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Source: *Music Perception: An Interdisciplinary Journal*, Vol. 2, No. 2 (Winter, 1984), pp. 131-165

Published by: University of California Press
Stable URL: http://www.jstor.org/stable/40285289
Accessed: 12-05-2015 23:04 UTC

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Music Perception
Winter 1984, Vol. 2, No. 2, 131–165

Tonal Schemata in the Perception of Music in Bali and in the West

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Krumhansl and Shepard's probe-tone method, in which listeners rate the musical relatedness of probe tones to preceding musical contexts, was adapted for a cross-cultural comparison of the perception of Western and Balinese melodies by both Western and Balinese listeners. Half of the Balinese listeners were remote villagers with no previous exposure to the diatonic scales or music of the West, and the Western listeners were unfamiliar with the pelog and slendro scales and the music of Bali. The Balinese and Western listeners used similar response strategies, but tended to demonstrate an internalization of tonal schemata most often in response to music of their own culture.

A variety of perceptual phenomena, including perceptual filling-in of impoverished stimuli, perceptual interpretation of ambiguous stimuli, apparent motion, categorical perception, and perceptual priming through mental imagery, reveal that perceptual experience is determined by internal schemata as well as by external inputs (e.g., Bartlett, 1932; Neisser, 1976; Piaget, 1952; Shepard, 1984; Woodworth, 1938). The perception of music is no exception.

Psychoacoustic approaches, beginning with Helmholtz (1885/1954), did make great progress in identifying physical features of tones (such as frequency ratios and the beating of noncoincident harmonics) that account for

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much about how tones are perceived and, hence, about why musical scales, melodies, and chords have the structures that they do. However, data collected by cognitive psychologists have recently been confirming expectations deriving from music theory that the perception of a particular tone, a particular melodic or harmonic interval, or a particular chord also depends on the musical context in which it is imbedded. Together with Carol Krumhansl, we and our associates have been finding that for Western listeners, a context based on the Western diatonic scale (*do*, *re*, *mi*, *fa*, *sol*, *la*, *ti*, *do*) establishes a tonal schema for the corresponding musical key with a resulting conferral of unique tonal functions (called *tonic*, *dominant*, *mediant*, *subdominant*, *leading tone*, etc.—e.g., see Piston, 1941; Ratner, 1962) on the tones of that scale (Krumhansl, 1979; Krumhansl & Kessler, 1982; Krumhansl & Shepard, 1979; Shepard & Jordan, 1984).

The Probe-Tone Method

This line of work began with the introduction of a probe-tone method (Krumhansl & Shepard, 1979), in which a particular musical context is followed on each trial by a different probe tone from a set of alternative tones, usually consisting of the 13 chromatic tones inclusively spanning a certain test octave. The context can consist of a particular ascending or descending musical scale (as in the original study of Krumhansl & Shepard, 1979) or it can consist of a melody, a chord, a progression of chords, or indeed any musical excerpt (as in several of the subsequent studies—see, especially, Krumhansl & Kessler, 1982). On each such trial, listeners rate (typically on a seven-point scale) how well the single probe tone "fits in" with the immediately preceding musical context. After a given context has been probed with all the alternative tones within the test octave, the average fittingness ratings, when plotted against the tones of that octave, form a profile that tends to peak up at the tonic and, to decreasing extents at the dominant, the mediant, and other tones that belong to the musical key of the context. Such a profile thus yields a quantitative hierarchy of the tonal functions induced by that context.

Rating profiles that are more sharply defined and more fully in accord with the expectations of music theory tend to arise when the listeners have a greater interest or background in music and when a musically richer context is provided (Kessler, 1983; Krumhansl & Kessler, 1982; Krumhansl & Shepard, 1979; Shepard, 1982a,b). When relatively nonmusical listeners are presented with no more than a simple context (such as a scale) consisting of musically impoverished, sinusoidal tones, the hierarchy of tonal functions may largely fail to emerge, with ratings simply decreasing with the distance in pitch from the probe tone to the tonic tone of the context (see Figure 1a; and Shepard, 1982a,b). The hierarchy of tonal functions ex-

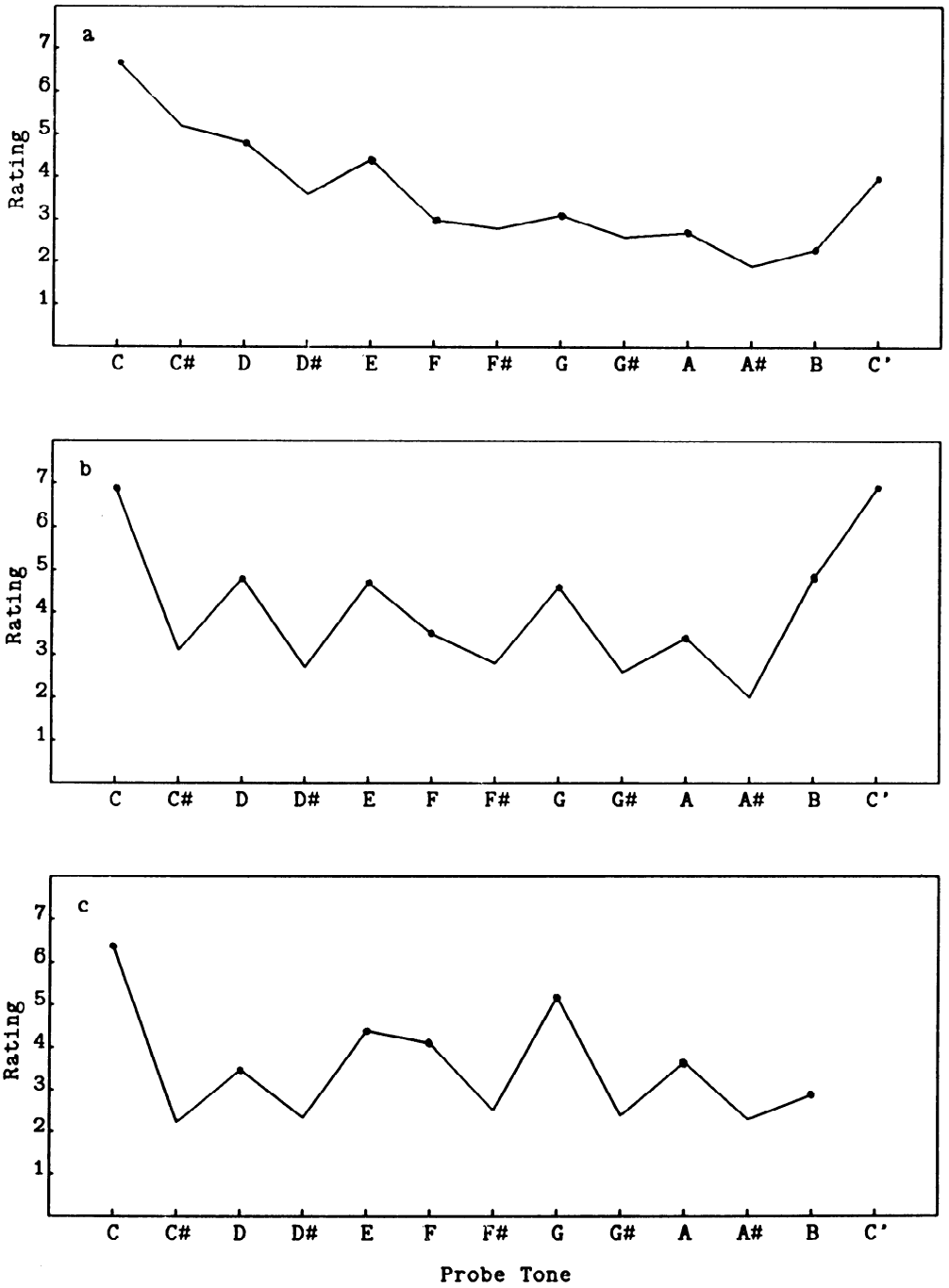


Fig. 1. Results from previous experiments that used the profile method to demonstrate the hierarchy of tonal functions in diatonic music. (a) The profile of ratings to probe tones following an ascending C major scale from a group of non-musical listeners. (b) The profile from a group of musically trained listeners. (c) The profile from musical listeners following chordal sequences that instantiated the key of C major. The darkened points correspond to the tones of the C major scale. (Adapted from Krumhansl & Shepard, 1979 and Krumhansl & Kessler, 1982).

pected from music theory consistently arises, however, when the listeners have some musical background (see Figure 1b), and, in a particularly pure form, when the context is musically rich, consisting for example of a chordal cadence, which strongly instantiates a single musical key (Figure 1c; Krumhansl & Kessler, 1982).

The Need for Cross-Cultural Extensions

The rating profiles displayed in Figure 1 are for Western listeners only; that is, for listeners accustomed to tonal music, whether popular or classical, based on the seven-tone major and minor diatonic scales that have prevailed in Western culture for hundreds of years. The musics of many other cultures are based on scales that divide each octave into different numbers of intervals departing from the pattern of whole- and half-tone steps of the diatonic scales. Moreover, whereas rules of harmony place strong constraints on the construction of chords and chord sequences in a particular key, such rules are largely absent in the music of those cultures that emphasize melodic or rhythmic structure over harmonic structure and that may not even use chords as such.

Questions therefore arise concerning the generality of the findings that we and our associates have obtained by using the probe-tone method only with Western listeners and only with diatonic contexts. If we were to try a similar probe-tone technique with listeners from a very different culture, following contexts taken from music based on their own very different musical scales, would we still find evidence for anything like hierarchies of tonal functions within their nondiatonic system? If not, might we nevertheless find that when presented with Western contexts, such listeners would be sensitive to the implied tonal hierarchy, suggesting that the potential for representing such hierarchies may be a cognitive universal of humankind? Finally, would Western listeners, when presented with non-Western contexts, give ratings similar to those of non-Western listeners? Or would they give quite different ratings, suggesting that they impose their own culture-specific tonal schema on music that is basically of a different kind?

In order to answer such questions, we and our associates have recently been trying the probe-tone method with listeners and musical contexts from India (Castellano, Bharucha, & Krumhansl, 1984) and from Bali (Hansen, Kessler, & Shepard, 1983). In what follows, we present the first written report of our study with Balinese listeners. In this study we tested listeners both in Bali and in the United States with identical contexts of both Balinese and Western music.

The Choice of Balinese Music and Listeners

There were several reasons why Bali offered a particularly attractive site for a cross-cultural application of the probe-tone technique. Balinese music,

although making extensive use of pitch, does so in ways that seem very different from Western music. In particular, Balinese music is based on five-tone modes of the *slendro* and *pelog* scales, which are both quite different from the seven-tone major and minor scales of the Western diatonic system. Also, Balinese music seems not to use anything analogous to the chords or harmonic rules that are so pervasive in Western music. Nevertheless, Balinese music has a long indigenous tradition and structure of its own, and plays an important role in the life of every Balinese villager. With the advent of battery powered radios and cassette-tape players, Western music is rapidly permeating virtually every society around the globe; however, we were able to find a remote Balinese village in which the villagers evidently had no previous exposure to Westerners or their diatonic music. We were able to gain the full understanding and cooperation of these Balinese listeners through an interpreter, Putra (Mervyn Dennehy, the husband of C. H.), who (like C. H.) speaks Indonesian but, more importantly for collecting data from the remote villagers, is fluent in all three levels of Balinese.

Balinese music is played by a group of musicians on an ensemble of instruments called a *gamelan*. Although a gamelan usually includes a drum and, sometimes, wind or stringed instruments, the predominant instruments consist of resonant metal bars and gongs that are permanently tuned to the particular pelog or slendro scale adopted for that gamelan, and that are struck with wooden or metal hammers. In addition to a single large gong, which plays a central role in defining the temporal structure of gamelan music, these instruments are primarily of two types: the *gender*, a metallophone consisting of a graduated series of tuned metal bars, and the *trompong*, consisting of graduated series of tuned pot-like gongs (Lindsay, 1979; Malm, 1977; McPhee, 1966).

