Perception & Psychophysics
1987, 41 (6), 635-641

Infants' perception of musical patterns

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This paper examines infants' ability to perceive various aspects of musical material that are significant in music in general and in Western European music in particular: contour, intervals, exact pitches, diatonic structure, and rhythm. For the most part, infants focus on relational aspects of melodies, synthesizing global representations from local details. They encode the contour of a melody across variations in exact pitches and intervals. They extract information about pitch direction from the smallest musically relevant pitch change in Western music, the semitone. Under certain conditions, infants detect interval changes in the context of transposed sequences, their performance showing enhancement for sequences that conform to Western musical structure. Infants have difficulty retaining exact pitches except for sets of pitches that embody important musical relations. In the temporal domain, they group the elements of auditory sequences on the basis of similarity and they extract the temporal structure of a melody across variations in tempo.

The production of music, either vocally or instrumentally, must await appropriate motor development, but the perception of music is not so constrained. Thus it is conceivable, in principle at least, to study musical-pattern perception in infants.

Why might this be of interest? For one thing, music is found in all known cultures and, although performance is often limited to relatively few individuals, listening to music, either intentionally or incidentally, is a universal activity. Second, despite recent advances in our understanding of music perception in adults (see Deutsch, 1982; Dowling & Harwood, 1986; Sloboda, 1985), it is still unclear what these abilities owe to long-term immersion in the distinctive sounds of our culture. Third, the psychological qualities of sounds that are important in music (pitch, duration, loudness, and timbre) are important to all sound patterns, musical or nonmusical, so that the study of music perception is of interest to the generalist as well as to the music specialist. Finally, the richness of structure, hierarchical organization, and multidimensionality of musical patterns provide virtually limitless possibilities for the study of auditory information processing. In short, research on music perception in infancy offers unique opportunities for examining the processing of auditory patterns in extremely naive listeners.

Over the past few years, Trehub and her colleagues (Thorpe, 1985, 1986; Thorpe & Trehub, 1987; Trehub, 1985; Trehub, Bull, & Thorpe, 1984; Trehub, Cohen, Thorpe, & Morrongiello, 1986; Trehub, Thorpe, & Morrongiello, 1985, 1987) have explored infants' ability to perceive various aspects of musical material that are significant in music in general and in Western European music in particular: contour, intervals, exact pitches, diatonic structure, and rhythm. Since *contour*, *diatonic structure*, and other terms relevant to the present paper derive from music rather than from psychology, some clarification may be in order. Individual notes of a melody can rise in pitch, fall, or stay the same relative to the immediately preceding note. This pattern of successive pitch changes within a melody defines its *contour*. What is relevant here is the direction of pitch changes, rather than the extent of such change. *Intervals*, on the other hand, define the pitch relations between notes in terms of the ratios of adjacent pitches. Melodies that have the same contour may or may not have the same intervals. When they do, they are called *transpositions*. In Western tonal music, the *semitone* (or half step) is the smallest interval between two notes, representing the frequency ratio of $2^{1/12}$ (1:1.059) and dividing the octave into 12 equal intervals that make up the chromatic scale. The key of a melody specifies a tonic or reference note and six other notes drawn from the chromatic scale, with the set of relations among these notes known as *diatonic structure*. Adjacent notes of the diatonic scale are separated by whole steps (2 semitones) or half steps (1 semitone). (See Dowling & Harwood, 1986, for more complete descriptions of these and other musical concepts.)

TESTING INFANTS' PERCEPTION OF MUSICAL PATTERNS

The study of music perception in infancy poses methodological problems of substantial magnitude. With conventional instructions and response modes precluded for obvious reasons, there is a premium on creative research design. In essence, one must devise experimental tasks that capitalize on naturally occurring behaviors, such as the infant's tendency to look toward a sound source, especially in the case of novel sounds. The general approach toward research in this domain is to present stimuli that exceed the infant's immediate memory span.

