Perceived complexity of western and African folk melodies by western and African listeners

Psychology of Music

Psychology of Music

vol 34(3): 337–371 [0305-7356 (200607) 34:3; 337–371]
10.1177/0305735606064842
http://pom.sagepub.com

TUOMAS EEROLA
UNIVERSITY OF JYVÄSKYLÄ, FINLAND
TOMMI HIMBERG
UNIVERSITY OF CAMBRIDGE, UK
PETRI TOIVIAINEN
UNIVERSITY OF JYVÄSKYLÄ, FINLAND
JUKKA LOUHIVUORI
UNIVERSITY OF JYVÄSKYLÄ, FINLAND

ABSTRACT Stylistic knowledge and enculturation play a significant role in music perception, although the importance of psychophysical cues in perception of emotions in music has been acknowledged. The psychophysical cues, such as melodic complexity, are assumed to be independent of musical experience. A cross-cultural comparison was used to investigate the ratings of melodic complexity of western and African participants for western (Experiment 1) and African folk songs (Experiment 2). A range of melodic complexity measures was developed to discover what factors contribute to complexity. On the whole, the groups gave similar patterns of responses in both experiments. In Experiment 1, western folk songs represented a style that was familiar for both groups and the results portrayed the differences in stylistic knowledge and high predictive rate of melodic variables. In Experiment 2, African folk songs were stylistically familiar only for the African group and the results illustrated a lower predictive rate of variables and differences between the groups in rhythm and structural variables. These results suggest that the melodic complexity ratings are influenced by musical enculturation.

KEYWORDS: *cognition, cross-cultural comparison, melodic complexity, music, psychophysical, style knowledge*

Listening to music brings together numerous automatic, innate processes involved in structuring auditory stimuli as well as structuring and interpreting these percepts in the light of learned, stylistic knowledge (Bregman, 1990). Recently, Balkwill and Thompson proposed a model (1999) in which emotions in music are communicated through a combination of psychophysical and cultural cues. Based on psychophysical cues such as tempo, melodic and rhythmic complexity, western listeners could decode the intended emotions of Hindustani raga excerpts without even possessing appropriate stylistic knowledge of that particular music. Similarly, determining emotional content from the vocal expression in different languages may use similar cues (Frick, 1985; Scherer et al., 2001). However, the model by Balkwill and Thompson (1999) raises two questions about the cues. First, to what degree do listeners' different levels of stylistic knowledge mediate the use of cultural cues? Second, to what degree do the psychophysical cues, such as melodic complexity, transcend cultural boundaries and what musical features contribute to this phenomenon?

The contribution of universal and cultural cues in music perception can be studied through infant research and cross-cultural comparisons. The former seeks to clarify the human (culture-transcendent) predispositions for processing music and to describe how the culture-specific properties develop (for a review, see Trehub et al., 1997). The latter approach considers the role of culture-transcendent and culture-specific factors in music by comparing the responses of listeners from culturally separate musical backgrounds. A handful of cross-cultural studies in music have been conducted. The results have echoed the findings in cross-cultural psychology, providing evidence of both substantial differences and similarities in the aesthetic responses of people from different cultures (Russell et al., 1997). These topics in cross-cultural studies of music have ranged from the emotional responses to music (Gregory and Varney, 1996; Hoshino, 1996; Meyer et al., 1998; Balkwill and Thompson, 1999), to melodic expectancies (Castellano et al., 1984; Krumhansl et al., 1999; Krumhansl et al., 2000), to pulse-finding (Magill and Pressing, 1997; Stobart and Cross, 2000; Toiviainen and Eerola, 2003), and to interval discrimination (Sampat, 1978).

Balkwill and Thompson define a psychophysical cue as 'any property of sound that can be perceived independent of musical experience, knowledge, or enculturation' (1999: 44), melodic complexity being one example, others including melodic contour, pitch range, rhythmic complexity, dynamics, texture and timbre. In western music, variations in components of melodic complexity such as pitch (e.g. Campbell et al., 2000) and timing patterns (Juslin and Madison, 1999), can elicit specific emotional responses in western listeners. Although the consistency of inter-participant agreement obtained in these experiments suggests that these effects are substantial, it is still unknown whether they would cross cultural boundaries. The literature on the development of emotional responses to music (Terwogt and van Grinsven, 1991; Gerardi and Gerken, 1995; Adachi and Trehub, 2000) suggests that enculturation has an important role in perceiving emotions. Accordingly, we assume that cultural cues (e.g. conformance to typical melodic structures of one's culture) also influence the formation of melodic complexity.

Cultural cues, in the form of stylistic information, aid the organization of the music into distinct categories and patterns, enabling more economical cognitive processing. This knowledge of the regularities in music, represented by schemas, is learned and is usually tacit, thus contributing to cognition from interpreting sensory data to memory retrieval and to organizing and guiding the information processing in general (Rumelhart, 1980: 33). In music, schematic knowledge influences a wide variety of processes, for example, perceptual discrimination (DeWitt and Samuel, 1990; Bey and McAdams, 2002), key-finding (Krumhansl, 1990), remembering music (Krumhansl, 1979; Boltz, 1991), and musical preferences (Tekman and Hortaçsu, 2002),

Previous research on melodic complexity has examined the relationship between the preference and stimulus complexity from the perspective of information theory and experimental aesthetics (Heyduk, 1975; Simonton, 1984; North and Hargreaves, 1995) employing psychophysical aspects of musical processing to account for complexity. Cross-cultural studies in experimental aesthetics with both visual and auditory stimuli (Poortinga, 1972; Bragg and Crozier, 1974; Poortinga and Foden, 1975) have found no differences in complexity ratings across cultures. A cross-cultural perspective on melodic complexity from Unyk et al. (1992) examined the simplicity of lullabies from various cultures and found, in accordance with Balkwill and Thompson (1999) that they were perceived as simpler than other folk melodies, due to the fact that their melodic structures reflect the properties in infant-directed speech. In summary, the culture-transcendent quality of melodic complexity has been proposed, but cultural cues in the evaluation of melodic complexity have been studied somewhat less.

The organization of pitch-classes into hierarchical order provides an example of both cultural and universal cues. Reliance on the hierarchical arrangement of pitches transcends musical cultures, although the exact way that it is accomplished varies from culture to culture. The pitch hierarchies have been investigated in, for example, classical Indian (Castellano et al., 1984), Balinese (Kessler et al., 1984), and Korean music (Nam, 1998) by means of probe-tones studies. For example, Castellano et al. (1984) demonstrated how the ratings of Indian listeners could be predicted by schematic knowledge of Indian music theory plus the short-term statistical properties related to excerpts of Indian music, whereas the American listeners' ratings reflected the tone and interval frequencies of the excerpts. Hence, in addition to cultural cues, listeners' sensitivity to the statistical properties of music also influences listeners' expectations (Oram and Cuddy, 1995; Krumhansl et al., 1999, 2000), which is apparently a universal process, exhibited by even 8-month-old infants (Saffran et al., 1999).

Two universal processes in temporal organization of auditory sequences have been identified (Drake, 1998): (1) segmentation sequence into groups of events; and (2) the extraction of an underlying pulse. The first, based on changes in pitch duration and salience, is already present in early infancy (Krumhansl and Jusczyk, 1990). The second involves the extraction of temporal regularities and likewise appears early in infants (Baruch and Drake, 1997), and is assumed to be culture transcending (Carterette and Kendall, 1999). However, the majority of work on temporal aspects in music cognition has concentrated on the role of cultural cues in the context of western music. Western notions of meter, grouping and metrical hierarchy by Lerdahl and Jackendoff (1983) have received considerable empirical attention (e.g. Deliège, 1987; Palmer and Krumhansl, 1990; Bigand, 1993; Todd, 1994), but only few studies have taken the cross-cultural approach, perhaps owing to the difficulty of reconciling western notions of meter with those of non-western cultures (Hughes, 1991: 330). For example, Magill and Pressing (1997) found that an 'African' asymmetric timeline-ground model corresponded better with the tapping of a Ghanaian percussionist than the 'western', hierarchical model. The universal applicability of western music-theoretic concepts was also challenged by Stobart and Cross (2000), who noted that western and Bolivian listeners perceived different meter and position of the downbeat in Bolivian Easter songs. For the western listeners, the Bolivian performers seemed to be clapping on 'off-beats'. This reflects a problem familiar in notating African music; western transcribers' view of the meter often contrasts with that of the African performers (Jones, 1959; Blacking, 1967; summarized by Temperley, 2000: 84–6). This was also the case in an experiment comparing beat-finding by western and African participants (Toiviainen and Eerola, 2003). To summarize, the literature on perception of pitch, rhythm and temporal structures in music has found that both cultural and universal cues have an effect on the perception of musical sequences. However, the nature of their interrelationship and relation to the listener's knowledge of the musical style remains unclear.

Rationale and hypotheses

The present study attempted to ascertain: (1) the role of stylistic knowledge; and (2) the consistency of the psychophysical cues in the listeners' assessments of melodic complexity. To investigate both objectives, a comparison of two groups rating the melodic complexity of two different musical styles to a set of melodic variables and to each other was conducted. Of the two styles, one was familiar to both groups whilst the other was familiar to only one group. In order to make such a comparison, both groups needed to have commensurable notions about melody, scale and tuning. To fulfil this criterion, we chose western and African folk songs and groups of western and African adolescent listeners that were familiar with western music.

To explore the variations in the stylistic knowledge, both groups rated the melodic complexity of western and African folk songs. The advantage of this task is that it combines different aspects of musical processing (pitch and rhythm-related processes), allows the presentation of complete musical examples to listeners and is thus more generic than, for example, the probe-tone, reaction time or rhythm production tasks. To look into the contribution that different components of complexity had in the listeners' ratings, a set of melodic variables representing pitch, rhythm and structural aspects of the melodies was used to predict the participants' complexity ratings.