When struck in different ways, these variously shaped metal resonators produce complex, transient overtones that do not conform to the simple harmonic series of frequencies (f, $2f$, $3f$, $4f$, . . .) characteristic of Western stringed and wind instruments (Benade, 1964; Chowning, 1973). Moreover, different instruments of the Balinese gamelan (unlike the instruments of a Western ensemble) are intentionally given slightly different tunings (Malm, 1977, p. 48). The auditory beats that consequently arise between tones and between their inharmonic overtones, as well as the nondiatonic structure of the underlying scale, gives gamelan music a peculiarly jangly quality quite foreign to Western ears. In overall structure, too, gamelan music is very different. Chords and harmonic progressions evidently play no role in structuring gamelan music. Instead, and in agreement with the Balinese conceptualization of the world, the music is organized into repeating cycles and epicycles that all come together, in unison, at the periodic sounding of the large gong. Between these gong beats, the different instruments go through their separate patterns in pitch without regard to Western rules of harmonization between parts.

In Balinese music, melodies are constructed of cyclically repeating, hierarchically stressed units (Deutsch & Feroe, 1981; Lerdahl & Jackendoff, 1977, 1983; McPhee, 1966). The fundamental structural unit, the *palet*, consists of 16 tones or beats. These beats are rhythmically emphasized to various degrees through the use of gong and drum beats. Typically, the first beat is given the most emphasis, the ninth (middle) beat is also strongly emphasized, the fifth and thirteenth beats are less emphasized, and the remaining beats are rhythmically unstressed (McPhee, 1966, pp. 87–88). The Balinese melodies that we use in this study all conform to this structure and contain 16 beats of equal duration, however the external stresses were not provided explicitly.

Method

Listeners

Western listeners. For comparison with the Balinese listeners (and for comparison with the previous studies that we and our associates have carried out with Western listeners), we chose, as representative of Western listeners, 21 members of the Stanford University community. The Western listeners either volunteered or participated to receive credit toward a requirement of an introductory psychology course. All of these listeners had considerable training (mean = 6.3 years) on Western instruments, while only one had had exposure to Balinese music. (One Western listener spent 6 months in Bali. Her results, however, turned out to be no more similar to those of the Balinese listeners than were the results of the other Western listeners.) All of the Western listeners reported having normal hearing and none claimed to possess absolute pitch.

Kokar listeners (students at a Balinese music conservatory). Kokar (more properly Sekolah Menengah Kerawitan) is the secondary school in Den Pasar specializing in the traditional music, dance, and shadow puppetry of Bali. Young people come there from all over the island of Bali, but predominantly from the villages. Although the Kokar students generally prefer gamelan, they are also exposed to Western diatonic music. As representative of Balinese who are seriously studying and performing traditional Balinese music but who also have had some exposure to Western music, we tested 25 students (class 2 and 3) and one teacher at the Kokar music conservatory.

Keker listeners (remote Balinese villagers). Finally, and most importantly, we tested 27 residents of a remote Balinese village that possessed a gamelan (ensuring that Balinese music was an important part of the villagers' daily

lives) but, as far as we could determine, had remained entirely unexposed to Western, diatonic music.

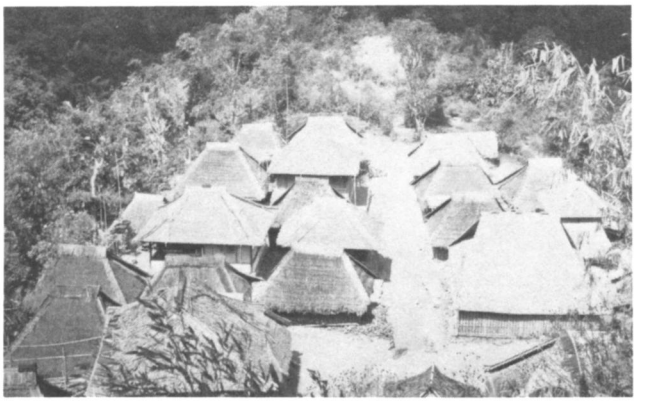
In order to find a village with these rare properties, one of us (C. H.) and an interpreter (her husband Putra), after having collected the data at Kokar, set out on motorbike toward the remote northeast part of the island of Bali. At each stop, local villagers were asked "What is the most isolated village in this area? Does it have a gamelan?" Then, when the indicated village was reached, the same question was repeated and the quest resumed. After various mishaps—flat tires, narrowly missed collisions, mechanical breakdowns, strained knees, motorbike spills, skin gouges, thorn punctures, infections, dysentery and fever—this search finally ended at a tiny thatch-roofed village (which we refer to as "Keker"), reachable only by footpath, on the slopes of the volcano Gunung Agung (whose 1963 eruption had destroyed and forced abandonment of the village for 3 years).

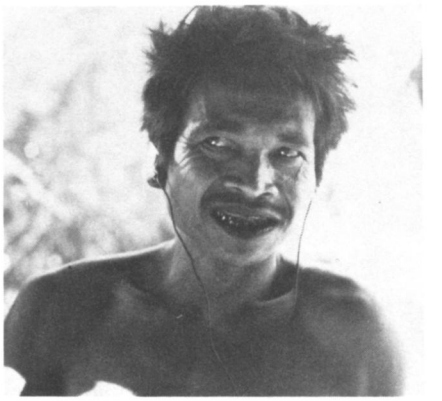
The village had never before been visited by Westerners. Indeed, the inhabitants considered the two visitors to be "Javanese," because their conception of the world was dichotomous—it consisted of Bali and, outside of that, only Java. They knew nothing of the Western world or its music. When a cassette tape was played, they recognized neither the sound of the piano nor the Indonesian national anthem played on it. The Indonesian anthem, which is Westernized and diatonic in structure, was as unfamiliar to them as was the official Indonesian language. Although there are two radios in Keker, the people listen almost exclusively to traditional Balinese music—gong, drama, wayang, and the like—and they do not like other kinds of music because they "don't understand" them. At first, the villagers were wary of their supposed "Javanese" visitors, fearing that they might be forced to abandon their homes once again. Soon, however, the combination of Putra's fluency in their Balinese dialect, the medical treatment of eyes, ears, and injuries that the two visitors were able to provide, and the novelty of the cassette tape player and the sounds it produced won the villagers over to friendly acceptance and complete cooperation. (Figure 2 shows the Keker village and some of the villagers participating in our experiment.)

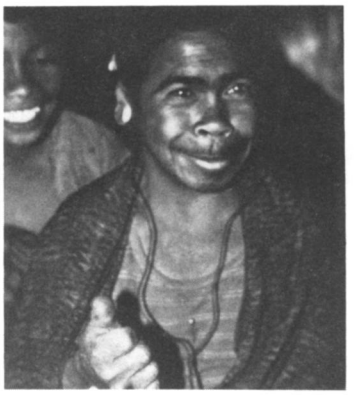
Musical Contexts

Listeners in each of the three groups (Western, Kokar, and Keker) were tested with melodies based on different modes of each of the three relevant types of scales: the diatonic scales (of Western music) and the pelog and the slendro scales (of Balinese music). The particular modes we selected are indicated in Figure 3.

Diatonic scales. For the two diatonic modes, we chose the keys of C major and C minor, each of which selects a subset of 7 of the 12 chromatic tones







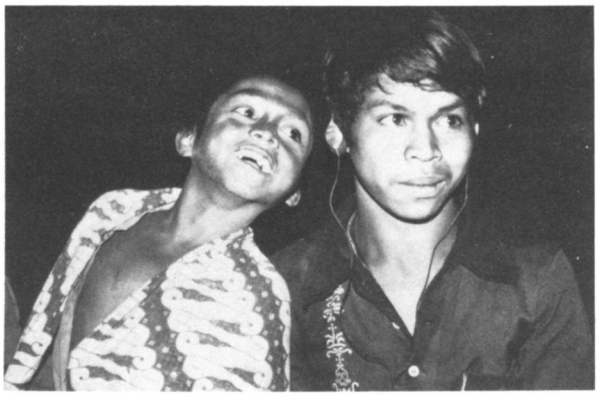


Fig. 2. Photographs of the remote Balinese village of Keker and some of the villagers participating in the study.

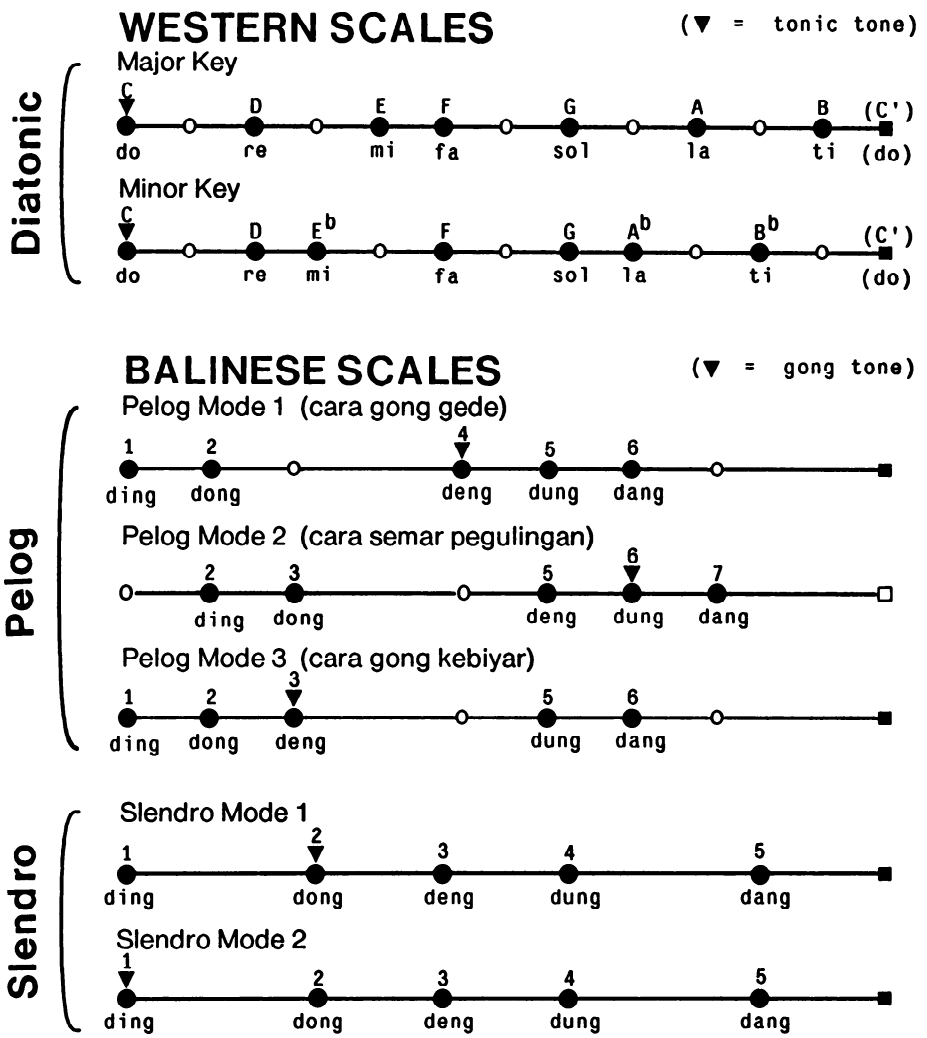


Fig. 3. The musical contexts were generated from the diatonic major and minor keys, three "modes" of the seven-tone pelog scale, and two "modes" of the five-tone slendro scale.

within an octave, as indicated by the solid black dots along the two lines across the top of the figure. Dots that are adjacent regardless of their black or white color are equally spaced in log frequency; in the top line, the black dots correspond to the white keys on the piano keyboard, while the white dots correspond to the black keys and thus to sharps or flats relative to C major.