The preparation of this manuscript was assisted by grants from the Natural Sciences and Engineering Research Council of Canada and the University of Toronto. Requests for reprints should be sent to Sandra E. Trehub, Centre for Research in Human Development, Erindale College, University of Toronto, Mississauga, Ontario L5L 1C6, Canada.

In this way, researchers attempt to uncover infants' strategies for organizing auditory information, such as the segmentation or chunking of input, distortions of input to simplify coding, and the synthesis of global representations from local details (Trehub, 1985).

The principal procedure for studying music perception in infants of at least 6 months of age involves the visual reinforcement of head turns to a sound change (e.g., Trehub et al., 1984; Trehub et al., 1986). The infant listens to a repeating melody presented to one side and is trained to turn toward the sound source when a comparison melody is substituted for the standard melody. Turns to such changes are reinforced by the illumination and activation of animated toys; turns in the absence of such changes are unreinforced. During the training period, the contrasting pattern is selected so as to be maximally distinctive. During the test trials that follow, more subtle changes can be presented. The infant receives an equivalent number of experimental (change) and control (no-change) trials, and these are subsequently compared to establish whether discrimination has occurred. There are various means of increasing the relative difficulty of the task, such as increasing the duration of interpattern (i.e., retention) intervals or inserting interpolated tones between background and test melodies.

MELODIC PROCESSING: CONTOUR

We know from the adult literature and from personal experience that the recognition of a familiar melody is not based on specific notes or pitches but rather on the relations between notes (Attneave & Olson, 1971; Bartlett & Dowling, 1980). What we have, then, is an abstract or configural representation of the relations between notes that is precise with respect to the frequency ratios of adjacent notes. With unfamiliar melodies, the situation is somewhat different. In this case, our representation is also independent of specific notes but is now less precise in coding the relations between notes (Dowling, 1978). The result is configural information about successive directional changes in pitch or melodic contour.

If infants are presented with melodies of five or six notes, what can we expect them to remember? If they do not structure or organize the input, then they might retain the exact pitches, constrained only by their limited memory capacity. This would be like a tape recording with tape of unknown length and durability. If, on the other hand, they do structure this input, then we might expect them to utilize a more global strategy, such as encoding the successive directional changes in pitch (i.e., the contour).

Trehub et al. (1984) familiarized 8- to 10-month-old infants with a six-tone melody and then tested their discrimination of various alterations of the melody: transpositions, which had the same intervals and contour but different component notes; contour-preserving transformations, which had different intervals but the same contour; and contour-violating transformations, which involved reordering the four internal notes. If infants discriminated transpositions from the original melody, that would suggest that their representation included exact pitches, as would be the case for those musicians or children with "absolute" or "perfect" pitch (Ward & Burns, 1982). If infants failed to detect transpositions but could detect the other transformations, this would suggest that they encoded interval relations between notes, as adults and children do with familiar melodies (Bartlett & Dowling, 1980; Trehub, Morrongiello, & Thorpe, 1985). If infants failed to detect transpositions and contour-preserving transformations but succeeded in detecting contour-violating transformations, this would imply that they coded contour, as adults and children do with unfamiliar melodies (Dowling, 1978; Morrongiello, Trehub, Thorpe, & Capodilupo, 1985).

With very brief retention intervals (800 msec), infants detected all transformations, but they performed better on contour-violating changes than on the others (Trehub et al., 1984, Experiment 1). Under these conditions, then, infants had access to exact pitch cues, which could be used to detect all of the changes. With longer retention intervals (2.6 sec, 15 sec), infants failed to detect transpositions and contour-preserving transformations, but did detect contour-violating transformations (Chang & Trehub, 1977; Trehub et al., 1984, Experiment 2). These findings imply that, under difficult conditions, infants encode and retain information about contour as opposed to specific pitches or intervals. Thus their perception of melodies is holistic in the sense that the global property of contour is perceived across specific changes in pitch and interval size.