The first question was how different types of stylistic knowledge mediated the use of cultural cues in evaluation of melodic complexity. To investigate this matter, we utilized western music, familiar to both groups but in different degrees. Our hypothesis was that the complexity ratings would be generally similar between the groups, but this difference in the stylistic knowledge would be reflected in the correlations of ratings with musical variables. More specifically, the more stereotypical knowledge of western musical style possessed by the African participants was hypothesized to lead to higher correspondence with the archetypal tonal and metrical hierarchies of western music.

The second question was whether the psychophysical cues, such as melodic and rhythmical complexity, actually transcend cultural boundaries as Balkwill and Thompson (1999) suggested, and, if so, which musical features are involved. This was examined by utilizing African folk melodies, a style only familiar to one of the groups. The hypothesis, derived from Balkwill and Thompson, was that the ratings of musical complexity would not be significantly affected by the cultural backgrounds of the listeners (in tasks requiring more cultural knowledge, such as judgements of musical meaning or function, the direction of the hypothesis would be reversed). A comparison between the ratings and musical features extracted from the melodies would reveal the musical features used by both groups.

Melodic complexity measures

In order to investigate the listeners' complexity judgements systematically, a set of variables was created. These variables are based on the note onset and duration information of the melody, rather than on the notated information, with one exception, *metrical hierarchy*, the reasons for which are detailed later. We looked at three different feature categories of melodic information: pitch, rhythm and structure. Within these categories, a broad range of features describing melodic complexity was conceived.

PITCH-RELATED VARIABLES

Pitch-related variables attempt to encompass horizontal aspects of the melody that can be summarized in many ways. The most straightforward way is to look at the pitch-class and interval distributions. These first-order statistics simply state the frequencies of pitch-classes (12 components) and intervals (25 components: unison and ± octave in semitones). These frequencies are weighted by note durations in order to account for increased perceptual salience of longer notes (see e.g. Thompson, 1994; Repp, 1995).

The weighting of durations is done according to Parncutt's (1994) durational accent model. To obtain an appropriate single measure of complexity, the distributions need to be summarized. Entropy (H) of the distribution is one appropriate statistic that characterizes the amount of information in the distribution that is often labelled as complexity (Knopoff and Hutchinson, 1983; Snyder, 1990). This is calculated by:

$$H = \frac{-\sum_{i=1}^{N} \rho_i \log_2 \rho_i}{\log_2 N} \qquad (1)$$

where H is the relative amount of information conveyed, N is the number of possible unique states (in this case pitches or intervals) in the repertoire and ρ_i is the probability of occurrence of state i in the repertoire. Consequently, we have two measures, *entropy of pitch-class distribution* and *entropy of interval distribution*. Another way of looking at the pitch-content of the melody is to calculate the *average interval size* of the melody. Several studies indicate that proximate tones tend to be judged by listeners as more predictable and hence less complex (e.g. Cuddy and Lunney, 1995; Krumhansl, 1995).

RHYTHM-RELATED VARIABLES

In the same way that the pitch-content of a melody can be characterized by the entropies of the pitch-class and interval distributions, the temporal quality of a melody can be summed up as the *entropy of note duration distribution* of the melody. To obtain the duration distribution, the note durations of the melody must be classified into discrete categories. We have chosen nine categories, evenly spaced on a logarithmic scale and with the centres ranging from 1/16 note to 1/1 note. The entropy provides a measure of disorder of the rhythmic organization in terms of note duration categories. However, it is possible for a rhythmic structure to be highly ordered in terms of duration categories (for example, a melody consisting of very short and very long note durations) but still highly variable and complex in terms of the durational changes. This *rhythmic variability* can be encapsulated by taking the standard deviation of the logarithmically transformed note durations. Another rhythmic variable is the *note density*, which is simply the number of notes per second.

STRUCTURAL VARIABLES

The structural variables combine pitch and rhythmic features that lead to tonal and temporal coherence. In other words, a lack of structural coherence gives rise to perceived complexity of a melody. The first variable, *tonal ambiguity*, distinguishes how stable each pitch-class is in a given key, which is a central characteristic of melodic coherence (Krumhansl, 1990). A measure of tonal ambiguity is obtained by assigning the empirically derived key profile values (Krumhansl and Kessler, 1982) to each pitch-class in the key of the excerpt. These values are weighted by note durations using Parncutt's durational accent model (1994), and finally the opposite number of the mean is taken to obtain a measure of *tonal ambiguity*.

The degree of structural incoherence of a melody is also a plausible variable of complexity. Boltz and Jones have proposed a model of joint accent structure (1986), which accounts for the structural clarity of the melody by observing whether melodic, harmonic and temporal accents coincide in the music. In production studies, the degree of regularity in tapping depends on the degree to which various accents coincide (Drake et al., 1991; Jones and Pfordresher, 1997). In this study, we will concentrate on melodic and temporal accents (both durational and metrical) and leave harmonic accents aside, since it is precarious to impose chordal analysis upon African folk song materials. Melodic accents refer to differences in note saliency caused by changes in the contour of the melody, i.e. notes in pivoting locations in the melodic contour have stronger accents than other notes (Thomassen, 1982). A way of characterizing the metrical importance of note events in western music has been proposed by Lerdahl and Jackendoff (1983). In their well-known model, the rhythmic structure is based upon the alteration of weak and strong beats, these being organized in a hierarchical manner. The positions in the highest level of this hierarchy correspond to the first beat of the bar and are assigned the highest values, the second highest level to the middle of the bar and so on, depending on meter.[1] The metrical hierarchy values are assigned to onsets according to the meter and the position in the bar, where these values range from 1 to 5 – the larger values standing for higher metrical accent (see the upper panel in Figure 1). In Figure 1, an

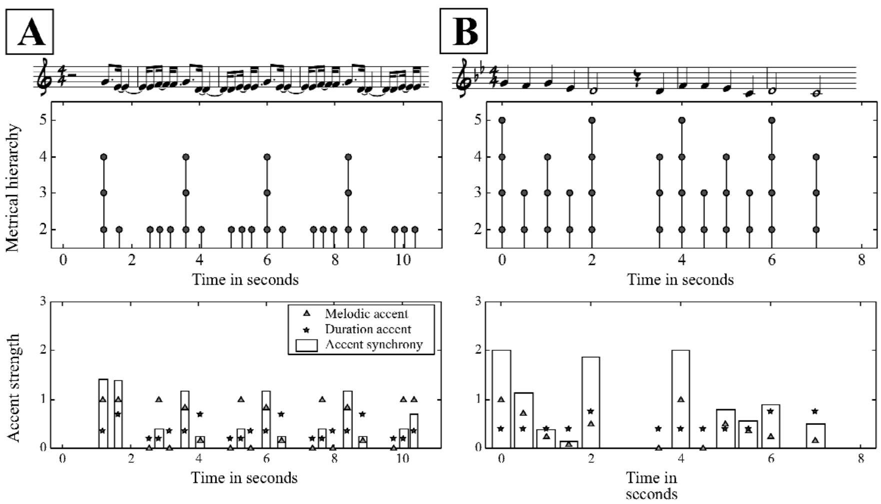

FIGURE 1 *Two examples of metrical hierarchy and accent synchrony. The first four bars of (a) Le mmone (African melody, Kutu and Van Niekerk, 1998) and (b) Satyre auf das Papstthum (western melody, Essen collection, Schaffrath, 1995).*

excerpt from African and western folk melodies is shown. According to the notation, the events in the African excerpt do not fall on the metrically most salient locations, except in a handful of cases whereas, in the western folk melody, the metrical accents form a typical pattern of western metrical hierarchy in quadruple meter, emphasizing the first and third beat of the bar.

Durational accents are also important in creating structural accents (Jones, 1987; Palmer, 1989). Longer notes are represented by larger durational accents and these accents are obtained by applying Parncutt's accent model (1994) to the note durations. By combining melodic, metrical and durational accents we get a measure of accent synchrony (see the lower panel in Figure 1). A suitable complexity measure, called *accent incoherence,* is thus obtained by taking the mean of the multiplied metrical hierarchy, melodic and duration accent values and multiplying this by –1. Melodies consisting of asynchronic melodic, durational and metrical accents generate high *accent incoherence* values. In Figure 1, the combined weights of the three accent types are displayed in the lower panel. In African melodies, different accent locations are often mismatched (high *accent incoherence*) while in western melodies, metrical and melodic accents often fall in the same location (low *accent incoherence*). Although the background to the components of this variable is deeply rooted in western music and supported by empirical findings on western listeners (e.g. Palmer and Krumhansl, 1990), the idea of similar metrical hierarchy in African music has been explicitly taken into African musical context by Temperley (2001), although opposing views exist in the literature (Koetting, 1970; Arom, 1991).