Pelog scales. As shown in Figure 3, pelog scales, like diatonic scales, consist of seven unequally spaced tones from each octave. However,

whereas in the diatonic scale the large (L) and small (S) intervals between the successive tones of the scale have the pattern LLSLLLS, the seven-tone pelog scale exhibits the complementary pattern SSLSSSL (where, here, we are including all dots, black and white). Moreover, each mode, from which a particular melody is constructed, selects a different subset of only five of these seven already unequally spaced tones, specifically the five indicated, in each case, by the solid black dots only. (The resulting patterns resemble circular permutations of the SLSSL pattern of the pentatonic scale, which is common in some Western folk music. However, the quantitative sizes of the intervals in the pelog modes differ from those of the Western pentatonic modes.) The pelog modes differ not only in which five of the seven tones are included in each mode, but also in which of those five included tones takes on the role of the *gong tone*. The major melodic sections within a piece end on the gong tone, accompanied by the sound of the gong. Like the tonic tone of a diatonic scale, the gong tone is supposed to be the most important tone in the mode (for a further discussion, see Jones, 1964, p. 81 and pp. 102–103; and McPhee, 1966, pp. 36–40). For ease of reference, the tones of the pelog scale are labeled by their position from lowest (1) to highest (7) in pitch.

Slendro scales. Because instruments with slendro tuning have only five tones per octave and because all five tones are usually played, the slendro modes do not differ with respect to which subset of tones is included in a melody. Slendro modes still differ, however, with respect to which of the five tones is treated as the gong tone—as indicated by the placement of the small black triangle above the gong tone for each mode in Figure 3 (McPhee, 1966, p. 52). Although the spacing between successive tones in each slendro mode again conforms qualitatively with a circular permutation of the SLSSL spacing of the pentatonic scale (Hood, 1954), the slendro spacing is quantitatively much more nearly equal than in Western pentatonic scales (Jones, 1964, p. 114; Kunst, 1973). This fact will be of theoretical significance in connection with the interpretation of our results. The tones of the slendro scale are also labeled from lowest (1) to highest (5).

The melodic contexts constructed from these scales. The particular contexts used in the experiment are presented in Table 1. All of the contexts contained 16 tones of equal duration. The first tone was A for the major context, A♭ for the minor context, and the gong tone of the intended mode for the Balinese contexts. The context melodies were constrained to contain tones only from a single octave, and at least one of each scale tone was present. Probe tones were selected from the same octave, except for the major context, where the tone C was a probe tone while C′ was used in the context. The diatonic melodies were composed by a graduate student from

TABLE 1
Melodic Contexts

	Sequence of Context Tones															
Major	A	C′	B	A	G	E	G	A	D	F	A	B	C′	B	A	G
Minor	A♭	G	F	E♭	D	E♭	F	A♭	B♭	A♭	G	C	E♭	F	E♭	D
Pelog 1	4	1	2	4	5	6	5	4	2	4	5	6	5	2	4	5
Pelog 2	6	7	6	5	6	3	5	6	7	5	7	6	5	2	3	5
Pelog 3	3	5	3	2	3	1	2	3	5	6	5	3	2	3	1	2
Slendro 1	2	4	5	4	5	3	4	5	4	1	2	3	4	5	4	3
Slendro 2	1	2	3	4	3	5	4	3	2	4	3	2	3	2	1	2

the Berkeley music department and the Balinese melodies were composed by teachers at the Kokar music conservatory in Bali. The major and minor diatonic contexts were played on a piano, the pelog contexts were played on a *gangsa* from the Kokar music conservatory, and the slendro contexts were performed on a *gender wayang* from Kokar. Although we intended for the major context to instantiate the key of C major, several of our listeners found this context to suggest both the key of C major and the related key of A minor. This ambiguity might have arisen in part because the tone A occurred more often than the tone C in the major context.

Experimental Design

Figure 4 summarizes the overall design of our cross-cultural experiment. The minor, pelog 2, and slendro 2 contexts were not used in the remote village of Keker until a follow-up experiment, to be discussed later, was run.

Procedure

The experimental trials were preceded by three brief musical excerpts—Pelog (Semar Pegulingan), slendro (Wayang Kulit), and diatonic (Indonesia's national anthem, "Indonesia Raya"). At the village location (Keker), the excerpts were used for familiarization with the equipment and to gauge the breadth of musical knowledge. The musical contexts and following probe tones, recorded on magnetic tape, were played to the Keker village listeners individually, through the earphones of a Sony Walkman portable cassette player which was helpful in reducing distractions (see Figure 2). The Kokar conservatory listeners were tested either individually with the Sony Walkman, or in groups of 2 or 4 with a Sony portable cassette player. Copies of the same recorded cassette tapes were also used to test the Western listeners, in our laboratory at Stanford.

The probe-tone method originally described by Krumhansl and Shepard (1979) had to be simplified for use with the nonliterate Balinese villagers. Instead of requiring a numerical rating between "1" and "7" inclusive, we instructed the illiterate villagers from the remote village of Keker simply to hold up one of their fingers or to point to one of the experimenter's fingers (see Table 2) to indicate how well each probe tone "fit in" with the preceding context (the concept of "fit" was described to the Balinese as: *anut*, *cocok*, *mangandung*, or *matim-*

EXPERIMENTAL DESIGN				LISTENERS		
				WESTERN	BALINESE	
				Stanford (college students) N = 21	Kokar (conservatory students) N = 26	Keker (remote villagers) N=27
MUSICAL CONTEXTS	WESTERN	Diatonic	Major			
			Minor			
	BALINESE	Pelog	Pelog 1			
			Pelog 2			
			Pelog 3			
		Slendro	Slendro 1			
			Slendro 2			

Fig. 4. Summary of the overall design of the experiment. All seven of the contexts were used with the Western and Balinese music conservatory listeners. In a follow-up investigation, data were obtained from the three contexts not used in the remote village for the main study.

pal). Correspondingly, we replaced the original seven-point rating scale with a five-point rating scale for the Western listeners in this study.

The melodies were blocked by context type, with three randomly selected practice trials beginning each block of trials. The probe tones following each context were presented in random order, twice in each block of trials, and were played on the same instrument as the context melodies. The melodies were repeated for each probe tone. The probe tones were the complete set of tones in one octave of the tuning system of the context; namely, the 12 tones of the chromatic scale for the diatonic contexts, 7 tones for the pelog contexts, and 5 tones for the slendro contexts. Two random orders of probe presentations were used for each context. A practice block of trials with a pelog context different from those in the experimental trials (labeled pelog 3 for the analyses) was presented to all subjects at the beginning of the experiment. In order to retain the interest and cooperation of the villagers, we had to confine our testing there to the first three experimental blocks (major, pelog 1, and slendro 1). The experimental session took about 25 minutes for each of the Keker listeners, and about 50 minutes for the Kokar and Western listeners.

TABLE 2
Rating Scale used by Balinese Listeners

Value	Finger	Balinese Description	English Translation
5	Thumb	*Becik pisan*	Very good
4	Index	*Becik*	Good
3	Middle	*Sedang*	Middling
2	Ring	*Kirang becik*	Poor
1	Little	*Kaon*	Very poor

Results and Discussion

The following analyses examine the responses of the listeners in three different ways. First, using multidimensional scaling, we show that the Kokar and Western listeners generally responded similarly, while the remote Keker village listeners were more variable in their responses, and tended to fall into three groups differing in response strategy. Second, we present the average rating profiles, separately, for the Kokar, for the Western, and for each of the three subgroups of Keker listeners. Third, we quantitatively examine the differences in response strategies using correlation and regression techniques.

Response Strategies

There naturally are many ways in which the subjective judgments of probe tones might be made. Several candidates for strategies that listeners might use have been identified (Castellano et al., 1984; Krumhansl & Shepard, 1979). For example, a simple procedure would be to rate the probe tones according to the number of times each one is sounded in the context melody. More elaborate schemes might give greater importance to tones that fall on stressed beats or toward the end of the context melody. Both of these strategies largely use information present in the context.

Based on past experience with the underlying musical scale, listeners might be able to abstract that scale out of the presented context melody. Listeners could then give high ratings to probe tones that are contained in the scale and low ratings to nonscale tones regardless of their frequencies of occurrence in the particular context melody. A more elaborate, but related strategy would be to base the ratings on the tonal functions each tone characteristically plays in the scale of the context melody. The relationships between the musical tones are often made explicit in music theory in terms of a tonal hierarchy. One tone is considered most important and stable in the key of the context and acts like a reference point (Rosch, 1975) for the other tones in the scale. This hierarchy also prescribes the various degrees of

importance for each of the other tones in the scale. Yet another possible strategy is to give ratings based simply on the pitch of the probe tones themselves. Listeners using this pitch–height strategy might give high ratings to probes of low pitch and low ratings to tones of high pitch, with ratings varying monotonically between.

Individual Differences

The results of Krumhansl and Shepard (1979; see also Kessler, 1983; Shepard, 1981) show that probe tone rating profiles can vary dramatically with the background and musical training of listeners and that these differences tend to reflect different strategies in performing the task. To examine the similarity in rating profiles between all of the listeners, we computed interlistener correlations of the obtained profiles separately for each of the contexts for which we had responses from all of the listeners (i.e., the major, pelog 1, and slendro 1 contexts). These correlation matrices then served as the input to nonmetric multidimensional scaling analyses (Kruskal, Young, & Seery, 1973; Kruskal, 1964; Shepard, 1962). Distances between points represent the degree to which corresponding individual listeners' profiles differ. To aid in the interpretation of the scaling results, we have superimposed several reference profiles on the scaling solutions (Kruskal et al., 1973) using a technique similar to multidimensional unfolding. Each such reference point on the solutions represents an ideal or model profile corresponding to a single strategy. In descending (D) and ascending (A) profiles, the ratings linearly decrease and increase, respectively, with the pitch of the probe tone. Reference profiles are also provided based on tonal hierarchy (T), which is specific to the mode of the context; scale membership (M), which differentiates scale from nonscale tones; and occurrence frequency (O), which represents the number of times each of the tones was sounded in the context. The Western listeners are represented by plus signs, the Kokar conservatory listeners by octagons, and the Keker villagers by triangles. We have drawn a convex polygon with a minimal area (a convex hull) around the listeners from each group.

Major Key Context. Figure 5 shows the scaling solution for the major context. Reference profiles for the tonal hierarchy based on C major (T) and on A minor (t) are those obtained by Krumhansl and Kessler (1982) (see Figure 1c). In addition to membership in the C major scale (M), membership in the harmonic A minor scale (m) is also presented because the "major" context is somewhat ambiguous and does not instantiate C major any more strongly than the closely related key of A minor. We identify the vertical axis as corresponding to pitch height and a perpendicular horizontal axis as roughly representing tonal hierarchy.