Not only can infants detect changes in contour that result from reordering four tones of a six-tone melody, they can also detect contour changes resulting from alterations of a single component tone in any serial position (Trehub, Thorpe, & Morrongiello, 1985). On the basis of these studies of contour discrimination, it would seem that, except in the case of very brief retention intervals, infants encode global information about a melody at the expense of local detail about specific pitches. It is possible, however, that the failure of Chang and Trehub's (1977) and Trehub et al.'s (1984) infants to respond to same-contour and same-interval changes reflected their perception of the similarity between standard and comparison melodies that shared common intervals or contour. With the use of a single standard and comparison melody for each infant, Trehub and her associates could determine only that infants detected differences, not whether they perceived similarities. To establish the latter claim would require that infants discriminate between *sets* of variable standard and comparison melodies. If infants could *categorize* discernible tone sequences on the basis of common intervals or contour, this would provide additional insight into their representation of melodies.

Trehub et al. (1987) tested infants for their discrimination of five-tone melodies with contrasting contour in the context of transpositions (new pitches, same intervals) or contour-preserving variations (new pitches, new intervals, same contour). Infants listened to a repeating background of variable tone sequences (in contrast to the constant repeating sequences used by Trehub et al., 1984). In one condition, the variable sequences were characterized by common intervals; that is, they were all transpositions of one another. In the other condition, the background sequences had variable intervals but common contour. In both cases, infants were reinforced for responding only when one of a set of variable sequences with contrasting contour replaced a background sequence. Success would require that infants extract some property common to the variable melodies. If the infants encoded intervals, then they would have no difficulty detecting contour changes in the transposition condition, which conserved intervals in the background set but changed intervals (and contour) in the contrasting set. However, such an interval-encoding strategy would pose difficulty in the second condition, in which both target and background changes embodied interval variation. If, on the other hand, infants encoded the less precise contour information, then both conditions would be essentially equivalent. Finally, in the event that the infants encoded exact pitches, this would lead to failure in both conditions, which embodied pitch variation in the background and target sets of melodies.

In fact, infants detected changes in melodic contour in both conditions of variation, and their performance in these conditions did not differ. Naturally, Trehub et al. (1987) established that the background variations were, indeed, discriminable. There would appear to be little doubt, then, that infants categorize sequences of sounds on the basis of global, relational properties. The absence of performance differences between conditions implies but does not definitively establish that infants encoded contour in both conditions rather than intervals in one condition and contour in the other. In any case, this study lends further credence to the abstract nature of infants' representation of melodies.

For infants to encode the contour of a five- or six-note sequence, they must first establish that each note is rising or falling in relation to the note immediately preceding and following. Thorpe (1986) attempted to ascertain how much information infants require to perceive the pitch as rising or falling. She presented infants 7 to 10 months of age with repeating but variable (transposed) two-tone sequences with rising pitch and trained them to turn when a two-tone sequence with falling pitch replaced one of the background stimuli (15 exemplars in each set). Infants were presented with four types of trial: (1) a directional change with a large interval; (2) a directional change with a smaller interval; (3) no-change or control trials; and (4) probe trials with change to a smaller interval size but no change in pitch direction. This final change was included to ascertain whether interval size provided an additional discriminative cue.

Infants were assigned to one of three conditions, each with two interval sizes: 6 and 2 semitones; 4 and 2 semitones; and 2 and 1 semitones. They successfully detected directional changes in pitch for all interval sizes and, surprisingly, performance was unaffected by the magnitude of pitch change. Moreover, performance on same-direction probe trials did not differ from that on no-change trials. Thorpe's (1986) results are especially remarkable in view of the reported difficulty of pitch direction discrimination for preschool (Webster & Schlentrich, 1982) and school-aged (Hair, 1977) children. Her results also reveal that infants can extract information about pitch direction from the smallest musically relevant pitch change in Western European music, the semitone. Once again, these findings underline the relational orientation that infants bring to the processing of complex auditory patterns and provide further evidence of the salience of contour.