The third structural variable deals with the common melodic device of repeating melodic segments or phrases. These repetitions render parts of the melody more familiar, more redundant and hence reduce the overall complexity of the melody. This measure is based upon the self-similarity of the melodic contour. The melodic contour is defined in terms of pitch height, sampled at 250 ms intervals using nearest neighbour interpolation during the sampling. Also, the rests are omitted and the previous pitch is assumed to prevail over the rest (see the upper panels in Figure 2). Next, this contour vector c is normalized (mean pitch height = 0; SD = 1), and then the self-similarity (S) of this contour vector is assessed by the following function:

$$S(t) = \frac{\int_0^T \rho\left[R_{cc}(t)\right]dt}{T} \qquad (2)$$

where R_{cc}(t) is an autocorrelation of c with time lag t and where T denotes the length of the contour. In the equation, ρ denotes half-wave rectification, operationally defined as:

$$\rho(x) = (x + |x|)/2 \qquad (3)$$

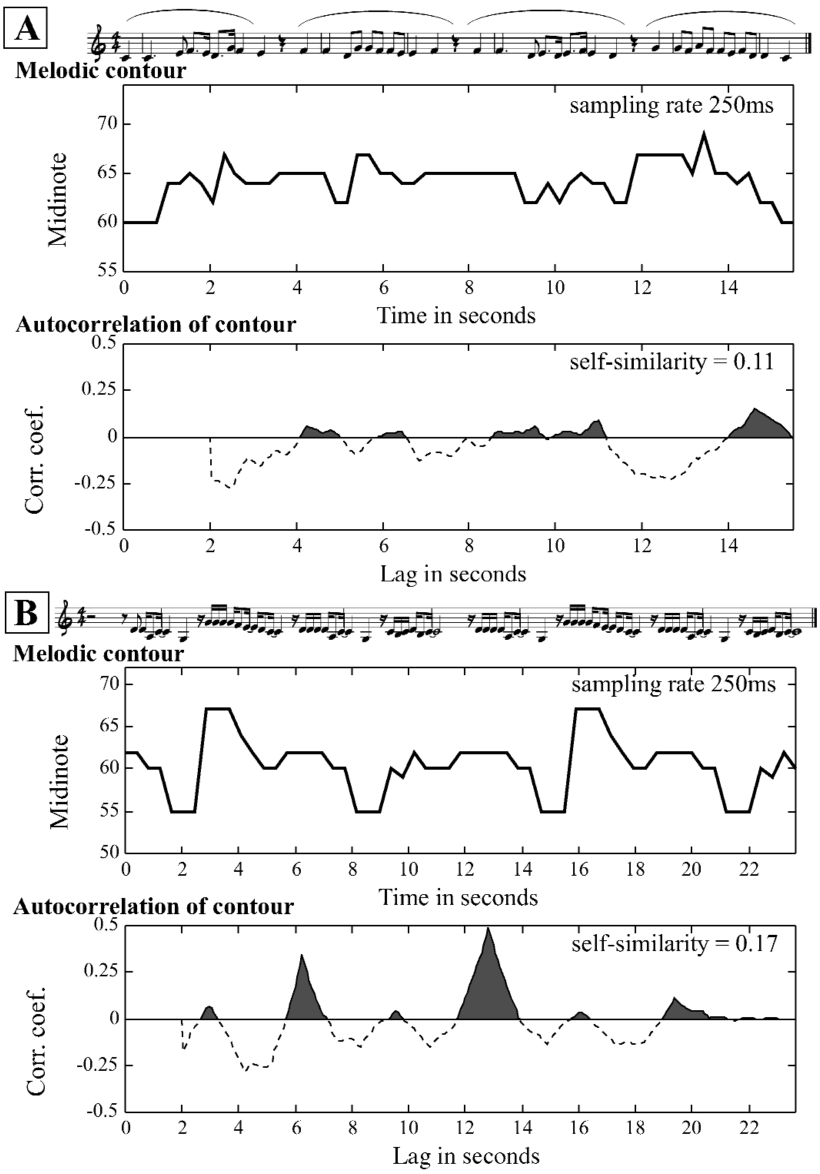

FIGURE 2 *An example of low (a) and high (b) contour self-similarity. Example (a) shows a western melody, Bald Prangt den Morgen zu Verkuenden (Essen collection, Schaffrath, 1995) and example (b) is an African melody, Mma-Selina (Kutu and Van Niekerk, 1998).*

Self-similarity *S* is thus defined as the mean of the positive half-wave of the autocorrelation, shown graphically in the lower panels of Figure 2. As a result, *S* represents an index of the *contour self-similarity*. Example (a) in Figure 2 represents a melody with little repetition in the melodic contour, evident in the lower panel of Figure 2 as only irregular and weak positive

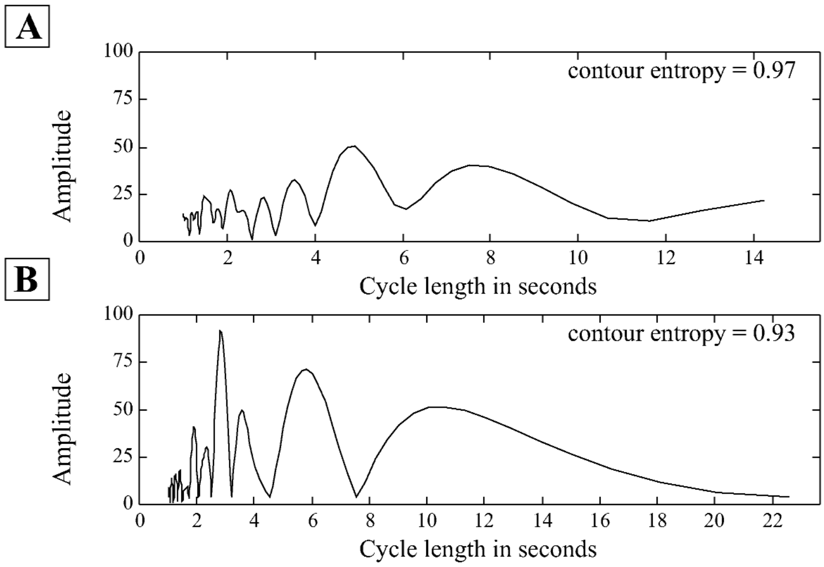

FIGURE 3 *Two examples of spectral amplitude resulting from DFT of the melodic contour.*

autocorrelations. Example (b), by contrast, shows a high degree of self-similarity in the melodic contour, witnessed by recurring motifs and a division into two near identical parts.

Finally, melodic contour can have another type of recurring, periodic structure. An estimate of the regularity of melodic contour patterns can be formed by calculating discrete Fourier transform (DFT, $N = 512$) of the normalized melodic contour vector c and taking the entropy of the amplitude spectrum. Moreover, high frequencies (less than 1 Hz, i.e. noise from the sampling rate) were filtered out from the amplitude spectrum. Melodic contour with a simple oscillating pattern will yield a sparse amplitude spectrum and thus low entropy, whereas fluctuations at different rates in melodic contour will result in a more dense amplitude spectrum and hence higher entropy. For the sake of clarity, this measure will be abbreviated as *contour entropy*.

Figure 3 displays the amplitude spectra of the contour vectors in the two example melodies from Figure 2. The main difference in the amplitude spectrum of the contours is evident in example (b), where there are several clear peaks in the spectrum, indicating that there is a discernible periodic structure in the melodic contour. These recurring periods correspond to the lengths of 3, 6 and 9–10 seconds in example (b). The peaks in the amplitude spectrum of example (a) are less distinct and lower, resulting in higher *contour entropy*. In the examples shown in Figures 2 and 3, the *contour self-similarity* and *contour entropy* are closely related, but the two measures represent different types of melodic information, which can give divergent results.

PRINCIPAL COMPONENTS ANALYSIS OF THE VARIABLES

We wanted to explore whether the selected variables represented the feature categories outlined in the theoretical section and whether such variables are related to each other in real music, manifested in collinearity of variables within the feature categories. High correlations between the variables in separate categories would imply an inconsistent selection of variables and would pose problems for analytic techniques such as regression. A suitable method for discovering both the main dimensions of the variables and the commonalities between them is the *principal component analysis* (PCA). PCA finds new variables, which are linear combinations of those observed, so that they have maximum variation and are uncorrelated (Everitt and Dunn, 2001). Principal components extraction with varimax rotation was performed on 6236 melodies from the Essen collection (Schaffrath, 1995). Four factors were extracted, explaining a total of 84.6 percent of the variance in the collection. The loadings of variables on factors, communalities (h^2), and percentages of variance are shown in Table 1. In this table, loadings under .40 (20% of variance) are replaced by zeros. Interpretative labels of the factors are suggested as follows: F_1 = STRUCTURE (hierarchical), F_2 = PITCH, F_3 = RHYTHM, F_4 = STRUCTURE (periodic). The three categories derived from the theoretical background are clearly evident in the rotated loadings, although the structural variables have been divided into two: hierarchic and periodic factors. The hierarchic factor contains *tonal ambiguity* and *accent incoherence,* whereas the periodic factor contains both contour measures, reflecting periodic or cyclical patterns in the melodic contours.

Notice the negative sign of the *contour self-similarity* in Table 1. This is due to the fact that only this variable describes melodic simplicity rather than complexity. Although *contour self-similarity* and *contour entropy* are in the same factor (F_4), the latter also correlates with the first factor, implying that,

TABLE 1 *Principal components of the 10 melodic variables in the Essen collection*

Variable	F_1	F_2	F_3	F_4	h^2
Entropy of pitch-class distribution	0	.70	0	0	.67
Entropy of interval distribution	0	.88	0	0	.85
Mean interval size	0	.76	0	0	.71
Entropy of duration distribution	0	0	.96	0	.94
Rhythmic variability	0	0	.96	0	.94
Note density	.95	0	0	0	.91
Tonal ambiguity	.98	0	0	0	.96
Accent incoherence	.96	0	0	0	.94
Contour self-similarity	0	0	0	–.85	.75
Contour entropy	.55	0	0	.69	.80
Percent variance	33.9	22.8	16.2	11.7	

though related, these two measures are distinct. The two exceptions to the theoretical prediction are *note density* and *contour entropy*. *Note density* is located in the same factor as hierarchical, structural variables. It appears that in the Essen collection (Schaffrath, 1995), the melodies with clear and coherent tonal and accent structure are also less sparse in their note density (yielding prominent correlations of .90 and .87, d.f. = 6234, $p < .0001$, respectively with *note density*).