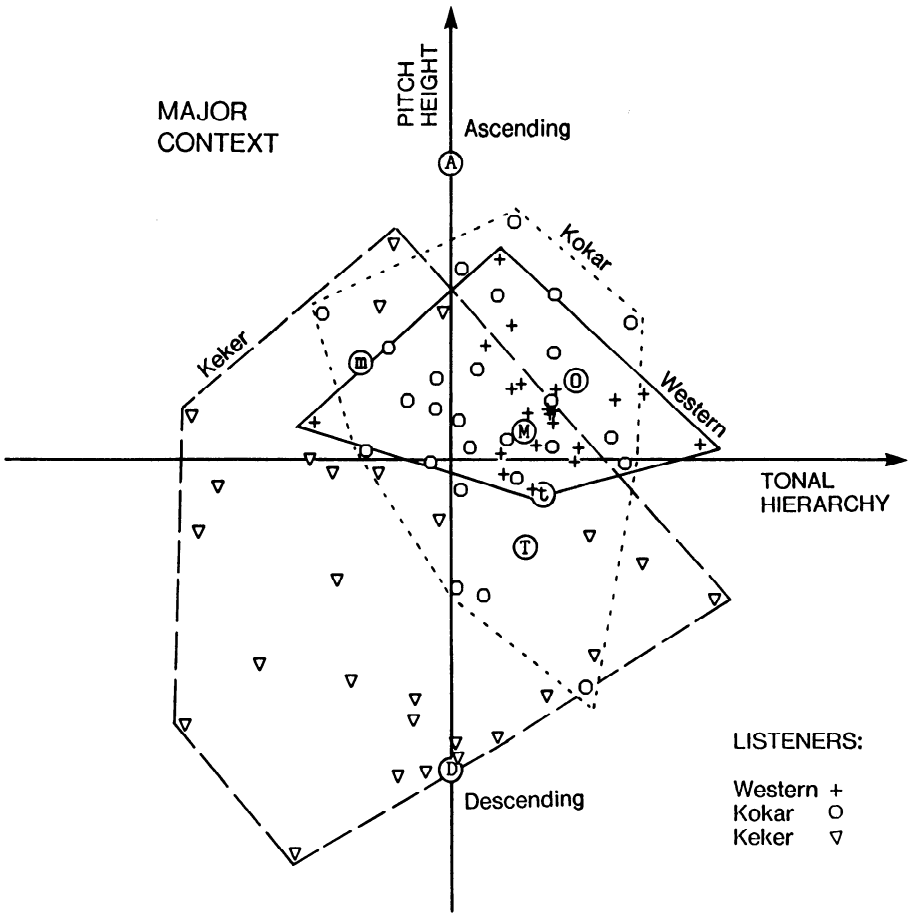


Fig. 5. Multidimensional scaling solution of the interlistener correlations for the profiles for the C major context. Note the concentration of listeners around the major scale membership reference (M) and the dispersion of the listeners from the village of Keker.

The points corresponding to the Western listeners are the most tightly grouped and are concentrated around the model profile of membership in the C major scale. The Kokar listeners are in the same general region as the Westerners, but tend to be somewhat more widely scattered. The Keker villagers are much more widely scattered, with only a few located in the region where the Western and Kokar listeners fall.

Pelog 1 Context. The tonal hierarchy for the pelog context was modeled by assigning the gong tone a rating of five, the other four tones of this mode a rating of three, and the two nonscale tones a rating of one. The pattern of results in Figure 6 shows that again the Western and Kokar listeners are more densely concentrated around the tonal anchor points (T, M), with the

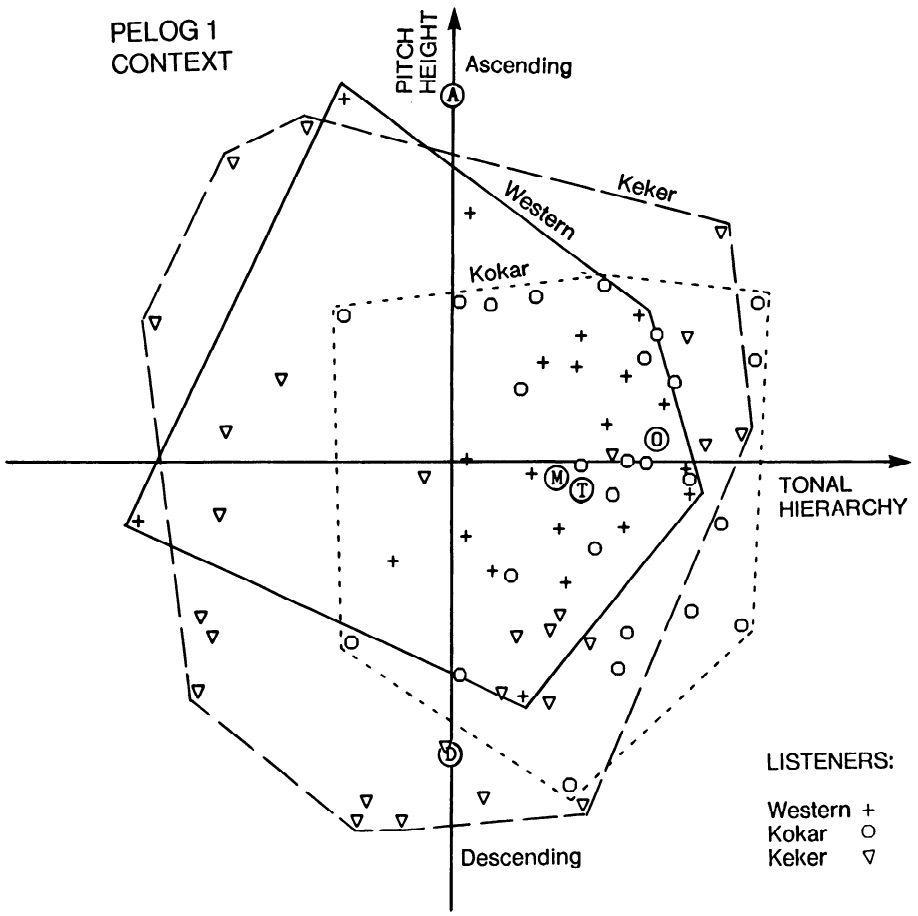


Fig. 6. Scaling solution of the interlistener correlations for the pelog 1 context.

Western listeners somewhat more spread out than the Kokar conservatory listeners (although only two Western listeners lie far from the Kokar listeners). The Keker listeners are again widely scattered, with a preponderance falling near the model profile for descending pitch height (D).

Slendro 1 Context. As Figure 7 shows, there are large individual differences in the responses to the slendro 1 context for all three groups of listeners. Model profiles for tonal hierarchy (T), specifying higher ratings for the gong tone, and for the number of times each of the slendro scale tones occurs in the context melody (O) help little in interpreting the arrangement of listeners. The Kokar conservatory listeners, however, are somewhat more concentrated toward what we have interpreted as the tonal anchor (T).

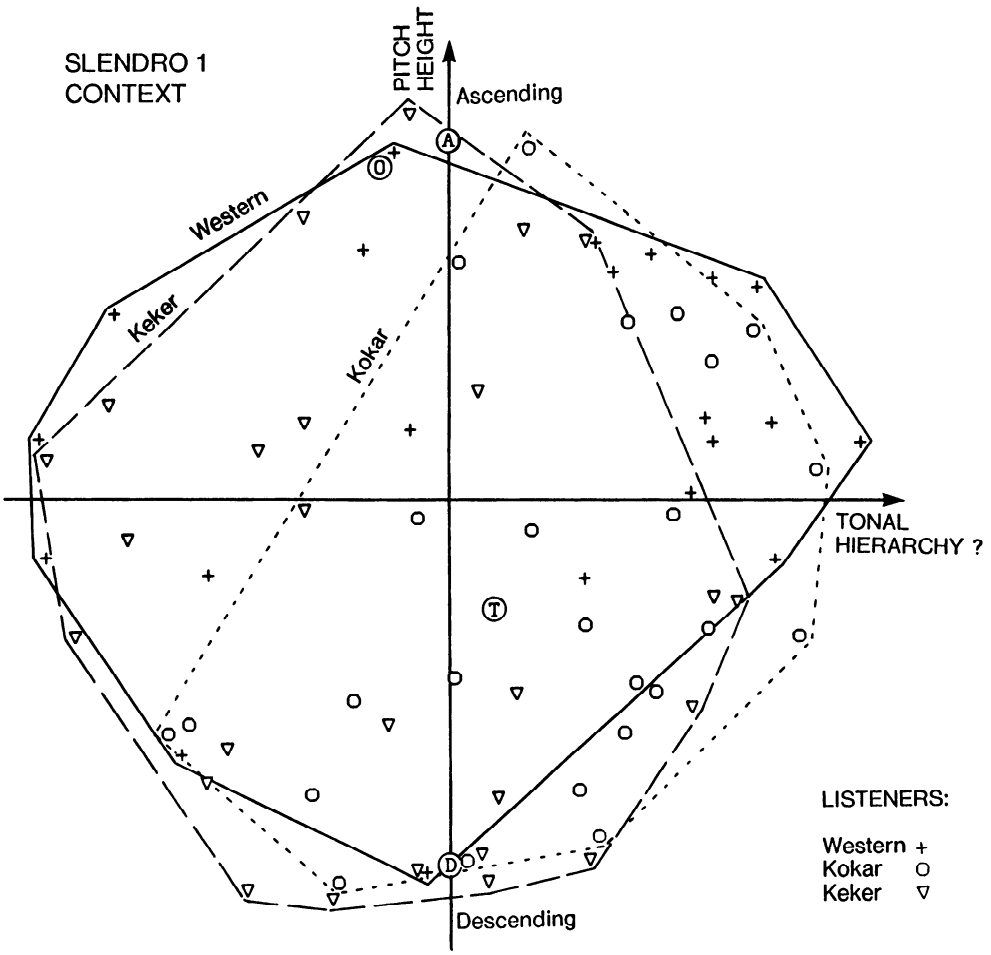


Fig. 7. Scaling solution of the interlistener correlations for the slendro 1 context. There is very little grouping of any of the listeners in this solution.

Without directly examining the individual listeners' profiles, a picture of the differences among the three groups and among the three contexts emerges. Listeners with extensive musical training (those from the Kokar conservatory and the West) responded similarly, with the listeners from the two groups generally overlapping in the multidimensional scaling solutions. But also, the Kokar and Western groups each showed less variation than the other in responses to music of the type most familiar to their own group. The increased variability in responses to less familiar contexts can be attributed to a lack of experience with the musical scale underlying the context and to an absence of the internalized cognitive structures required to represent and process the music.

Subgroups of Keker Village Listeners. The listeners from the remote village, although competent performers, spent less time playing and have had less extensive exposure to the different types of Balinese music than the listeners from the Kokar conservatory. They also have had less experience with and a lower ability to concentrate on mental tasks than have the other groups of listeners. These factors, combined with the novelty of the task, the unfamiliarity of the contexts, and the great differences in culture may have contributed to the variation in listener responses. Unlike the responses from the Western and Kokar conservatory listeners, the Keker villagers exhibited a wide variety of patterns of responding. A further analysis of the patterns obtained from these listeners, replicated with hierarchical clustering procedures (Johnson, 1967), shows that some of the individual differences are systematic. Figure 8 presents the configuration already shown for the major key context (Figure 5), but with the Keker listeners divided into three subgroups. The first subgroup of 11 Keker listeners lies within the same region on Figure 8 as the Western and Kokar listeners and appears to respond predominantly according to the tonal hierarchy of the major key. The second subgroup (8 listeners), at the bottom of the figure, is concentrated around the descending pitch height profile (D). The third, a more dispersed subgroup of 8 listeners, gave responses that we could not consistently interpret on the basis of the reference profiles.

Keker Response Profiles. To demonstrate that these are not simply arbitrary divisions of the listeners, we present the response profiles averaged for each of the Keker subgroups in Figure 9. The responses for the C major key context are given in the first column. The response for the probe of the tonic, C, is labeled with a filled-in diamond, and the remaining scale tones have an outlined diamond above their ratings. The responses for the three subgroups are indeed quite consistent across contexts. The first group manifests the tonal hierarchy through the higher ratings given to the tones in the C major scale. The tonic, C, may have been rated lower than the other scale tones because it was presented only twice in the context melody and sounded only in the octave above the C probe tone, and because the context was ambiguous in that both C major and A minor were instantiated. The pitch height subgroup shows ratings consistently decreasing with increasing pitch of the probe tones. Slight peaks at G and A indicate that for at least some of the listeners, information in the context was being used. G and A were the last two notes of the context melody and were among the most common. We have not been able to find an overall interpretation for the third group's rating profile except to note a slight preference for tones in the middle of the range of probes, perhaps due to a bias against large melodic intervals.