Such processing strategies have implications for infants' perception of other auditory sequences, for example, speech. It is likely that, for the prelinguistic listener, suprasegmental parameters of speech (e.g., intonation) have processing priority in early life (Crystal, 1973; Lewis, 1951; Lieberman, 1967). In fact, there is evidence that pitch contours play an important role in infants' response to the mother's voice (Fernald, 1985; Mehler, Bertoncini, Barriere, & Jassik-Gerschenfeld, 1978). Papoušek and Papoušek (1981) have claimed that musical elements in the caretaker's vocalization attract the infant's attention, modulate his or her state, and facilitate indentification of the speaker. It appears that an early stage in infants' analysis of the speech stream is the extraction of its fundamental frequency configuration, which is analogous to the contour of a musical pattern. This permits infants to recognize their caretaker's voice by its characteristic singsong or tune.

MELODIC PROCESSING: DIATONIC STRUCTURE

Adult listeners can detect semitone changes in brief melodies when the melodies conform to diatonic structure; they make more errors as the melodies increasingly deviate from such structure (Cohen, 1982; Cuddy, Cohen, & Mewhort, 1981). Moreover, listeners with musical training show greater sensitivity to diatonic structure than those without training (Krumhansl & Shepard, 1979). Even children 6 or 7 years of age show evidence of the internalization of diatonic scale structure in their preference for diatonic over nondiatonic tones (Krumhansl & Keil, 1982; Speer & Adams, 1985) and in their superior retention of diatonic over nondiatonic melodies (Zenatti, 1969). Whereas the music reception skills of young children are likely to reflect propensities attributable to musical acculturation, the skills of infants may well reflect innate propensities for structuring complex auditory patterns. It is possible, although unlikely, that such propensities include favored status for tones related by diatonic scale structure.

Trehub et al. (1986) tested infants 9 to 11 months of age and children 4 to 6 years of age for their ability to detect a semitone change in a five-tone melody composed entirely of diatonic tones (diatonic context) or another melody that had one nondiatonic tone (nondiatonic context). Since a subtle contour-preserving change was involved, a brief retention interval was used, as in Trehub et al. (1984, Experiment 1). The diatonic context involved a melody based on the major triad, C-E-G-E-C. In music theory, the major triad is considered to be a prototype of tonal structure (Schenker, 1906/1954), and its component tones are effective in establishing diatonic context in various tasks (Cuddy, 1985; Krumhansl & Kessler, 1982). The nondiatonic context differed from the major triad melody by raising G to G♯, (C-E-G♯-E-C), yielding a melody with one incorrect note in terms of the diatonic (major) scale. Aside from this difference, the diatonic and nondiatonic contexts were similar in contour and approximate interval sizes. Processing priority for diatonic structure, whether attributable to innate or experiential factors, would lead to greater difficulty detecting deviations from the nondiatonic melody.

The results indicated that infants and young children detected the semitone change in various positions of both five-tone melodies, but that the children were superior in detecting deviations from the diatonic compared with the nondiatonic sequence. Infants' detection of semitone changes in a musical context confirms their ability to abstract the smallest intervals necessary for the acquisition of information about diatonic structure but offers no support for an innate bias favoring diatonic over nondiatonic sequences. Instead, the preference for diatonic structure on the part of preschool children with no musical training suggests incidental musical exposure as the critical factor.

