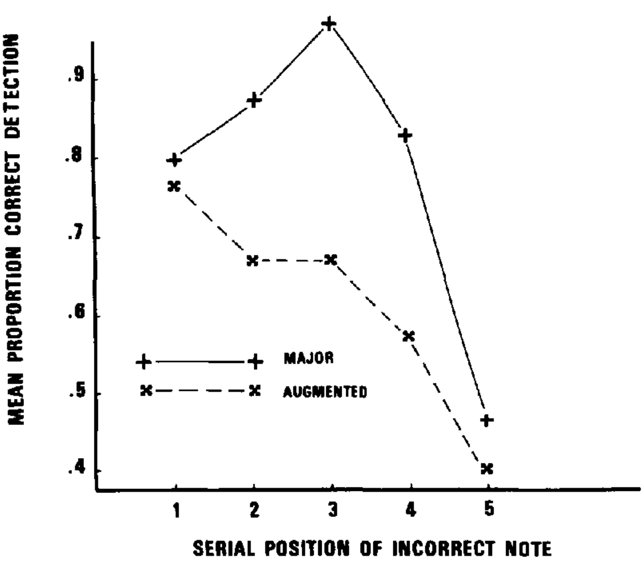

Figure 2. Mean proportion correct detection of a difference of a semitone as a function of serial position and melody type.

Because the new sequences created by a change of one semitone are not neutral with respect to diatonicism, performance differences for different positions in the sequence may have resulted from different relations of diatonic structure between standard and comparison sequences at each serial position. The change of a raised semitone at each position of the augmented sequence produces a diatonic sequence, a minor triad. Thus, all comparisons with the augmented triad sequence involve a nondiatonic standard and diatonic comparison. For the major triad standard, a nondiatonic sequence results from the change in Serial Position 3; changes in the remaining serial positions lead to diatonic sequences.

The degree of diatonicism, in itself, can act as a basis for discrimination between sequences that are otherwise very similar. For example, Cuddy, Cohen, and Miller (1979) showed that detection of a semitone difference between two transposed sequences is more difficult if both standard and comparison are diatonic than if only the standard is diatonic. Similar results were obtained by Bharucha and Krumhansl (1983, Experiment 2) using sequences of chords and comparing all four combinations of diatonic and nondiatonic standards and comparisons. In the present study, performance on major triad standards could have benefited from the advantage of the different degree of diatonic structure only at Serial Position 3, and here, indeed, superior performance was obtained.

The order of presentation of diatonic and nondiatonic sequences as standard or comparison also influences discrimination. In a delayed recognition task with interpolated diatonic or nondiatonic contexts, Krumhansl (1979, Experiments 2 and 3) observed that a nondiatonic standard tone is more frequently confused with a diatonic comparison tone than is a diatonic standard tone with a nondiatonic comparison tone. The memory representation of a nondiatonic note in an otherwise diatonic context is unstable and becomes "assimilated over time into more stable elements within the tonal system" (Krumhansl, 1983, p. 43). Thus, the memory representation of nondiatonic standards in the present study would become assimilated toward diatonic standards and would be less easily discriminated from diatonic comparisons. Conversely, the more stable representations of diatonic standards would contrast easily with the nondiatonic comparisons. This would account for poorer performance on the augmented triad standards as well as superior performance at Serial Position 3 with the diatonic standard. Poorer performance for the final serial positions as compared with Serial Positions 1 and 2 may reflect genuine serial position effects.

In order to separate the roles of serial position and musical structure, it would be necessary to examine, at each serial position, the effects of diatonic and nondiatonic standards and comparisons. It is also possible that if the augmented triad were changed to another nondiatonic structure, performance level might have been higher in accordance with Bharucha and

Krumhansl's (1983) observation for nondiatonic standard and comparison chord sequences. On the other hand, similar conditions with melodies led to the poorest performance (Cuddy et al., 1981) on a two-alternative, forced-choice, transposed-recognition paradigm.

Regardless of differences at particular positions, the overall level of performance on semitone discrimination indicates that preschool children can detect the smallest musically relevant interval in a musical context. This is consistent with evidence from Maxon and Hochberg (1982) for the discrimination of isolated tones. Children also revealed superior performance for major triadic as compared with augmented triadic structure. Because the two sequences did not differ in contour, and differences in interval composition were small, it would appear that the properties of the completely diatonic configuration have significance to young children. Finally, the present findings raise the possibility that semitone discrimination and priority of diatonic over nondiatonic sequences might be evident even in younger children. In an effort to examine further the ontogenesis of these music processing skills, we extended our research to infants.