The addition of higher order statistical features (the entropies of the second-order statistics of pitch-class, interval and duration distributions) do not change the factor structure, since they are highly collinear with first order statistics (r = .86, .88 and .95, respectively). In conclusion, the selected variables seem to be well balanced across the factors and the individual variables within the factor are conceptually different and will therefore provide additional information for the analysis of behavioural responses.

Experiment 1: western folk songs

METHOD

Participants

Sixty-two South African and 36 Finnish female and male adolescents participated in the experiment. We will refer to the group of Finnish adolescents as *western participants* and to the South-African group as *African participants*.

The African participants were a group of adolescents currently studying western classical music in Pretoria, South-Africa. Their mean age was 16.4 years (SD = 4.3) and they had received 1–6 years of training in a western musical instrument (average = 3.6, SD = 1.07) in the STTEP Music School of Pretoria, which provides classical music education for children from disadvantaged communities around Pretoria. The curriculum consists of theory, instrumental tuition, music history, and chamber music and orchestral playing. The predominant musical style at the school is archetypical classical music: Mozart, Bach and Handel. This group of adolescent music students is interesting for the current study for several reasons: for example, the students are studying western music while surrounded by their African, urban township culture.

In-depth ethnographic information about the musical tastes, habits and the environment of the STTEP music students in general was collected (Kivinen, 2003), enabling us to make assumptions about their stylistic knowledge of western music and what kind of music they otherwise listen to. Before enlisting in the STTEP school, the students had not listened to classical music at all, as it is still a rather rare type of music in the townships (Kivinen, 2003). In popular music, their musical taste is quite similar to any European teenager, with the exception that they are especially keen on *kwaito* – a genre that mixes European and American house, pop and techno music with

African elements (Allen, 2003) – and other contemporary popular trends such as *retro* and *latino* (Primos, 2001). For the African participants, western music represents a learned culture, something they have learned through formal learning of western classical music in the STTEP school.

The western participants were chosen from a class with a special emphasis upon music. They had a degree of formal musical training equivalent to that of the African participants, an average of 6.2 years (SD = 3.5) and they had, on average, 6.9 years of experience playing an instrument. Their age range was also similar to that of the African participants (mean age = 16.6 years, SD = 1.8). The western group had no prior experience of African music, other than occasionally hearing it on the TV or radio. Though none of the western melodies were particularly familiar to the western listeners, the style in general was. In other respects, their musical taste resembled that of the African participants, listening to house, techno and hip-hop among other contemporary musical styles.

The western participants have acquired the appropriate stylistic knowledge of western folk melodies within their own culture, although the melodies in the experiment were not actual Finnish folk melodies. They were also familiar with western and Finnish classical music; consequently, their pertinent stylistic knowledge was less constrained than that of the African participants.

Experimental apparatus and stimuli

The stimuli were edited, generated and played using sequencer software and a software synthesizer. The stimuli were amplified through a lightweight portable amplifier/speaker combination suitable for the field trip.

The melodic material consisted of 52 western folk songs from the Essen collection (Schaffrath, 1995). This collection contains over 6000 melodies, mainly from Germanic regions of Europe. The aim was to select melodies that would not be familiar to the average listener, would be in duple meter, relatively short, and represent different levels of complexity. All chosen melodies were transposed to C mode and encoded as MIDI files with constant note-on velocity values and tempo (120 bpm). The mean duration of the melodies was 16.0. The mean range was 11.8 semitones (ranging from 5 to 20). Thirty-five of the 52 melodies were in a major key. For the experiment, they were synthesized and played back to the participants. A neutral, English horn sound was used. All western melodies are listed in Appendix 1 and the notations are available online at http://www.jyu.fi/musica/cognition/crossculture/stimuli.html.

Procedure

The western and African participants were tested as groups. The participants were told that they would take part in an experiment about melodic complexity. Their task was to rate the complexity of the melodies on an 11-point scale from 0 to 10. A value of 0 was explained as *very simple* and 10 *very complex*. The experiment started with three example melodies to test the volume level and to allow the participants to get used to the types of melodies and the sounds used, and to rehearse the use of scale. The order of presentation of melodies in the experiment was random, although the same random order was used for both groups. In the test, each melody was preceded by a voice announcing the number of the melody in English or Finnish. After each melody, participants had 10 seconds to mark their rating on the response sheet before the next number was called. To examine the familiarity of the melodies, the participants were asked to circle the numbers of familiar melodies on their response sheets.

RESULTS

In the data screening stage, the responses of two western participants (from a total of 36) had to be discarded from the analysis, due to the high skewness of their ratings (both over ± 2). Sixty-two African listeners participated in the experiment. The responses of seven African participants were eliminated because of an incorrect number of responses and several missing values. Two more participants were removed due to a probable error in the order of their responses that became apparent in the data screening. Finally, eight more participants were discarded because of their extremely limited use of the rating scale (skewness over ± 1.5).[2] Neither the western nor the African participants were familiar with any of the melodies used in Experiment 1.

The consistency of the participants' ratings was assessed with Cronbach's alpha (α), measuring intersubject agreement. For the western participants, the alpha was high (α = .94, d.f. = 51,1683, $p < .001$) and for the African participants, the agreement was somewhat lower (α = .91, d.f. = 51,2244, $p < .001$) although still well above the reliability criteria (an alpha of 0.8 is considered highly reliable (McGraw and Wong, 1996)). Because of the significant internal consistency within the groups, the average results of the groups will be used in all further analyses of the data.

The order of presentation did not have an effect on listeners' ratings. A correlation of mean ratings to the presentation order yielded no significant correlations (for African and western listeners, $r = .02$ and $r = .20$, both d.f. = 50, $p > .05$, NS, respectively). We then examined whether the use of scale was similar between the groups. No differences emerged (ANOVA, $F = 2.838$, d.f. = 1,102, $p > .05$, NS). The pattern of results between the groups was also highly similar, yielding a correlation of .73 (d.f. = 50, $p < .001$) between the mean responses. Both groups have experience of western music and it is therefore reasonable that the groups generally rated the western folk melodies in the same way.

Next we explored the contribution of individual musical variables to the complexity ratings by means of correlations. Table 2 displays the simple correlations between the variables obtained from the melodies and the complexity ratings of both groups concerning the western melodies.

TABLE 2 *Correlation matrix of the variables and complexity ratings of both groups for western folk melodies* (N = 52)

Variables	Eur. ratings	Afr. ratings	PC distr.	IV distr.	Mean int. size	Dur. distr.	Rhythm var.	Note density	Tonal ambig.	Acc. incoh	Contour sim.
African ratings	.73**										
PC distr.	.28*	.27									
IV distr.	.57**	.59**	.32*								
Mean int. size	.55**	.52**	.03	.78**							
Dur. distr.	.35*	.28*	.04	.15	.18						
Rhythm var.	.34*	.34*	.00	.12	.15	.80**					
Note density	.56**	.88**	.18	.40**	.43**	.19	.23				
Tonal ambig.	.51**	.83**	.25	.40**	.36*	.24	.28*	.94**			
Accent incoh.	.54**	.81**	.24	.41**	.38*	.23	.27	.90**	.93**		
Contour sim.	–.34*	–.48**	–.04	–.41**	–.33*	–.25	–.22	–.46**	–.50**	–.48**	
Contour entr.	.45**	.61**	.04	.47**	.46**	.23	.29*	.63**	.67**	.62**	–.64**

Notes: * $p < .05$; ** $p < .01$

The overall structure of the correlation matrix is highly congruent with the principal components analysis of the Essen collection. For example, the pitch-related and structural variables correlate and the *contour self-similarity* is inversely correlated with all other variables, since it is the only measure representing simplicity. There are several interesting pairs of correlations between the melodic variables. *Note density* correlates highly (.94) with *tonal ambiguity*, implying that more dense melodies are also more tonally unstable in this set of melodies. This is often the case in western folk music; for example, in the Essen folk song collection, the correlation between *tonal ambiguity* and *note density* is high, .74 (d.f. = 6234, $p < .0001$). Also, *accent incoherence* correlates with *tonal ambiguity* (.93), further suggesting that metrically coherent melodies tend to be tonally coherent as well. This is also representative of the western folk songs; a reasonable correlation exists between these variables in the Essen collection ($r = .55$). *Note density* is also related to *accent incoherence* (.90), indicating that more dense melodies are less structurally coherent. Again, this relationship is also present in the Essen collection ($r = .50$). In addition, *tonal ambiguity* and *contour entropy* correlate significantly ($r = .67$, d.f. = 50, $p < .01$), indicating that in western folk tunes, melodically varied contours tend to be tonally less coherent. The majority of these relations seem reasonable in a musical sense – at least in the western musical context – and provide a good basis for analysis of the group's responses.

As predicted from the correlations between the groups, the complexity ratings of both groups are conspicuously similar in terms of individual variables. The ratings of the western participants correlate highly with *entropy of interval distribution* (.57), *note density* (.56), *average interval size* (.55), *accent incoherence* (.54) and *tonal ambiguity* (.51). For the African participants, the same melodic variables generally seem to correlate with complexity ratings, except that the correlation of certain variables is higher for the African listeners. *Tonal ambiguity* (.83), *note density* (.88), *accent incoherence* (.81) and *contour entropy* (.61, d.f. = 50, for p values, see Table 2) all demonstrate a considerably higher degree of correlation with the African ratings than with the western ratings. In summary, the complexity ratings of both groups correlate with the same variables, though the magnitudes of structural variables correlations are higher for the African listeners. This is in line with the first hypothesis, according to which the differences should reflect the different degrees of stylistic knowledge possessed by the groups. The melodic variables showing a better correlation with the African participants' ratings may portray archetypal qualities of baroque and classical music – tonal and metrical coherence – corresponding with the musical qualities with which they are most familiar.