Cohen, Thorpe, and Trehub (1987) evaluated infants' perception of semitone changes in diatonic and nondiatonic melodies in the context of transposed rather than fixed background sequences (Trehub et al., 1986). They reasoned that infants in Trehub et al.'s (1986) study could have accomplished the semitone discrimination task by attending to absolute frequency cues as opposed to the single-position interval change. In contrast, Cohen et al.'s transposed background and comparison sequences necessitated the encoding of interval structure. Moreover, Cohen et al.'s study offered another opportunity for examining possible facilitation of the diatonic context in this more difficult task. In one condition (Experiment 2), infants were presented with diatonic background sequences and nondiatonic contrasting sequences involving a semitone change in the third position. In another, they heard nondiatonic background and diatonic comparison sequences that involved a comparable semitone change. Interestingly, they detected the semitone change in the context of the diatonic background but not in the nondiatonic. This implies that the diatonic context has greater coherence or stability for infants than does the nondiatonic, as has been demonstrated for preschool children (Trehub et al., 1986), school-aged children (Krumhansl & Keil, 1982; Zenatti, 1969), and adults (Cuddy et al., 1981; Cuddy, Cohen, & Miller, 1979).

It is nevertheless unclear whether diatonic structure in general or major triad tones in particular, with their simple ratio relations (4:5:6), are responsible for the observed effects. Moreover, one cannot entirely rule out possible contributions of prior exposure to music, however limited. For example, there is evidence to suggest that infants' ability to discriminate native and nonnative speech sounds shows effects of linguistic exposure as early as 10 to 12 months of age (Werker, 1986; Werker & Tees, 1984).

Since the identical diatonic and nondiatonic melodies served as standard (background) and comparison, the findings point to an interesting asymmetry. There are numerous examples in the adult literature of the greater detectability of alterations that violate coherence than of those that establish it, whether the materials are melodic (Bharucha, 1984), rhythmic (Bharucha & Pryor, 1986), or linguistic (Bharucha, Olney, & Schnurr, 1985). These studies indicate that listeners can more readily differentiate contrasting sequences when a sequence with a disruptive element follows rather than precedes a coherent sequence. Bharucha and Pryor suggested that the matching of a test sequence with the memory representation of the original is necessarily asymmetric because elements of the test sequence are checked for inclusion in the representation of the original pattern but not vice versa. Moreover, the difficulty of representing anomalous elements in the original sequence leads to superior detection of anomalous additions, compared with omissions.

Bharucha and Pryor (1986) also suggested that, since the representation of the original sequence is more abstract than a simple encoding of individual elements, confusion is likely to arise when new elements in a comparison sequence are consistent with the representation of the original. In line with this view, Cohen et al. (1987) found that infants succeeded in detecting deviations from minor as well as major standards (both diatonic), but they performed less accurately on a major/minor comparison than on a diatonic standard with nondiatonic comparison. It appears, then, that infants can extract and retain precise frequency-relational information from repeated auditory sequences that are "well formed" or consonant in the musical sense.

Cohen (1986) obtained further evidence on the "well formedness" issue by evaluating infants' ability to retain absolute information about a set of three pitches. Infants 8 to 11 months of age were presented with repetitions of the three tones of the major triad (260, 330, 392 Hz) in random order (i.e., contour cues eliminated). Contrasting sequences contained three new tones (in varying order), each differing from one of the originals by one or two semitones. As in the aforementioned studies of melody discrimination, head turns to presentations of a contrasting tone set led to visual reinforcement. Although the level of performance was poorer than that observed for the detection of contour changes (Trehub et al., 1984, 1987), infants nevertheless succeeded in differentiating the contrasting set from the background set of permuted major triad tones. What is particularly noteworthy is that, in further comparisons of three-tone sets, infants failed when the background tones embodied "poor structure" in the musical sense (i.e., nondiatonic relations). Thus, although infants exhibit recognition memory for specific sets of three pitches, this memory seems to depend on particular relations between the pitches. These studies of diatonic relations imply that infants possess skills that are fundamental to the representation of Western musical scales and, consequently, to the appreciation of the tonal music of our culture.