The second column of Figure 9 shows the responses of the Keker subgroups to the pelog 1 context. The interpretations are consistent with

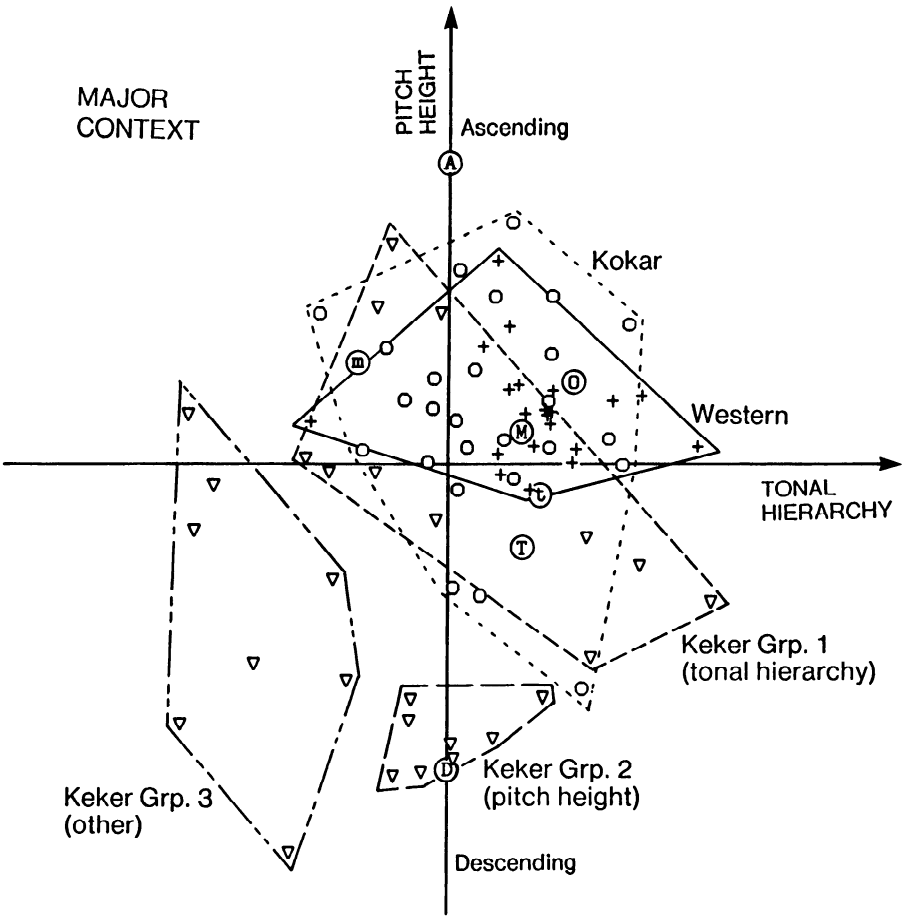


Fig. 8. Scaling solution for the major key context with the Keker village listeners divided into the three subgroups: tonal hierarchy (respond similarly to the Western listeners), pitch height, and other (nonspecified) group strategies are identified.

those from the major context: the tonal hierarchy group rates the gong tone (4) highest, the context scale tones next, and the nonscale tones lowest, with the one exception that the scale tone 6 is rated the same as the nonscale tone 3. The pitch height group again shows ratings generally lower for the higher pitched probe tones, with a slight peak at the gong tone (4). The third group's profile again seems uninterpretable. The results for the slendro 1 context for the three Keker subgroups are in the third column. Here, the tonal hierarchy group gives the highest rating to the gong tone (2) and the pitch height group's ratings monotonically decrease with increasing probe tone pitch, both consistent with the major and pelog 1 contexts. The third group, which had previously yielded seemingly uninterpretable profiles, did

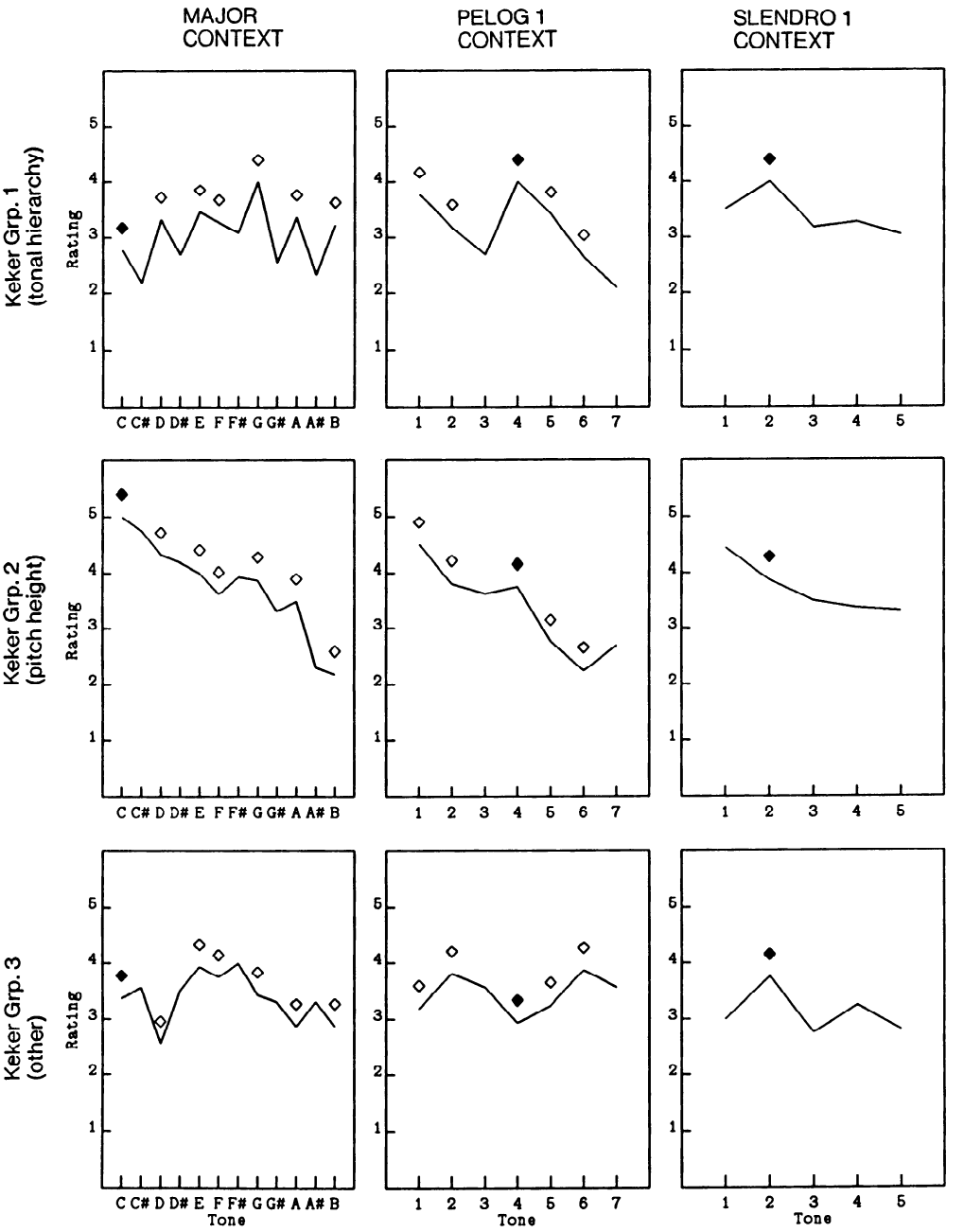


Fig. 9. Response profiles for the three subgroups of Keker listeners showing the profiles for the major, pelog 1, and slendro 1 contexts. The three groups use consistent response strategies across contexts, except that the third group responds much like the first group for the slendro 1 context.

identify the gong tone of the slendro 1 context by giving it the highest rating; this profile is very similar to that of the tonal hierarchy group.

The three subgroups of Keker listeners, initially grouped by their probe tone ratings for the major key context, thus show striking consistency across all three contexts. This consistency implies that the Keker village listeners used similar response strategies and heuristics in responding to music both in familiar and in novel scale systems. That 11 of the Keker village listeners seem to have picked up something of the tonal hierarchy underlying Western diatonic music is intriguing. It raises several questions that we cannot presently answer: Had this particular subgroup had exposure to a greater variety of music than the other Keker listeners? Were these listeners more talented, or experienced, musicians? Are there universally available strategies whereby some listeners unexposed to Western tonal music can pick up the underlying tonal hierarchy from even a brief exposure?

Ratings from Western and Balinese Music Conservatory Listeners

The Western and Kokar conservatory listeners were generally homogeneous within the two groups, in contrast to the Keker villagers who formed subgroups with distinct and interpretable differences in responses. The ratings we present for the Western and Kokar listeners have therefore been averaged across all of the listeners within each group.

Major Key Context. On the left-hand side of Figure 10, we show three of the relevant reference profiles. The top graph shows the number of times each tone occurred in the context melody. As before, the marks appear above the ratings for the important tones. Because of the way the major key context was constructed, it instantiates the key of A minor almost as strongly as C major. For comparison with the results, we therefore present the tonal hierarchies for C major and for A minor (Krumhansl & Kessler, 1982). Here we have marked the tones that were used in the intended scale of the context (i.e., C major). In the right-hand column of Figure 10, we show the results for the Western listeners at the top, for the Kokar Conservatory listeners in the center, and for the first Keker subgroup (tonal hierarchy) at the bottom. The Western and Kokar listeners' profiles are quite similar, though the Kokar listeners' profile is more compressed as a result of greater individual differences (as seen in Figure 5). The first Keker subgroup's responses closely resemble the profile from the Kokar music conservatory listeners. Note that the intended tonic, C, is not given the highest rating by any of the three groups, reflecting again the tonal ambiguity of this context.

Minor Key Context. The ratings for the C minor context are given in Figure 11. The graph at the top left of the figure plots the number of