Further analysis using standard multiple regression analysis was conducted to clarify how specific variables relate to the complexity ratings (Table 3). The table displays the multiple correlation (R), R squared (R^2), squared semipartial correlations (sr^2) and simple correlations (r). R^2 portrays

TABLE 3 *Multiple regression results for all variables in western folk melodies (N = 52)*

Variables	R	R^2	sr^2	r
European participants				
All variables	.75**	.56**		
Pitch variables	.62**	.39**		
Entropy of pitch-class distribution			.04	.28*
Entropy of interval distribution			.01	.57**
Mean interval size			.06*	.55**
Rhythm variables	.61**	.37**		
Entropy of duration distribution			.01	.35*
Rhythmic variability			.00	.34*
Note density			.24**	.56**
Structural variables	.56**	.32**		
Tonal ambiguity			.00	.51**
Accent incoherence			.03	.54**
Contour self-similarity			.00	−.34*
Contour entropy			.01	.45**
African participants				
All variables	.93**	.87**		
Pitch variables	.61**	.37**		
Entropy of pitch-class distribution			.02	.27
Entropy of interval distribution			.04	.59**
Mean interval size			.02	.52**
Rhythm variables	.89**	.79**		
Entropy of duration distribution			.00	.28*
Rhythmic variability			.01	.34*
Note density			.67**	.88**
Structural variables	.84**	.71**		
Tonal ambiguity			.03*	.83**
Accent incoherence			.01	.81**
Contour self-similarity			.00	−.48**
Contour entropy			.00	.61**

Notes: *$p < .05$; **$p < .01$.

the overall prediction rate with the particular set of variables. Squared semipartial correlation expresses the unique contribution of the variable to the total variance in that set of variables. All variables explain up to 56 percent of the variance in western participants' ratings and a remarkable 87 percent of the variance in the African listeners' ratings. In both cases, R for regression was significantly different from zero, $F(10,41) = 5.03$ and $F(10,41) = 25.90$, $p < .001$.

Looking at the variable categories (Table 3) explaining the ratings of the western listeners, we notice that the contributions of these three categories are of almost equal importance. The most substantial single variable in the regression is *note density* (sr^2 = .24) whilst *average interval size* also carries a portion of the variance (sr^2 = .06). Aside from these, the other variables merely contribute shared variability to the regression equation. Hence, the western listeners considered the most complex melodies to be those that contained large pitch skips, had a high note density and were structurally complicated. Notice that none of the structural variables rise above the other variables in the regression analysis, although the simple correlations suggest that they all correlate with the complexity ratings.

Breaking down the high prediction rate (87%) of African listeners' ratings into variable categories, a slightly different picture emerges (Table 3). The most effective variable is the same as that of the western listeners, *note density*, explaining 67 percent of variance in the regression model containing the rhythm variables. Nonetheless, this particular variable does not explain the better fit of the regression model to the ratings given by the African listeners. The difference may be caused by the discrepancy in the type of stylistic knowledge of the groups. In this case, in predicting the complexity ratings of the African listeners, the pitch-related variables have less predictive impact than rhythm and structural variables. The explanatory power of the rhythm and structural variables is considerably larger for the African listeners than for the western listeners. In the case of the African listeners, the simple correlations of structural variables with complexity ratings are all higher than those of the western listeners. One possible explanation may be the more specific stylistic knowledge of the African listeners, based mainly upon music from the baroque and classical eras. These musical styles contain regular rhythmic structures and are not tonally ambiguous. Hence, they seem to have rated the melodies that are rhythmically irregular and tonally unstable as more complex than the western listeners, whose stylistic norms were probably broader and more generic for this type of music.

DISCUSSION

Two main issues were investigated in Experiment 1. First, we explored how the stylistic knowledge possessed by the two groups affected the complexity ratings. In general, the two groups gave fairly similar patterns of responses. This was illustrated by the high level of agreement in the ratings, both within and between the groups. This agreement was expected, since both groups were familiar with the musical style in question. However, the differences in the magnitude of the correlations suggested that the type of stylistic knowledge the two groups possess produced minor differences. The African participants' ratings were better accounted for by the variables derived from western music theory. Their more stereotypical stylistic knowledge might explain why they rated all deviations from typical baroque or classical musical idioms as more complex than the western listeners, who had a wider and more generic stylistic knowledge of western music. However, these differences between the two groups were not particularly large.

The second issue considered was the separation of complexity ratings into different components. The contribution of pitch, rhythm and structural variables to the overall complexity was fairly equal in this set of folk melodies. However, the moderate differences in particular rhythmic and structural variables that may be characterized as psychophysical (e.g. *note density*) suggested that stylistic knowledge contributes to the formation of melodic complexity. Despite this, the notion of psychophysical cues that transcend cultural boundaries, proposed by Balkwill and Thompson (1999), is not challenged, since the comparison involved music that was stylistically familiar to both groups. To further explore the issue of culture-transcending cues and the role of stylistic knowledge in the formation of melodic complexity, a second experiment was conducted, utilizing melodic material from a musical culture only familiar to one of the groups.

Experiment 2: African melodies

METHOD

Participants

The same people from Experiment 1 took part in Experiment 2. The African participants defined the type of African folk music used as very familiar, even though not their favourite musical style. The style was unfamiliar for the western listeners.

Experimental apparatus, stimuli, and procedure

Stimuli were generated and presented to participants using the same equipment as in Experiment 1. The stimuli consisted of 44 sub-Saharan African folk songs used today in different parts of Southern Africa. These were taken from the *Sina's Songs* collection (Kutu and Van Niekerk, 1998) and the *Spot On! Songbook* (Cock and Wood, 2001). The selection of African melodies from these collections was done in cooperation with two African musicians, discarding songs that were in English, obviously European in origin or had clear flaws in the notation. The songs represented various levels of complexity, even though this could not be used as a selection criterion due to the limited size of the original pool of songs. Both duple and triple meters were represented. All melodies were transposed to the C mode and encoded as MIDI files with constant note-on velocity values. The mean duration of the melodies was 22.8 seconds. The mean range of the melodies was 10.4 semitones (range 5–15). The tempo varied from 75 to 120 bpm (mean 100 bpm). The variations in the tempi were introduced by the native experts. All melodies were in a major key and are listed in Appendix 2 and are also available online at http://www.jyu.fi/musica/cognition/crossculture/stimuli.html. A *kalimba* timbre was used in the African melodies to ensure that they were recognized and accepted by the African participants. The instructions and the procedure were the same as those of Experiment 1, except the participants were told that they would hear African melodies in this experiment.

RESULTS

The participants identified as outliers in Experiment 1 were removed in the data screening phase. Thereafter, the consistency of the western participants was high (α = .94, d.f. = 43,1419, $p < .001$). For the African participants, the agreement was lower (α = .87, d.f. = 43, 1892, $p < .001$), although still well above the reliability criteria (α = .80). Again, the grand means of the groups were used in the data analysis. The order of presentation did not appear to have an effect on the ratings, as the correlations to presentations remained low (for African and western listeners, r = .19 and r = .22, both d.f. = 42, p >.05, NS, respectively).

The two groups rated the African melodies differently (ANOVA, F = 24.54, d.f. = 1,86, $p < .001$), with the African participants giving higher complexity ratings in general. However, these differences are based upon absolute ratings and might therefore reflect each group's different use of the rating scale. To remove this effect, the responses were normalized separately for both groups (transformed into Z-scores). The pattern of responses of both groups was less similar than in Experiment 1, indicated by the lower between-groups correlation (r = .46, d.f. = 42, $p < .01$). Nevertheless, a basic agreement on the overall complexity seems to reign in the African melodies, despite the western group's unfamiliarity with the African musical style. This provides the first indication that the complexity ratings of music are comparable, regardless of the cultural backgrounds of the listeners. However, the agreement between the groups was markedly less than with the western melodies, suggesting that the stylistic knowledge of the participants had influenced the complexity ratings. Again, correlation and regression analyses were used to probe this question more systematically. Table 4 shows the simple correlations between the variables obtained from the melodies and the complexity ratings of both groups for the African melodies.

Initially, let us concentrate on what the correlation matrix in Table 4 conveys about the African melodies. The composition of the correlation matrix is again largely congruent with the principal components analysis of the Essen collection, although there are certain differences. For example, the rhythm variables appear to diverge, since *note density* correlates negatively with *rhythmic variability* and the *entropy of the duration distribution*. In the western melodies and in the Essen collection, these correlations were positive although similar in magnitude. This discrepancy suggests that the African melodies contain different types of rhythmic features, with significantly more variation in the slower note duration structures. Also, the contour measures are not as clearly related to other structural features as in the western melodies. *Contour self-similarity* does not correlate with *tonal ambiguity* and *accent coherence*, and *contour entropy* is only weakly correlated with these variables. Still, *tonal ambiguity* correlates highly with *note density* (.91, d.f. = 42, for p values, see Table 4) and *accent coherence* (.62) in the African melodies, matching the correlations in the western folk melodies. To

TABLE 4 *Correlation coefficients between the variables and complexity ratings in African melodies (*N = *44)*

Variables	Eur. ratings	Afr. ratings	PC distr.	IV distr.	Mean int. size	Dur. distr.	Rhythm var.	Note density	Tonal ambig.	Acc. incoh	Contour sim.
African ratings	.46**										
PC distr.	.00	–.07									
IV distr.	.05	.06	.32*								
Mean int. size	–.10	–.04	.11	.57**							
Dur. distr.	.36*	.26	–.20	–.27	–.26						
Rhythm var.	.25	.06	–.14	–.06	–.15	.73**					
Note density	.02	.41**	–.13	–.04	–.14	–.21	–.31*				
Tonal ambig.	.12	.47**	–.01	–.11	–.29	–.10	–.24	.91**			
Accent incoh.	.33*	.38*	–.29	–.02	–.11	.09	–.05	.62**	.65**		
Contour sim.	–.13	–.09	–.02	–.64**	–.39*	.20	.06	.09	.09	–.13	
Contour entr.	.05	.10	–.18	.30*	.24	–.08	.05	.28	.20	.26	–.43**

Notes: * $p < .05$; ** $p < .01$

summarize, the African melodies show marked differences in the inter-correlations of the rhythm variables and the contour variables appear unconnected to other structural variables.