TEMPORAL PROCESSING: RHYTHM

When presented with auditory sequences, adult listeners tend to group elements within the overall sequence. They create subgroups based on duration, frequency, and intensity information. The tendency to impose temporal grouping is so compelling that even uniform clicks or tones are likely to be grouped (Bolton, 1894; Fraisse, 1982). Such temporal grouping processes lead us to perceive pauses between the words of continuous speech (Studdert-Kennedy, 1975) and between the subgroups of notes within a melody. Indeed, Fitzgibbons, Pollatsek, and Thomas (1974) and Thorpe (1985) demonstrated that adults' discrimination between a standard tone sequence with equally spaced tones and one with a single extended intertone interval was poorer when the extended interval occurred *between* subgroups of a tone sequence (i.e., when the sequence was structure-conserving) than when it occurred *within* a subgroup (i.e., when the sequence was structure-violating). Thus, listeners perceive the temporal intervals between groups as longer than physically equivalent intervals within groups.

The operation of comparable temporal mechanisms in infancy would have implications for cognitive development, since such mechanisms for organizing sensory inputs are believed to operate preattentively and to underlie all cognitive processing in adults (Neisser, 1967; Pomerantz, 1981). Moreover, temporal grouping processes enhance our memory of auditory patterns (Huttenlocher & Burke, 1976) and our perception of speech (Martin, 1972).

Thorpe, Trehub, Morrongiello, and Bull (1987) tested infants 6 to 8 months of age and children 5.5 years of age for their detection of extended silent intervals between elements of auditory patterns. The standard patterns consisted of six 200-msec tones, three at 440 Hz and three at 659 Hz, with 200-msec intertone intervals. Contrasting patterns differed only in the addition of an increment of silence following the third tone (*between* tone groups, or structure-conserving) or following the fourth tone (*within* a group, or structure-violating). Infants exhibited no performance differences for different increment locations, but children showed the expected grouping effect in their superior detection of within-group increments.

Thorpe and Trehub (1987) extended this line of research by testing infants with comparably structured sequences that embodied (1) a greater frequency disparity (2.5 octaves compared with the 0.5-octave disparity of Thorpe et al., 1987), or (2) a disparity in overtone structure (three sawtooth-wave tones followed by three sinusoidal tones, all 440 Hz). In both cases, the detectability of structure-violating (within-group) increments was significantly greater than that of structure-conserving (between-groups) increments, suggesting that infants grouped or chunked the patterns on the basis of similar frequency in one case and similar overtone structure in the other. Thus infants imposed rhythmic patterns on melodic sequences with equal durations of notes and internote intervals.

Since the sequences with an extended intertone interval were always tested in relation to a background sequence of equally spaced tones, one cannot search for asymmetries such as those identified by Cohen et al. (1987). In line with Bharucha and Pryor's (1986) reasoning, the task of discriminating a coherent sequence from a coherence-disrupting background may be difficult or even impossible for infants.

These effects of auditory context on temporal organization and discrimination have parallels in infants' perception of speech. For example, infants' perception of the duration of formant transitions is affected by overall syllable duration. This suggests that they may process such information relationally and compensate for differences in speaking rates (Eimas & Miller, 1980). Similarly, infants show superior discrimination for the order of phonetic elements in syllable-like (consonant-vowel-consonant, CVC) contexts compared with syllable-unlike (consonant-consonant-consonant, CCC) contexts (Bertoncini & Mehler, 1981).

Temporal patterning provides important cues for adults' perception of speech (Bailey, 1983; Martin, 1972). For example, rhythmic changes in speech direct attention to highly salient aspects of a message (Martin, 1972). Moreover, temporal alterations in the duration of speech segments are difficult to detect when the overall timing between accented syllables is preserved (Huggins, 1972). Similarly, infants (Thorpe & Trehub, 1987) and children (Thorpe et al., 1987) found alterations in the timing of multitone sequences to be less noticeable when these preserved the overall grouping structure.