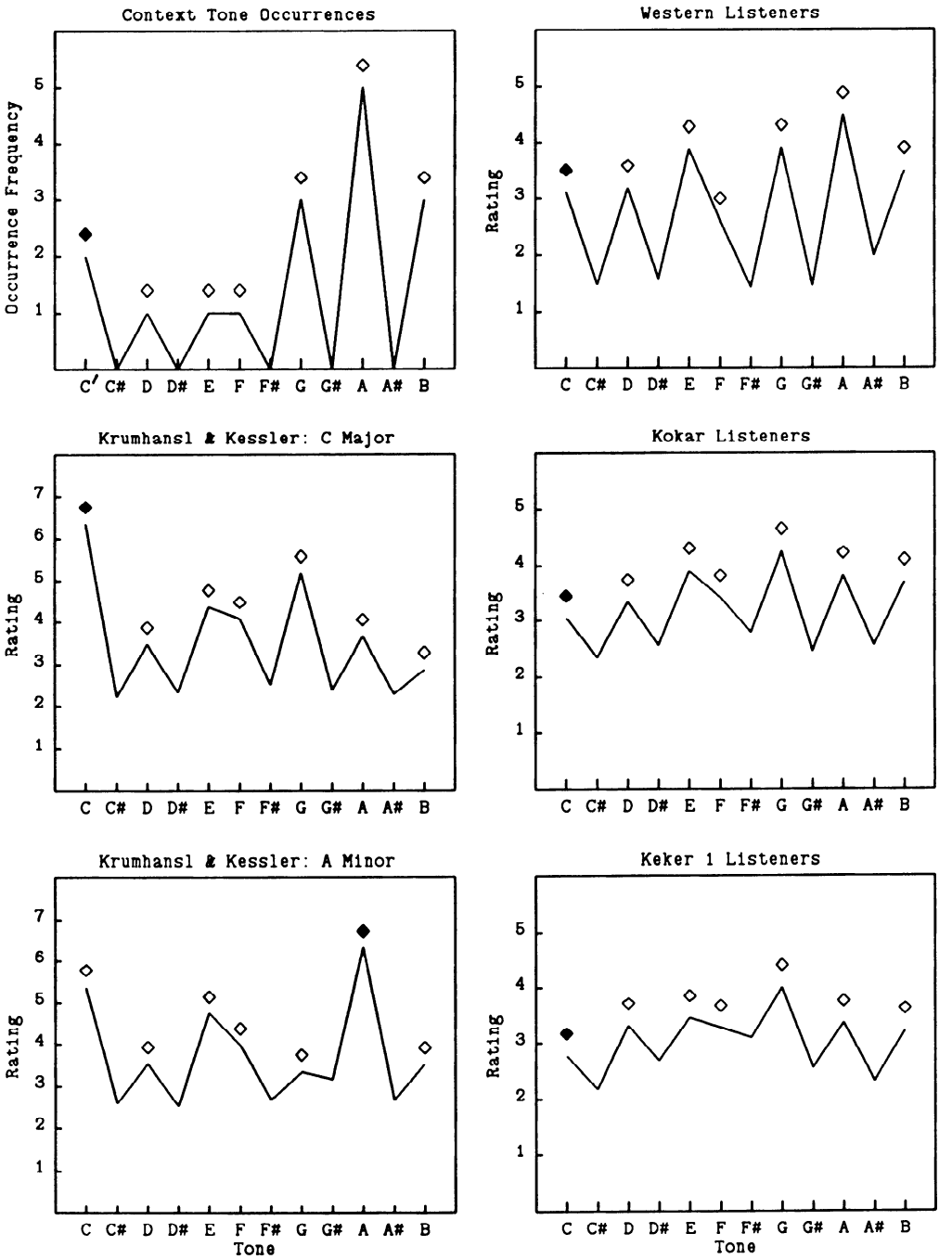


Fig. 10. Results for the major key context. Presented are the number of times each of the tones occurs in the context and the response profiles for the Western, Kokar, and Keker 1 groups, as well as the profiles obtained by Krumhansl and Kessler (1982) for the C major and A minor contexts. All three groups tend to rate the scale tones (indicated with diamonds) higher than the nonscale tones; however, the patterns don't closely resemble either the plot of context tone occurrences or the C major key profile.

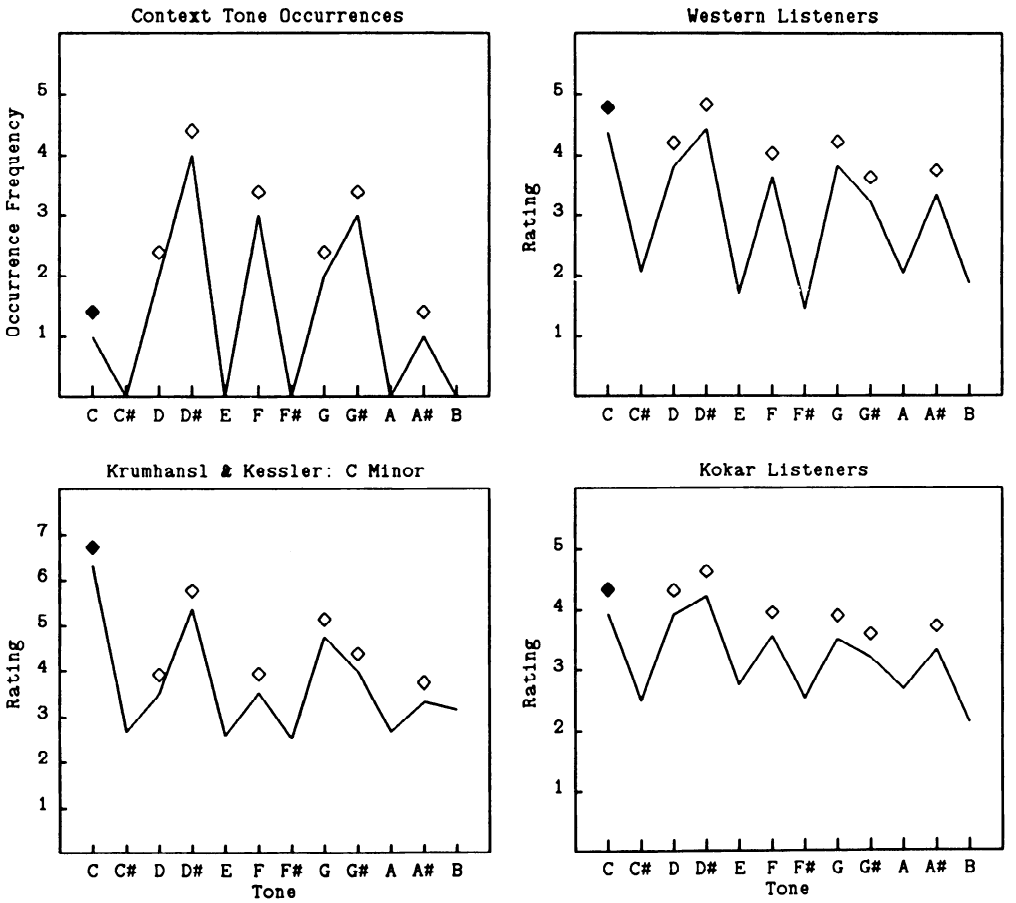


Fig. 11. Results for the minor key context. Scale tones are preferred to nonscale tones, and the Western and Kokar profiles resemble both the context tone occurrences and the C minor key profiles.

occurrences in the context of each of the tones in one octave of the chromatic scale. The bottom left graph is the tonal hierarchy for C minor from Krumhansl and Kessler (1982). Although the tone C occurred only once in the context melody, it is theoretically the most important tone in the context. The rating profiles from the Western and Kokar conservatory listeners are on the right-hand side of Figure 11. Notice that the C probe tone is given almost the highest rating of all of the probe tones. For both groups, the ratings for the C minor scale tones tend to decrease with increasing probe tone pitch. As with the major key context, the averaged rating profiles for the two groups have almost the same shape; however the Kokar profiles are more compressed, again probably as a consequence of more variability in their data.

Pelog Contexts. The results for all of the pelog contexts for both the Western and Kokar conservatory groups are contained in Figure 12. The ratings for the scale tones have diamonds above them, and the "gong tone," considered to be the most important or central tone in the mode of each context, has a filled-in diamond above it. The pelog 1 context is the same one presented earlier with the data from the Keker village listeners. Pelog 2 is in a mode that normally does not use tones 1 and 4 and whose gong tone is tone 6. Pelog 3 is the context used for the practice trials; it does not include tones 4 and 7, and tone 3 is the gong tone. We have included results from the practice trials because both groups of listeners were able to give reliable ratings, and the additional data afford useful comparisons. The top set of graphs plot the number of times each of the seven pelog scale tones occurs in each of the three pelog contexts. The middle and bottom row of graphs are the profiles from the Western and Kokar listeners. For all three contexts, the results differ very little between the two groups. The correlations between the ratings for the Western and those of the Kokar conservatory listeners are $r = .96$, $r = .84$, and $r = .87$ for the pelog 1, 2, and 3 contexts. The scale tones are consistently rated higher than the nonscale tones, although the gong tone is not consistently rated higher than the other scale tones. The ratings of scale tones are, however, not all equal; highest ratings tend to be given to the group of three adjacent tones that are contained in the mode of the context and that include the gong tone. The Western and Kokar pelog 1 profiles somewhat resemble the Keker 1 group's pelog 1 profile, but don't resemble the profiles of the other two Keker subgroups.

Slendro Contexts. Figure 13 shows the ratings for the two slendro contexts, and a pattern of results that differs strikingly from the previous contexts we have presented. The occurrence frequency of each of the tones in the contexts is presented at the top. All five tones in the slendro scale are used in both contexts; however the gong tones (marked by filled-in diamonds) are not presented especially often in the contexts. In neither context do the Western listeners give highest ratings to the gong tone; however their rating profiles somewhat resemble the profiles of occurrence frequency. The Kokar conservatory listeners do give their highest rating to the gong tone in both contexts. The Kokar listeners' slendro 1 profile is similar to the profiles from two of the Keker subgroups presented earlier, which also have the gong tone rated higher than the other probe tones.

Quantitative Comparisons of Strategy Use across Contexts

To answer a number of questions about the use of the basic strategies we have identified, we performed correlation and regression analyses with the averaged profiles from the five groups of listeners (Western, Kokar, and the

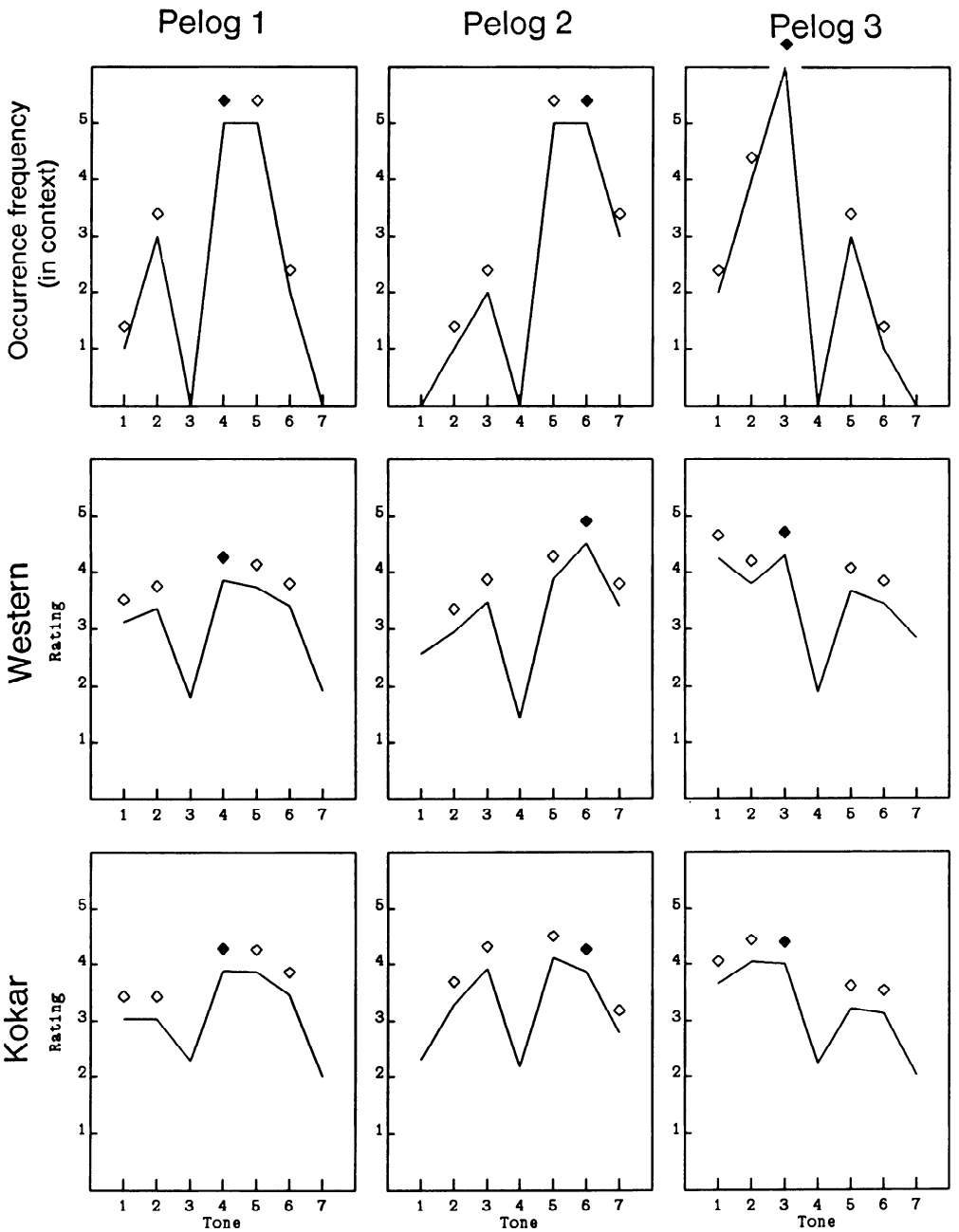


Fig. 12. Results for the pelog 1, 2, and 3 contexts for the Western and Kokar groups. There is a close similarity between the responses for these two groups.