Turning next to the correlations between ratings and variables, it seems they are lower than those of Experiment 1. To examine the role of individual variables and variable categories in predicting the complexity ratings, a multiple regression analysis was performed, summarized in Table 5. All variables explain up to 29 percent of the variance in western participants' ratings and 40 percent of the variance in African listeners' ratings. Only the latter regression equation differs significantly from zero, $F(10,33) = 1.33$, $p < .01$.

Investigation of the variables and variable categories explaining the western listeners' ratings reveals that the pitch variable category appears to be irrelevant for the complexity ratings (see Table 5). Only two variables correlate significantly with the western listeners' complexity ratings. The first of these is the same as in Experiment 1, namely *accent incoherence* ($sr^2 = .10$). The other is *entropy of duration distribution* ($sr^2 = .07$). The individual contribution of these variables to the regression equation is small. Surprisingly, *note density* does not seem to play any role in the complexity ratings of the western listeners, although this variable correlates with the African listeners' ratings and was one of the most important predictors of melodic complexity in Experiment 1.

There are several possible explanations for the low prediction rate of the variables and the western listeners' complexity ratings, of which we examine two. The first is that the western listeners had many different evaluation strategies for music that was stylistically unfamiliar to them. In this case, the inter-rater reliability index of the western listeners would be low. However, in the western melodies, this index was higher for the western ($\alpha = .94$) than for the African listeners ($\alpha = .91$). In the African melodies, the ratings of the western listeners were still more internally consistent ($\alpha = .94$) than the ratings given by the African listeners ($\alpha = .87$), effectively discounting this explanation. Second, it may be that the western listeners were principally trying to parse the metrical structure in the African melodies by looking for a coherent beat structure. Whilst attempting this difficult task, they failed to uncover other differences between the melodies. None of the variables measure the difficulty of pulse finding directly but an indirect hint to the validity of this explanation is the low correlation of *note density* with the ratings given by the western listeners. In Experiment 1, it was always one of the best variables, but in this case it curiously does not even correlate with the ratings of the western participants. This might reflect the fact that pulse finding is easier when there are more note onsets available, since it makes it easier to impose a metrical structure to the melody (Toiviainen and Snyder, 2003).

A related study examined what kind of metrical structure these listeners actually imposed upon the melodies. African and western participants tapped

TABLE 5 *Multiple regression results for all variables in African melodies (*N *= 44)*

Variables	R	R^2	sr^2	r
European participants				
All variables	.54	.29		
Pitch variables	.16	.03		
Entropy of pitch-class distribution			.00	.00
Entropy of interval distribution			.02	.05
Mean interval size			.02	–.10
Rhythm variables	.37	.14		
Entropy of duration distribution			.07	.36*
Rhythmic variability			.00	.25
Note density			.01	.02
Structural variables	.37	.14		
Tonal ambiguity			.01	.12
Accent incoherence			.10*	.33*
Contour self-similarity			.01	–.13
Contour entropy			.00	.05
African participants				
All variables	.63*	.40*		
Pitch variables	.16	.03		
Entropy of pitch-class distribution			.01	–.07
Entropy of interval distribution			.02	.07
Mean interval size			.01	–.04
Rhythm variables	.54**	.30**		
Entropy of duration distribution			.09*	.26
Rhythmic variability			.01	.06
Note density			.19**	.41**
Structural variables	.50*	.25*		
Tonal ambiguity			.10*	.47**
Accent incoherence			.00	.38*
Contour self-similarity			.02	–.09
Contour entropy			.00	.10

Notes: *p < .05; **p < .01.

the pulse of melodies using subsets of the stimuli from Experiments 1 and 2 (Toiviainen and Eerola, 2003). In this study, the phase and accuracy of tapping within the western melodies was similar across groups, but discrepancies arose within the African melodies. The tapping of the western listeners corresponded better with western musical metric hierarchy, whereas the African group made use of style-specific knowledge in inferring the beat in the African melodies. Hence, these results tentatively suggest that the complexity ratings given by the western participants could well reflect the difficulty of pulse finding.

Turning now to the multiple regression results of the African listeners' ratings in Table 5, we notice that the fit of the regression is statistically significant, although modest in size (R^2 = .40) compared to the results obtained in Experiment 1. The same variables that explained the central part of the variance in the western melodies still explain a large amount of the variance in the complexity ratings of the African melodies. *Note density, tonal ambiguity* and *accent incoherence* correlate statistically significantly with the complexity ratings given by the African listeners. The pitch variables did not seem to be important in their ratings, but rhythm and structural variables, specifically *note density*, *tonal ambiguity* and *accent incoherence* predict a portion of them. The low prediction rate combined with high agreement between the African participants suggests that other factors, not covered by the melodic variables, may have influenced their complexity ratings.

DISCUSSION

This experiment examined (a) if there were major differences between the two groups; (b) which components the complexity ratings consisted of; and (c) whether psychophysical cues such as melodic and rhythmic complexity actually transcend cultural boundaries. As a whole, the two groups gave similar patterns of responses. However, a more thorough analysis of the components contributing to the complexity ratings illustrated certain differences between the groups. The African listeners' ratings were better accounted for by the rhythmic and structural variables than the western listeners' ratings. The lower prediction rate of the western listeners' ratings was thought to be due to the western listeners' difficulty in comprehending rhythmic structure in African melodies.

The question of melodic complexity as a psychophysical dimension transcending cultural boundaries could also be assessed, as the musical style was only familiar for one of the groups. The overall pattern of responses was similar, thus agreeing with the notion of melodic complexity as a psychophysical dimension of music. However, a look at individual musical variables suggests that cultural cues did in fact affect the complexity ratings. For example, the *note density* correlated highly with the African ratings but not with the ratings given by the western listeners. However, before concluding that the stylistic knowledge (or the lack of it) has an effect on the perception of melodic complexity, we must consider the possibility that knowledge of western classical music may be reflected in the results of the Experiment 2, although it was clear to both groups of participants that the melodies they heard during Experiment 2 were African folk songs. This possibility is difficult to rule out. In the post-experiment interviews, the African participants, engaged at the time of the study in learning the western classical repertoire, said that they evaluated both sets of melodies in terms of performance difficulty, which may have influenced them to rate the African melodies also using other western concepts. Moreover, there is no adequate way to assess the role of the African group's stylistic knowledge of African music in the complexity ratings as such information was not represented by the musical variables.

Familiarity with the stimuli may also have affected the ratings. Familiarity lowers the perceived complexity, though this mainly occurs with a relatively large amount of repetition (Smith and Cuddy, 1986). The participants were asked to circle any trial in which they recognized the melody. The western participants indicated none in all the trials. The African participants, however, recognized one to two of the melodies on average, although some participants recognized up to seven melodies. However, none of the melodies was familiar to all of the African participants; thus the effect of familiarity with the particular melodies remains relatively small compared with the role of stylistic knowledge.

Comparison of results from Experiments 1 and 2

As we have responses to two sets of melodies for comparison, given by two different groups of listeners, it is important to know whether the melodic sets in Experiments 1 and 2 actually differed in terms of the melodic variables. For instance, it is possible that the complexity ratings reflect the variables that featured most variation within the experiment. Also, if there were large differences in variation between the experiments, the correlations are not directly comparable. Table 6 shows that the means and standard deviations of the variables (scaled from zero to one to assist comparison) are rather uniform across the experiments, the latter ranging from .16 to .29, the mean standard deviation being .23 in western and .24 in African folk melodies. Consequently, the low correlation of pitch variables in Experiment 2 cannot be explained by a limited variable range.

TABLE 6 *Comparison of melodic variables in Experiments 1 and 2*

	Western folk melodies		African folk melodies	
Variable	M	*SD*	M	*SD*
Entropy of pitch-class distribution*	0.69	0.16	0.56	0.24
Entropy of interval distribution	0.49	0.23	0.57	0.29
Mean interval size	0.32	0.20	0.35	0.19
Entropy of duration distribution	0.48	0.25	0.60	0.25
Note density	0.47	0.22	0.40	0.19
Rhythmic variability**	0.32	0.23	0.41	0.23
Tonal ambiguity	0.49	0.28	0.55	0.23
Accent incoherence*	0.55	0.27	0.59	0.26
Contour self-similarity	0.21	0.18	0.33	0.21
Contour entropy	0.57	0.24	0.53	0.26

Note: Variables have been scaled between 0 and 1 to allow comparisons of means and variances. Means with different asterisks differ significantly at * $p < .05$ and ** $p < .001$ in t-test using the original, non-scaled values.