Thorpe, Trehub, and Cohen (1986) attempted to ascertain the generality of infants' representation of rhythmic patterning by examining their discrimination of contrasting sets of rhythms. Since the members of each set varied in tempo or rate of presentation, success would necessitate the formation of equivalence classes for sets of patterns. In one experiment, there were two patterns of three tones, the first having *anapestic* form (-- -), the second having *dactylic* form (- --). Each form had five discriminable tempos or rates. In a second experiment, infants were required to discriminate between contrasting temporal patterns of four elements (-- -- or --- -) at five rates. The results of both experiments revealed discrimination between contrasting rhythms and, by implication, the ability to create perceptual categories or equivalence classes based on temporal structure. Just as infants, under most conditions, encode pitch relations (contour) within a melody independent of specific pitches, so do they encode relational aspects of temporal structure independent of specific durations.

TEMPORAL PROCESSING: STREAM SEGREGATION

Demany (1982) examined grouping processes in infancy within the framework of "primary auditory stream segregation" (Bregman & Campbell, 1971). Stream segregation refers to the phenomenon whereby rapidly repeating sequences of discrete tones are grouped or segregated according to similarities in pitch, timbre (overtone structure), or other stimulus parameters. This effect, which has been studied extensively in adults (Bregman, 1978, 1981; Bregman & Campbell, 1971), is believed to reflect the probability that sounds with highly contrastive properties emanate from distinct sources. Demany (1982) presented infants 7 to 15 weeks of age with sequences of high- and low-frequency tones that were shown to "split" into two perceptual streams for adults. One of the consequences of stream segregation is that adult listeners are unable to track the order of elements across streams at presentation rates that permit the ordering of elements within streams (Bregman & Campbell, 1971). In analogous fashion, Demany (1982) found that infants could discriminate between temporal reorderings only for sequences or streams that preserved their temporal coherence for adults. The implication of infants' failure to detect reorderings of tones in disparate streams (for adults) is that infants, like adults, must have grouped the high and low tones on the basis of frequency similarity. Thus, pitch proximity contributes to the coherence of melodies for infants, as it does for adults.

SUMMARY AND IMPLICATIONS

The foregoing research on infants' perception of melodic and temporal patterns would seem to indicate that infants possess various prerequisite skills for analyzing complex auditory input. They can discriminate between multitone sequences or melodies and can recognize component pitches when the retention interval is very brief (Trehub et al., 1984). Infants' accuracy in musical pitch perception is also implied by their ability to imitate sung pitches after relatively limited training (Kessen, Levine, & Wendrich, 1979). If the retention interval is longer, they organize the surface patterns into contours (Chang & Trehub, 1977; Trehub et al., 1984, 1987), which are more general and also more durable. What is remarkable, however, is evidence that infants have access to some aspects of the underlying structure of musical patterns, as reflected in their superior detection of deviations from diatonic as opposed to nondiatonic sequences (Cohen et al., 1987) and in their enhanced ability to recognize sets of exact pitches that embody major triadic relations (Cohen, 1986). It is unclear, however, whether this apparent preference for major triadic structure reflects the simple ratio relations among such tones, their relation to the overtone structure of natural sounds in the environment, or some degree of musical acculturation.

This evidence of facilitation for "good" melodic patterns has a temporal parallel in the effects of structure-preserving and structure-violating alterations of tone sequences (Thorpe & Trehub, 1987; Thorpe et al., 1987) and in the effects of large pitch changes and rapid presentation rates on the temporal coherence of such sequences (Demany, 1982). Presumably, a temporal structure that is inconsistent with the frequency structure of a pattern would be "bad" in the musical sense and would likely function as a relatively ineffective context against which to evaluate deviations. Finally, infants' perception of rhythmic structure across variations in tempo is analogous to their perception of contour in the context of variations in pitch and interval size.

Infants' processing of melodic and temporal aspects of tone sequences reveals numerous parallels to the music perception skills of adults. Such abilities may correspond to musical "universals." Cultures the world over seem to have discrete pitches, five to seven pitch levels, small pitch intervals from note to tone, melodic contour as an organizing device, and an underlying beat structure (Dowling & Harwood, 1986), so the skills reported for infants might be of universal significance.

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