Experiment 2

The principal purpose of the present investigation was to examine semitone discrimination in the context of the two standard melodies of Experiment 1. On the basis of previous research that indicated retention of absolute frequency information over brief temporal intervals (Trehub et al., 1984), we anticipated that infants would detect semitone changes under comparable conditions. In the absence of compelling evidence for an innate basis for diatonic preferences, we expected infants to perform equivalently in diatonic and nondiatonic contexts. For the purposes of the present experiment, then, the contrasting contexts could be viewed as simple replications of the semitone discrimination task.

Method

Subjects. Participants included 45 healthy, full-term infants ranging in age from 9.1 to 11.0 months. Infants were excluded from the sample if they failed to meet a predetermined training criterion (N = 3), or if they did not complete the 30-trial testing session (N = 2). Each infant was tested with either the major or augmented triad sequence. The final sample of 20 infants tested with the major triad sequence included 7 males and 13 females, with a mean age of 10.2 months. The final sample of 20 infants in the augmented triad condition comprised 13 males and 7 females, with a mean age of 10.0 months.

Apparatus. The apparatus was the same as for Experiment 1.

Stimuli. The same major and augmented triad sequences of Experiment 1 were used, along with the five comparison sequences for each standard melody.

Procedure. During the session, the infant was seated on the parent's lap in one corner of the testing booth, facing the experimenter. To the infant's left, at an angle of 45°, were the loudspeaker and the Plexiglas display box. During testing, the experimenter and parent both wore headphones carrying music to mask the nature of the stimulus presented to the infant.

Infants were tested with a conditioned headturn procedure (e.g., Eilers, Wilson, & Moore, 1977; Trehub et al., 1984), as described below. Each infant was presented repeatedly with one of the two standard tone sequences separated by 800-ms silent intervals. The experimenter first attracted the infant's gaze with a small silent toy. When the infant was quiet and facing directly ahead, the experimenter initiated a training trial by pressing a button. During the training phase, only change trials were presented. These change trials included the substitution of a comparison melody for the standard melody on two successive repetitions. The first note of the contrasting melody was raised by two semitones relative to the standard melody. If the infant turned 45° or more toward the loudspeaker, the experimenter pressed a button. If this response occurred within 3.6 s of the first changed note, the computer illuminated and activated one of the reinforcer toys for 4.0 s. Turns at other times or in the opposite direction were not reinforced. Following the presentation of the contrasting melody and reinforcer (if relevant), repetitions of the standard background melody continued as before. Again, when the infant was facing forward, the experimenter called for a trial, thereby initiating the contrasting melody with the possibility of visual reinforcement. If the infant turned on two consecutive trials, the change in the first note of the subsequent contrasting melody was reduced to one semitone. If the infant failed to turn correctly on two consecutive trials, the change in the first tone was increased to three semitones, with successive reductions in frequency change contingent on correct performance. Infants were required to meet a training criterion of four consecutive correct responses, with the one-semitone change within 20 training trials.

Once the training criterion was met, the test phase began immediately. The standard repeating background melody (major or augmented triad) remained the same, and at least two repetitions of the background sequence were required prior to the presentation of any trial. During the test phase, there were change and no-change trials. Change trials included the substitution of one of the five comparison melodies in place of the background melody for two consecutive presentations. No-change trials involved the monitoring of infant turns during an equivalent period. The experimenter and mother wore headphones carrying masking music and were therefore blind to the occurrence of change and no-change trials. The response interval for change trials began with the onset of the first presentation of the changed tone and ended 3.6 s later. During this period only, headturns to the sound change were reinforced. If the infant responded during the first presentation, the second presentation of the test sequence was omitted and the background sequence reinstated. An equal number of no-change trials were presented during which the background melody continued to play. On no-change trials, the response interval of 3.6 s began with the onset of the first note of the melody. These no-change trials provided an estimate of random turns in the direction of the loudspeaker.

The test phase consisted of 30 trials: 15 change trials (3 of each of the 5 contrasting melodies) and 15 no-change trials. Three consecutive randomized blocks of the five possible contrasting melodies were randomly interleaved with the 15 no-change trials, with the constraint that no more than 2 no-change or change trials would be presented consecutively.