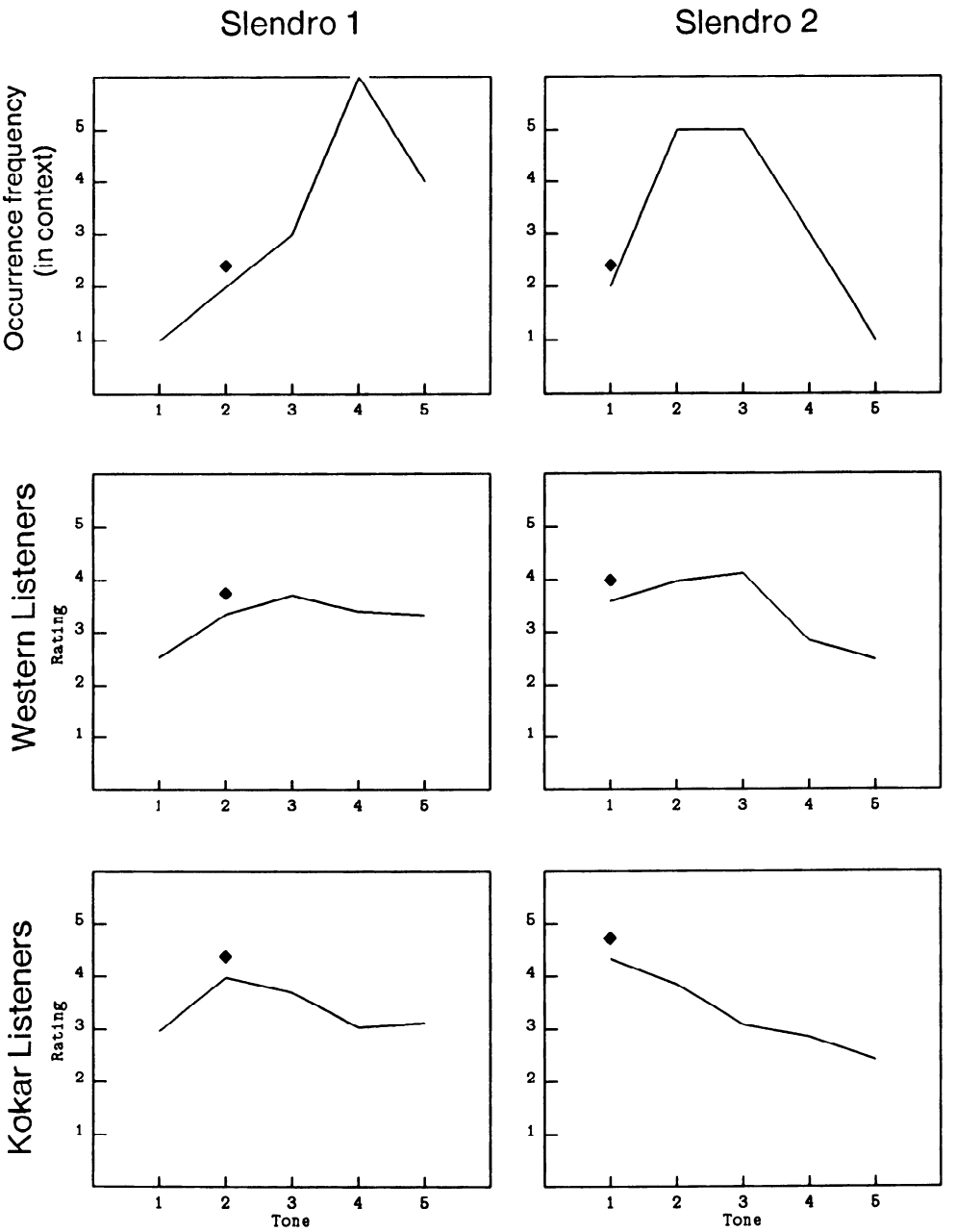


Fig. 13. Results for the slendro 1 and 2 contexts for the Western and Kokar groups. The Kokar group, but not the Western group, consistently rates the important gong tone higher than the other tones of the slendro scale.

three from Keker). Occurrence frequency is coded as the number of times each tone occurred in the context melody; membership is coded (0 or 1) by whether or not the tone is in the scale of the context (and thus does not apply to slendro); hierarchy is coded as described previously [i.e., from Krumhansl & Kessler (1982) for the major context, gong tone then other scale tones then nonscale tones for the pelog context, and gong tone then all other tones for the slendro context]; and pitch height is coded by scores that are high for the low pitch tones and that linearly decrease for each upward scale step.

Correlations with Strategies. As a preliminary measure of strategy use, we correlated the average profiles of each of the five groups with the model profiles described above. For the major context, Figure 14a exhibits two distinct patterns. The Western, Kokar, and Keker 1 (tonal hierarchy) groups all have high correlations with membership and occurrence, slightly lower correlations with hierarchy, and low correlations with descending pitch height, whereas the Keker 2 (pitch height) and 3 (other) groups show a strikingly different pattern; the correlations with hierarchy are higher than with either membership or occurrence, but are lower than those of the other groups. Correlations with pitch height, however, are higher than those for the other three groups. All four of the strategies yield higher correlations for the Keker 2 group than the Keker 3 group, which indicates that the Keker 3 group is not making heavy use of any of the strategies that we have identified. Corresponding correlations for the pelog 1 context are quite similar and are presented in Figure 14b. The results for the slendro 1 context (Figure 14c) do not include the membership strategy because all tones in the slendro scale are included in the slendro 1 context. The results differ from those for the other two contexts in that all of the Balinese groups tend to give the same pattern, while the Western group gives an opposite pattern. The Balinese groups yield high correlations for both hierarchy and pitch height, and low correlations with occurrence, while the Western group yields low correlations with hierarchy and pitch height, and high correlations with occurrence. The patterns of correlations for the other contexts were very similar to those presented here.

In summary, the Western and Kokar groups used the four identified strategies to similar extents for the major and pelog contexts, and the Keker 1 group responded similarly to these groups for the major context and somewhat similarly for the pelog context. The Keker 2 group had high correlations with hierarchy and pitch height and low correlations with occurrence for all of the contexts. For the slendro context, all of the Balinese listeners showed this pattern, while the Westerners had low correlations with hierarchy and pitch height, and a high correlation with occurrence.

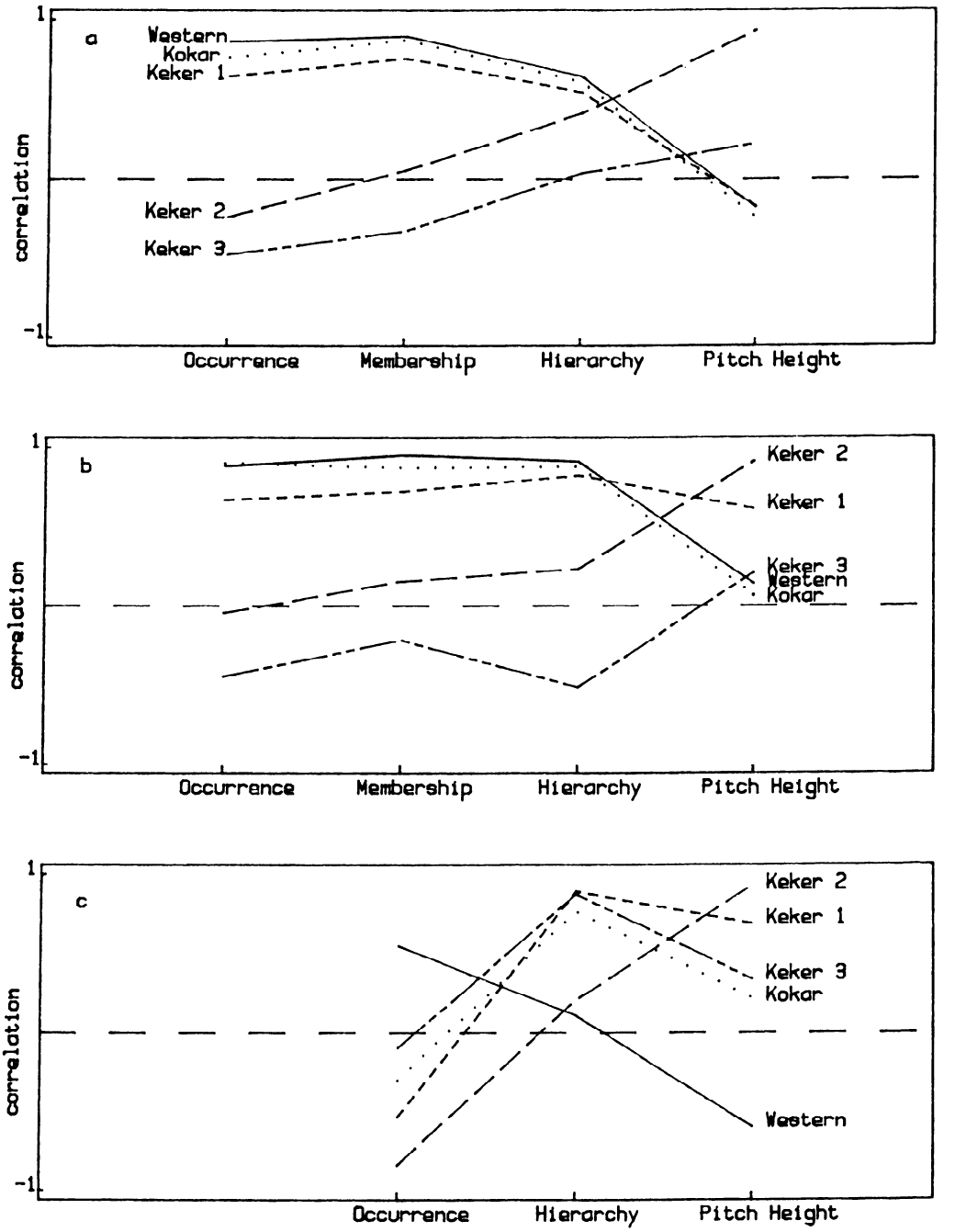


Fig. 14. Correlations for each of the five groups with the occurrence, membership, hierarchy, and pitch height strategies for the major (a), pelog 1 (b), and slendro 1 (c) contexts.

TABLE 3
Regression Analyses of Diatonic Contexts

	Occurrence	ΔR^2	Membership	ΔR^2	Hierarchy	F_1 $df = (1,9)$	F_2 $df = (1,8)$
Major							
West	.751	.156	.907	.000	.907	15.10**	.00
Kokar	.590	.215	.805	.003	.808	9.92*	.13
Keker 1	.421	.188	.609	.000	.609	4.33	.00
Keker 2	.058	.091	.149	.224	.373	.96	2.86
Keker 3	.232	.000	.232	.116	.348	.00	1.42
Minor							
West	.627	.256	.883	.070	.953	19.69**	11.91**
Kokar	.613	.180	.793	.041	.834	7.83*	1.98

NOTE. $*p < .05$; $**p < .01$.

Regression Analysis of Averaged Profiles. In order to ascertain the importance of each of the major strategies that we have identified in the obtained rating profiles, we performed several hierarchical regressions. When do listeners' ratings reflect a structure or scheme that is not explicitly present in the stimulus contexts? We reasoned that if ratings were given on the basis of context cues alone, the profiles would most closely match the pattern of tone occurrences in the context melody. Additional information about the scale of the context would be necessary to represent scale membership. We presume that the hierarchy of tonal functions that we have identified for Western listeners using diatonic contexts requires that the listener first be able to distinguish scale from nonscale tones. Thus, with respect to the variance of the ratings accounted for, we seek first the portion attributable to the number of times each of the probe tones occurred in the context melody, then the increase over that portion attributable to membership in the musical scale for that context, and finally the increase over that attributable to the presumed tonal hierarchy for that context. Since all of the slendro tones are used in the slendro contexts, we only test the increase due to the use of hierarchy above and beyond tone occurrence for those contexts. Hierarchical regression (as opposed to a simple correlational analysis of the profiles) enables us to obtain independent estimates of the use of each strategy despite correlations between the profiles predicted by these strategies.