The two variables containing the least amount of variation in the western melodies were *contour self-similarity* and *entropy of pitch-class distribution*. Both variables correlate significantly with both groups' complexity ratings of western melodies (see Table 2), with the exception of *entropy of pitch-class distribution* and the African participants, which borders statistical significance, $r = .27$, $p = .054$, NS. These two variables contain higher variation in the African melodies, but did not correlate significantly with the complexity ratings of either group (see Table 4). Thus the notion that variables with constrained variability cannot predict ratings is unsustainable.

The variables that have statistically significantly different means between the experiments, using the non-scaled values in *t*-test, are marked in Table 6 with asterisks. *Entropy of the pitch-class distribution*, *rhythmic variability* and *accent incoherence* are the variables where the most substantial differences between the mean values of experiments exist. Another way of examining the differences between the two experiments is to look at the standardized ratings. When the ratings of both groups in both experiments are investigated using normalized scores within groups, it is apparent that the African participants gave lower complexity ratings for the African melodies ($F = 8.13$, d.f. = 1,94, $p < .01$), whereas the western participants' ratings did not differ between the groups of melodies ($F = 0.66$, d.f. = 1,94, $p > .05$, NS).

General discussion

To study the role of stylistic knowledge and psychophysical cues in the listeners' assessments of melodic complexity, a cross-cultural comparison was used, investigating the ratings of two groups for two styles of music in two experiments. In the first part of the study, a range of melodic complexity measures were developed to discover which factors contribute to the complexity ratings. The consistency of these variables and redundancies between them were investigated by analyzing a large folk song collection with principal component analysis. In the second part of the study, two experiments were conducted. In Experiment 1, the excerpts from western folk songs represented a style that was familiar for both groups. In Experiment 2, the excerpts of African folk songs were stylistically familiar only for the African group. The results are discussed in light of the two research questions: the role of (1) stylistic knowledge; and (2) psychophysical cues in the listeners' evaluation of melodic complexity.

The first question concerned the systematic differences that the listeners from different musical cultures might exhibit due to their stylistic knowledge. Although perception of music is assumed to use many universal low-level processes, the remaining differences can be connected to the cultural backgrounds and stylistic knowledge of the listeners. In a cross-cultural study of melodic expectations by Krumhansl et al. (2000), the results from three groups of listeners showed how certain universal psychological principles of melodic expectations accounted for the ratings of the groups and how the various types of stylistic knowledge then explained the remaining differences. In Experiment 1 of the present study, the more stereotypical stylistic knowledge of the African participants than that possessed by the western participants was evident in the higher overall predictive rate of the archetypical western variables.

In Experiment 2, the melodic variables once again gave a better prediction of the African participants' ratings than those of the western listeners. We believe that there are two reasons for this: western listeners had difficulties finding the pulse in African melodies, and the response strategy used by the African participants reflected the western notions of musical coherence and performance difficulties. For example, the same variables, *tonal ambiguity*, *note density* and *accent incoherence* that predicted their ratings in Experiment 1, were significant predictors again for the African group but not for the western group. These same three variables came up as the first and the most important factor in the principal components analysis of a large collection of folk music that was interpreted to represent hierarchical, structural aspects of the melodies. Hence, interpreting the differences in terms of a data-driven strategy or an emphasis upon structural features of melodies by African group could be valid, but we subscribe to a simpler explanation, according to which this difference reflects the difficulties the western listeners had in parsing the rhythmic structures in African music.

Stylistic knowledge is the most important factor when the subject of the study is composed of highly specific patterns of culture, such as the language content or specific emotions in music. However, stylistic knowledge could be assumed to be less important in tasks that emphasize processing instead of interpretation. Demorest et al. (2002) conducted an experiment using western participants and western classical and traditional Chinese music in comparison. They found no differences between Chinese and western music conditions, suggesting that the processing of these two styles of music was parallel. Similarly, in the present study, the nature of the task emphasized the common underlying features, since the question of melodic complexity is rather different from an aesthetic evaluation of a melody.

The second research question examined whether the psychophysical cues, such as melodic complexity, actually transcend cultural boundaries. Indeed, the complexity ratings of both groups demonstrated overall similarities in both experiments. Thus, Balkwill and Thompson's proposition of culture-transcendent cues (1999) was supported with some reservations, as the stylistic knowledge was also observed to have an effect upon the ratings. If melodic complexity was truly independent of cultural cues and stylistic knowledge, there should not have been such differences in the correlations of variables such as *note density* and *entropy of duration distributions* between the two groups in Experiment 2. If the listeners are unfamiliar with the musical style, they still need to comprehend and structurally organize the music. Such difficulties in the case of the western listeners led to differences in the components of complexity between the groups. For example, the western listeners indicated that complex melodies are rhythmically difficult but not necessarily high in note density, as there will be numerous cues for perceiving the pulse in melodies that have a large amount of tones per second.

In addition to our style knowledge hypothesis, we present three alternative explanations for the observed differences, two of which emerged from the interviews with the African participants. These alternative explanations are: (1) the Eurocentric perspective of the experimental approach; (2) familiarity; and (3) complexity as an indicator of performance difficulty. First, the present study, as with most musical perception work, suffers from a western or Eurocentric perspective. This is reflected in the choice of methodology and musical material. The validity of the exact tasks and models for both represented music cultures can be questioned; perhaps even the idea of melodic complexity, as heard and rationally evaluated by listeners, is such a western-oriented concept that it does not do justice to the African way of musical thinking. The presentation of the stimulus material was a compromise between control (e.g. omitting timbre and performance nuances) and ecological validity, but in the end omitting clapping, four-part harmonizing and other stylistic features of African music might have contributed to the western perspective taken by both groups.

The variables used to predict the listeners' ratings were not derived from distinctly African theories or concepts and thus represented more western musical concepts. For example, body movements and motor theories were not considered, despite their apparent role in the musical processing, especially in African music (Hornbostel, 1928 as cited in Blum, 1991, Kubik, 1994; Agawu, 1995).

The second alternative explanation is the role of familiarity, which is known to decrease the perceived complexity of stimuli (Smith and Cuddy, 1986; North and Hargreaves, 1995). The African group was familiar with some of the western melodies but the western group was not familiar with any African melodies. In addition to this relatively minor direct familiarity, there might be another familiarity effect. In Experiment 2, both groups were familiar with western music, which may have influenced their ratings, and thus stylistic knowledge does not separate the group responses in such a straightforward manner as theorized.

A third alternative explanation is that the African participants were paying attention to the production difficulty of the melodies. In the post-experiment interviews, several African participants reported having used difficulty of playing the melodies as one criterion of assessing complexity. *Note density* certainly corresponds with this explanation. Also, *tonal ambiguity* may be an index of playability since tonal scale structures are used in the practice of western music. Therefore it is more difficult to play a tonally ambiguous piece because the internalized representations and motor programmes are unsuitable to the music.

Further research into the mechanisms underlying the formation of melodic complexity across cultures is important in music cognition, despite the aforementioned methodological and epistemological concerns. The theories and experimental work in music perception are being developed within a very narrow scope, habitually with participants from a single socio-cultural background in laboratory settings. Many music researchers from the area of humanities object to this limited perspective, and often rightly so. Nevertheless, according to these critics, broadening the scope of empirical work to encompass participants from various cultures and arranging experiments outside the laboratory may not be enough, since they maintain that the essential features of musical cultures lie in their unique features, which can only be studied from within. We would not go that far, as the study of common mental mechanisms is an appealing topic in the research of musical behaviour, despite – and due to – the fact that there are large differences in musical parameters across cultures.

ACKNOWLEDGEMENTS

We thank Philip and Julie Clifford for consultation on the project and the access to participants (STTEP music school). We also thank Peter Rantho and Joseph Mathibe from Pretoria, South Africa, for extensive contributions to this research and for serving as our expert guides in selecting and editing the African melodies for Experiment 2. Sanna Kivinen from the University of Jyväskylä, Finland, gave us insightful comments about the South African township music culture and the background of STTEP music students. The contribution of the STTEP music school and Cygnaeus high-school students is gratefully acknowledged.

NOTES

1. In notated music, where barring is explicitly stated and the metrical hierarchy therefore relatively easy to infer, this model helps to find an analytic solution, although this is not necessarily an ecologically valid one. However, in an analysis based solely upon note onset and note duration information, finding the meter and the metrical hierarchy is a separate challenge and beyond the scope of this current study. Therefore, the notation was the basis for the meter and metrical hierarchy information.
2. The considerably high number of eliminated results (17 in all) may be due to the difficult field conditions, as no apparent difficulties or misunderstandings in the experimental procedure were encountered in a pilot study run a year earlier with a similar South African group. Also, the post-experiment interviews with the African participants indicated that the task was well understood and that they were highly motivated to try their best at the experiment.

REFERENCES

Adachi, M. and Trehub, S.E. (2000) 'Decoding the Expressive Intentions in Children's Songs', *Music Perception* 18(2): 213–24.

Agawu, V.K. (1995) *African Rhythm*. Cambridge: Cambridge University Press.

Allen, L. (2003) 'Bubblegum', in L. Macy (ed.) *Grove Music Online*, accessed March 2003 [http://www.grovemusic.com].

Arom, S. (1991) *African Polyphony and Polyrhythm*. Cambridge: Cambridge University Press.

Balkwill, L.L. and Thompson, W.F. (1999) 'A Cross-Cultural Investigation of the Perception of Emotion in Music: Psychophysical and Cultural Cues', *Music Perception* 17(1): 43–64.

Baruch, C. and Drake, C. (1997) 'Tempo Discrimination in Infants', *Infant Behavior and Development* 20(4): 573–77.