Results and Discussion

A three-factor weighted analysis of variance was carried out on the proportion of correct headturns on change trials and incorrect headturns on no-change trials for each trial type (two levels: change, no-change), position of change (five levels: one for each position change), and melody type (two levels: major, augmented). These data are shown in Figure 3. Because there were five times as many no-change trials as change trials for each serial position, the no-change cell received a weight of 5. There was a main effect of trial type, $F(1, 38) = 60.42$, $p < .0001$. Newman-Keuls' multiple-range tests revealed significant

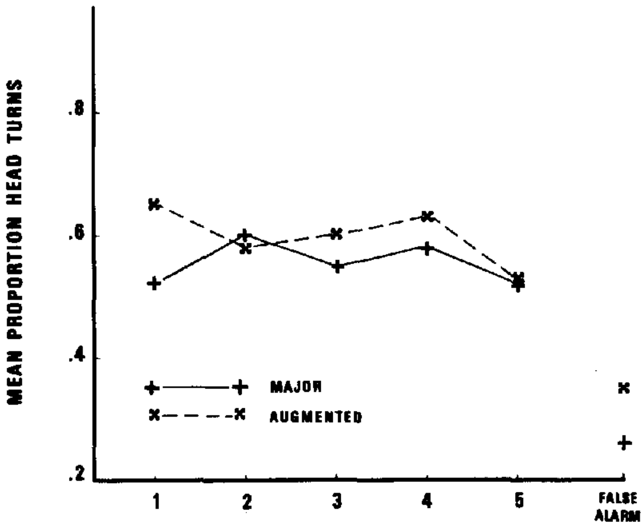

Figure 3. Mean proportion headturns as a function of trial type (serial position 1 to 5 for change trials, no-change trials) and melody type.

differences between false-alarm responses on no-change trials and correct responses on change trials for each serial position (all $ps < .01$), indicating that the semitone change was discriminated in all serial positions. There were no differences among serial positions, nor were there any effects of melody.

The present findings confirm and extend previous evidence of infants' detection of a 10-semitone change in each position of a 6-tone sequence (Trehub et al., 1985). These results also supplement Olsho et al.'s (1982) evidence on the discrimination of isolated frequencies by indicating that musical context does not interfere with the frequency resolution of a semitone. Finally, in contrast to preschool children (Experiment 1), infants did not show differential performance for the major triad and augmented triad melody.

General Discussion

The present investigation was designed to ascertain whether infants and preschool children could detect a semitone change in a musical context, whether they would give priority to diatonic sequences, and whether differences were evident between infancy and childhood. The principal findings were that both infants and preschool children detected a semitone increment in the context of a musical sequence, but only children showed superior performance for the diatonic sequence. It is clear, then, that sensitivity to the semitone in a musical context is not a limiting factor in the internalization of musical structure in infancy or early childhood. In fact, the infant is capable of abstracting the smallest intervals that are significant for the acquisition of knowledge about diatonic structure. Thus, the present findings offer no support for an innate bias favoring diatonic over nondiatonic sequences but do indicate priority of diatonic structure at considerably earlier ages than have been reported to date.

Children's difficulty with the augmented triad may arise from the unstabilizing effect of the augmented fifth in the otherwise major triadic context. Such disruptive effects of nondiatonic tones in a diatonic context have been illustrated by Cuddy et al. (1981). Children's poor performance on the augmented triad sequence is in accord with Krumhansl and Castellano's (1983) finding that nondiatonic chords are poorly remembered and interfere with the memory of neighboring tones.

One must consider, however, whether the obtained superiority for diatonic over nondiatonic sequences would apply to all diatonic and nondiatonic sequences or simply to the specific examples in the present investigation. Given the similarity of contour, intervallic composition, and absolute frequency of the two sequences, it would seem that these standard melodies provided a rather strong test of the hypothesis of diatonic superiority. Nevertheless, it would be important to extend this research to other diatonic and nondiatonic sequences. Further research should be directed to the question of the effect on performance of the degree of diatonicism of the standard and comparison. In particular, the possibility that performance on the augmented triad could be increased if the comparison were also nondiatonic should be considered following Bharucha and Krumhansl (1983, Experiment 2; but cf. Cuddy et al., 1981, Experiment 2).

It is possible that the present exemplars go beyond revealing preschoolers' internalization of diatonic structure to show their internalization of major triadic structure. Perhaps other diatonic note patterns would not lead to the same pattern of performance for preschool children as do the notes of the major triad. In any case, the present findings provide further evidence for the internalization of aspects of musical structure in early childhood.

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