The regression results for the diatonic major and minor contexts are presented in Table 3. Below each of the three strategies—occurrences, membership, and hierarchy—we give the proportion of variance accounted for (R^2) by that strategy together with those to its left. In each column between, we give the increase in variance accounted for due to the addition of the next

strategy included in the regression. In the last two columns we give the appropriate F statistic (Wonnacott & Wonnacott, 1981, p. 184) for adding membership (F_1) and for adding hierarchy (F_2). The corresponding degrees of freedom are given at the tops of these last two columns. For the major context, the use of number of occurrences of the tones in the context melody accounts for significant portions of the variance of the ratings for the Western, Kokar conservatory, and Keker 1 group of villagers ($R^2 = .751, .590, .421$, respectively). When membership is added into the regression equation, there is a significant increase in variance accounted for for all three of these groups. For the Western listeners, the increase was .156, $F(1, 9) = 15.10, p < .01$. The increase of .215 for the Kokar listeners, although a larger increase, was less significant [$F(1, 9) = 9.92, p < .05$]. The Keker 1 group increased .188 to $R^2 = .609$ which was, however, only marginally significant [$F(1, 9) = 4.33, p = .065$]. The other two Keker groups did not achieve a significant increase in variance explained. Beyond occurrence frequency and membership, the addition of hierarchy (from Krumhansl & Kessler, 1982) did not yield a significant increase for any of the groups of listeners. This result is interesting in light of the results we have previously found. Trained Western listeners seem to give ratings following major contexts that *do* represent hierarchy beyond scale membership. The present departure from this pattern can perhaps be accounted for by the tonally ambiguous nature of this context, which instantiates A minor as well as C major.

In agreement with this conclusion, a clearer picture emerges from the regression analysis for the less ambiguous minor context. The R^2 values are once again significant for both the Western and the Kokar listeners for all three regressions. The increase in variance when membership is added to occurrence ($\Delta R^2 = .256$) is larger and more significant for the Western group [$F(1, 9) = 19.69, p < .01$] than the increase (.180) for the Kokar group [$F(1, 9) = 7.83, p < .05$]. When hierarchy is added into the regression, in contrast to results for the major context, there is a larger and significant increase for the Western group [.070, $F(1, 8) = 11.91, p < .01$], but not for the Kokar group [.041, $F(1, 8) = 1.98, p > .10$]. In agreement with previously reported results, this implies that when a diatonic context is clearly instantiated, the hierarchy of tonal functions for the key is present in the ratings in addition to the information about the number of occurrences of each tone in the context and whether the probe tone belongs to the context scale.

The analogous regression results for the pelog contexts are presented in Table 4. For the pelog 1 context, the occurrences strategy accounts for the results of the Western and Kokar listeners fairly well ($R^2 = .792$ and .823). The increase in variance accounted for once scale membership is added, however, is much more significant for the Western [.199, $F(1, 4) = 88.44$,

TABLE 4
Regression Analyses of Pelog Contexts

	Occurrence	ΔR^2	Membership	ΔR^2	Hierarchy	F_1 $df = (1,4)$	F_2 $df = (1,3)$
Pelog 1							
West	.792	.199	.991	.003	.994	88.44**	1.50
Kokar	.823	.098	.921	.004	.925	4.96	.16
Keker 1	.453	.120	.573	.119	.692	1.12	1.16
Keker 2	.002	.080	.082	.158	.240	.35	.62
Keker 3	.200	.028	.228	.223	.451	.15	1.22
Pelog 2							
West	.787	.041	.828	.011	.839	.95	.20
Kokar	.619	.333	.952	.016	.968	27.75**	1.50
Pelog 3							
West	.585	.226	.811	.007	.818	4.78	.12
Kokar	.755	.162	.917	.007	.924	7.81*	.28
Keker 1	.303	.578	.881	.000	.881	19.43*	.00
Keker 2	.139	.155	.294	.283	.577	.88	2.03
Keker 3	.217	.056	.273	.321	.594	.31	2.37

NOTE. *$p < .05$; **$p < .01$.

$p < .01$] than for the Kokar listeners [.098, $F(1, 4) = 4.96$, $p < .10$]. The increase for the Keker listeners was even less significant. All of the increases when hierarchy was added (though again largest for Keker 1) were small and not significant. These results agree with those from the major context. One might expect, however, that as with the Western listeners for the Western contexts, the Balinese listeners would show greater increases in variance explained than the Westerners when the membership and hierarchy strategies were included for the Balinese contexts. This is in fact what we see for the remaining four Balinese contexts.

The pelog 2 and 3 results are reversed from the patterns found for the diatonic contexts. For the pelog 2 context, there is a greater increase in explained variance due to membership for the Kokar [.333, $F(1, 4) = 27.75$, $p < .01$] than there is for the Western listeners [.041, $F(1, 4) = .95$, $p > .10$]. The increases when the hierarchy strategy is added, although small and not significant, are greater for the Kokar listeners. For the pelog 3 context the increase in variance accounted for when scale membership is added to the regression is significant for the Kokar [$F(1, 4) = 7.81$, $p < .05$] and the Keker 1 groups [$F(1, 4) = 19.43$, $p < .05$] but falls short of significance for the Western listeners [$F(1, 4) = 4.78$, $p = .094$]. As for pelog 1 and 2, all of the increases in variance accounted for when hierarchy is added were small and non-significant for the pelog 3 context. The most plausible explanation for these findings, and the findings

TABLE 5
Regression Analyses of Slendro Contexts

	Occurrence	ΔR^2	Hierarchy	F $df = (1,2)$
Slendro 1				
West	.303	.107	.410	.36
Kokar	.088	.506	.594	2.49
Keker 1	.285	.575	.869	8.21
Keker 2	.705	.007	.712	.05
Keker 3	.009	.812	.821	9.07
Slendro 2				
West	.682	.248	.930	7.09
Kokar	.062	.811	.873	12.77

from the pelog 1 context, is that the Westerners sometimes used both occurrence frequencies and scale membership in making their ratings, but the model for tonal hierarchy that we use for the pelog contexts (gong tone then other scale tones then nonscale tones) is not an adequate representation of the structural relationships internalized by the Balinese listeners.

For the slendro contexts, Table 5 shows results that closely resemble those from the pelog 2 and 3 contexts. Instead of showing increases as a result of including scale membership, increases arise from the addition of hierarchy, which distinguishes the gong tone from the other slendro scale tones. However, the number of degrees of freedom are small and none of the F ratios achieve significance. The pattern of increases in variance nevertheless suggests that the Balinese listeners used the hierarchy strategy beyond occurrence frequency in the context. For the slendro 1 context, there are large increases in R^2 for the Kokar [.506, $F(1, 2) = 2.49$, $p = .26$], Keker 1 [.575, $F(1, 2) = 8.21$, $p = .10$], and Keker 3 [.812, $F(1, 2) = 9.07$, $p < .10$] groups. All three of these groups used the strategy of occurrence frequencies negligibly, whereas the Western group's profile had a moderate correlation ($r = .551$) with this variable. For the slendro 2 context, the Western group seemed to use mostly the strategy of occurrence frequencies ($R^2 = .682$), with only a slight proportion of variance explained by the use of hierarchy [.248, $F(1, 2) = 7.09$, $p = .12$]. The Kokar group, however, has a large and marginally significant increase in R^2 when hierarchy is added to the regression [.811, $F(1, 2) = 12.77$, $p < .10$]. These results support the notion that musically trained individuals have internalized a representation of the music of their own culture that is independent of the particular context presented.

Follow-up Study

Several months after the initial testing at the remote village of Keker, a follow-up study was run. The stimulus materials included the minor, pelog

2, and slendro 2 contexts which had not been previously used at Keker. In addition, a revised, unambiguous major key context and an ascending major scale context were tested. Twelve of the 27 original listeners performed the task—7 were from group 1 (tonal hierarchy) and 5 were from group 2 (pitch height). In the hope of uncovering response strategies other than pitch height, Shepard's (1964, see also Krumhansl, Bharucha, & Kessler, 1982) computer-generated circular tones were used for the melodic contexts in this experiment.

As expected, none of the listeners consistently used the pitch height strategy for all of the contexts. For the Balinese contexts, the averaged response profiles closely matched those from the Kokar listeners. The correlation between the profiles from the two Balinese groups was .82 and .89 for the pelog 2 and slendro 2 contexts, respectively. This suggests that the Keker listeners used the strategies of tone occurrence and scale membership for the pelog contexts, and tone occurrence and hierarchy for the slendro contexts in both the earlier study and in this follow-up study.

The results for the diatonic contexts in this follow-up study are even more suggestive that contexts that clearly instantiate a Western musical key can (when strategies such as pitch height are minimized) cause listeners without previous exposure to Western music to induce the tonal schema of a diatonic key. For the ascending major scale context, the correlation between the profile of probe tones in the octave above the scale and scale membership was only .06, whereas the correlation between the profile and the hierarchy of tonal functions (Krumhansl & Kessler, 1982) was .53. Similarly, for the revised major key context, correlations with the probe-tone profile were .45 for the number of times each of the chromatic tones occurred in the context, .34 for membership in the C major scale, and .54 for the hierarchy of tonal functions. A similar pattern was seen for the minor context. Correlations with the minor profile were .21 for tone occurrence, .39 for minor scale membership, and .73 for minor key tonal hierarchy.

General Discussion

Multidimensional scaling and regression analyses of the obtained ratings indicated the following. In both cultures, groups of listeners gave patterns of probe tone ratings that differentially reflected their use of the following response strategies: a hierarchy of tonal functions (roughly corresponding to the Western music-theoretic hierarchy of *tonic*, *dominant*, etc.); scale membership; pitch height (roughly corresponding to the psychophysical dimension of log frequency); the number of times each of the tones occurred in the context melody; and for some Balinese villagers, other, seemingly nonsystematic factors. In general, the use of the tonal hierarchy and scale membership response strategies were used to a greater extent when a group of listeners was familiar with the scales underlying the context. The tonal

hierarchy, when it arose in response to Balinese as well as to Western contexts, exhibited essentially the same pattern for listeners from each of the cultures, suggesting that such tonal hierarchies may reflect a human cognitive universal. There was less variation among both Western and Balinese groups of listeners when they heard contexts based on music of their own culture, and more within-group variation to unfamiliar contexts, indicating that cultural learning also has an appreciable effect. The factor of pitch height (which in Western listeners has previously been found to be strongest for those with the least musical background) arose most strongly for the Balinese listeners with the least exposure to Western music. The Western listeners appear to have had the least success in abstracting the tonal hierarchy from the slendro contexts, perhaps because of the almost equal spacing in pitch of the tones in the slendro scale.[1]

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1. This project was supported by National Science Foundation Grant BNS 80–05517 to Roger Shepard. The field work in Bali could not have been conducted without the assistance of Mervyn Dennehy (Putra), who served as interpreter and liaison. We are especially indebted to Bepak Suparta, Director of the Kokar music conservatory (Sekolah Menengah Kerawitan) in Denpasar, Bali, for making possible the collection of data there. We are also indebted to Michael Tenzer, who was in Bali studying gamelan on a Fulbright fellowship, for suggestions and assistance in constructing test materials. Suggestions and assistance have also been contributed by Bapak Pandji, Bapak Sinti, Bapak Sumandhi, Bapak I. B. Mayun, and Bapak Tama in Bali, and John Grey, Carol Krumhansl, and Anna Lowenhaupt in the United States. The Balinese field work, done while the second author held a visa for the study of Indonesian culture, received the clearance of the Republic of Indonesia Department of Education and Culture, Bogor office (Surat No. 208/II.I03.6/C.83). This work was conducted while Edward J. Kessler was receiving support from an IBM Graduate Fellowship and a National Science Foundation Predoctoral Fellowship.

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