Bey, C. and McAdams, S. (2002) 'Schema-Based Processing in Auditory Scene Analysis', *Perception and Psychophysics* 64(5): 844–54.

Bigand, E. (1993) 'The Influence of Implicit Harmony, Rhythm and Musical Training on the Abstraction of "Tension-Relaxation Schemas" in Tonal Musical Phrases', *Contemporary Music Review* 9: 123–37.

Blacking, J. (1967) *Venda Children's Songs: A Study in Ethnomusicological Analysis*. Johannesburg: Witwatersrand University Press.

Blum, S. (1991) 'European Musical Terminology and the Music of Africa', in B. Nettl and P.V. Bohlman (eds) *Comparative Musicology and Anthropology of Music: Essays on the History of Ethnomusicology*, pp. 3–36. Chicago, IL: University of Chicago Press.

Boltz, M. (1991) 'Some Structural Determinants of Melody Recall', *Memory and Cognition* 19: 239–51.

Boltz, M. and Jones, M.R. (1986) 'Does Rule Recursion Make Melodies Easier to Reproduce? If Not, What Does?', *Cognitive Psychology* 18: 389–431.

Bragg, B.W.E. and Crozier, J.B. (1974) 'The Development with Age of Verbal Exploratory Responses to Sound Sequences Varying in Uncertainty Level', in D. Berlyne (ed.) *Studies in the New Experimental Aesthetics*, pp. 91–108. Washington, DC: Hemisphere Publishing.

Bregman, A.S. (1990) *Auditory Scene Analysis: The Perceptual Organization of Sound*. Cambridge, MA: MIT Press.

Campbell, R.J., Krysciak, A.M. and Schellenberg, E.G. (2000) 'Perceiving Emotion in Melody: Interactive Effects of Pitch and Rhythm', *Music Perception* 18(2): 155–71.

Carterette, E.C. and Kendall, R.A. (1999) 'Comparative Music Perception and Cognition', in D. Deutsch (ed.) *The Psychology of Music*, pp. 725–91. San Diego, CA: Academic Press.

Castellano, M.A., Bharucha, J.J. and Krumhansl, C.L. (1984) 'Tonal Hierarchies in the Music of North India', *Journal of Experimental Psychology: General* 113: 394–412.

Cock, S. and Wood, M. (2001) *Spot On! Songbook*. South Africa: Penguin Publishing.

Cuddy, L.L. and Lunney, C.A. (1995) 'Expectancies Generated by Melodic Intervals: Perceptual Judgments in Melodic Continuity', *Perception and Psychophysics* 57: 451–62.

Deliège, I. (1987) 'Grouping Conditions in Listening to Music: An Approach to Lerdahl and Jackendoff's Grouping Preference Rules', *Music Perception* 4: 325–60.

Demorest, S.M., Morrison, S.J., Aylward, E.H., Cramer, S.C. and Maravilla, K.R. (2002) 'An fMRI Study of Cross-Cultural Music Comprehension', in C. Stevens, D. Burnham, G. McPherson, E. Schubert and J. Renwick (eds) *Proceedings of the 7th International Conference on Music Perception and Cognition*, p. 141. Adelaide: Causal Productions.

DeWitt, L.A. and Samuel, A.G. (1990) 'The Role of Knowledge-based Expectations in Music Perception: Evidence from Musical Restoration', *Journal of Experimental Psychology: General* 119(2): 123–44.

Drake, C. (1998) 'Psychological Processes Involved in the Temporal Organization of Complex Auditory Sequences: Universal and Acquired Processes', *Music Perception* 16(1): 11–26.

Drake, C., Dowling, J. and Palmer, C. (1991) 'Accent Structures in the Reproduction of Simple Tunes by Children and Adult Pianists', *Music Perception* 8(3): 313–32.

Everitt, B.S. and Dunn, G. (2001) *Applied Multivariate Data Analysis*, 2nd edition. London: Arnold.

Frick, R.W. (1985) 'Communicating Emotion: The Role of Prosodic Features', *Psychological Bulletin* 97: 412–29.

Gerardi, G.M. and Gerken, L. (1995) 'The Development of Affective Responses to Modality and Melodic Contour', *Music Perception* 12: 279–90.

Gregory, A.H. and Varney, N. (1996) 'Cross-cultural Comparisons in the Affective Response to Music', *Psychology of Music* 24: 47–52.

Heyduk, R.G. (1975) 'Rated Preference for Musical Compositions as it Relates to Complexity and Exposure Frequency', *Perception and Psychophysics* 17: 84–91.

Hoshino, E. (1996) 'The Feeling of Musical Mode and its Emotional Character in a Melody', *Psychology of Music* 24(1): 29–46.

Hughes, D. (1991) 'Grammars in Non-Western Musics: A Selective Survey', in P. Howell, R. West and I. Cross (eds) *Representing Musical Structure*, pp. 327–62. London: Academic Press.

Jones, A.M. (1959) *Studies in African Music*. London: Oxford University Press.

Jones, M.R. (1987) 'Dynamic Pattern Structure in Music: Recent Theory and Research', *Perception and Psychophysics* 41: 621–34.

Jones, M.R. and Pfordresher, P.Q. (1997) 'Tracking Melodic Events Using Joint Accent Structure', *The Canadian Journal of Experimental Psychology* 51: 271–91.

Juslin, P.N. and Madison, G. (1999) 'The Role of Timing Patterns in Recognition of Emotional Expression from Musical Performance', *Music Perception* 17(2): 197–221.

Kessler, E.J., Hansen, C. and Shepard, R.N. (1984) 'Tonal Schemata in the Perception of Music in Bali and the West', *Music Perception* 2(2): 131–65.

Kivinen, S. (2003) '"Jos Teet Musiikkia, Et Voi Tehdä Rikoksia". Musiikkiharrastus Eteläafrikkalaisten STTEP-Musiikkikoululaisten Identiteetin Rakentajana' ('If you play music, you cannot commit crimes': Music tuition in construction of social identity among the South African STTEP music school students), *Musiikin Suunta* 25(1): 5–17.

Knopoff, L. and Hutchinson, W. (1983) 'Entropy as a Measure of Style: The Influence of Sample Length', *Journal of Music Theory* 27: 75–97.

Koetting, J. (1970) 'Analysis and Notation of West African Drum Ensemble Music', *Selected Reports in Ethnomusicology* 1(3): 116–46.

Krumhansl, C.L. (1979) 'The Psychological Representation of Musical Pitch in a Tonal Context', *Cognitive Psychology* 11: 346–74.

Krumhansl, C.L. (1990) *Cognitive Foundation of Musical Pitch*. New York: Oxford University Press.

Krumhansl, C.L. (1995) 'Music Psychology and Music Theory: Problems and Prospects', *Music Theory Spectrum* 17: 53–90.

Krumhansl, C.L. and Jusczyk, P.W. (1990) 'Infants' Perception of Phrase Structure in Music', *Psychological Science* 1(1): 70–3.

Krumhansl, C.L. and Kessler, E.J. (1982) 'Tracing the Dynamic Changes in Perceived Tonal Organization in a Spatial Representation of Musical Keys', *Psychological Review* 89: 334–68.

Krumhansl, C.L., Louhivuori, J., Toiviainen, P., Järvinen, T. and Eerola, T. (1999) 'Melodic Expectation in Finnish Spiritual Folk Hymns: Convergence of Statistical, Behavioral, and Computational Approaches', *Music Perception* 17(2): 151–96.

Krumhansl, C.L., Toivanen, P., Eerola, T., Toiviainen, P., Järvinen, T. and Louhivuori, J. (2000) 'Cross-cultural Music Cognition: Cognitive Methodology Applied to North Sami Yoiks', *Cognition* 76(1): 13–58.

Kubik, G. (1994) *Theory of African Music*. Wilhelmshaven: F.J. Noetzel.

Kutu, F. and Van Niekerk C. (1998) *Sina's Songs*. Pretoria: University of Pretoria.

Lerdahl, F. and Jackendoff, R. (1983) *A Generative Theory of Tonal Music*. Cambridge, MA: MIT Press.

McGraw, K.O. and Wong, S.P. (1996) 'Forming Inferences about Some Intraclass Correlation Coefficients', *Psychological Methods* 1(1): 30–46.

Magill, J.M. and Pressing, J.L. (1997) 'Asymmetric Cognitive Clock Structures in West African Rhythms', *Music Perception* 15(2): 189–222.

Meyer, R.K., Palmer, C. and Mazo, M. (1998) 'Affective and Coherence Responses to Russian Laments', *Music Perception* 16(1): 135–50.

Nam, U. (1998) 'Pitch Distributions in Korean Court Music: Evidence Consistent with Tonal Hierarchies', *Music Perception* 16(2): 243–48.

North, A.C. and Hargreaves, D.J. (1995) 'Subjective Complexity, Familiarity and Liking for Popular Music', *Psychomusicology* 14: 77–93.

Oram, N. and Cuddy, L.L. (1995) 'Responsiveness of Western Adults to Pitch-Distributional Information in Melodic Sequences', *Psychological Research* 57: 103–18.

Palmer, C. (1989) 'Mapping Musical Thought to Musical Performance', *Journal of Experimental Psychology: Human Perception and Performance* 15(2): 331–46.

Palmer, C. and Krumhansl, C.L. (1990) 'Mental Representation for Musical Meter', *Journal of Experimental Psychology: Human Perception and Performance* 16(4): 728–41.

Parncutt, R. (1994) 'A Perceptual Model of Pulse Salience and Metrical Accent in Musical Rhythm', *Music Perception* 11(4): 409–64.

Poortinga, Y.H. (1972) 'A Comparison of African and European Students in Simple Auditory and Visual Tasks', in L.J. Cronbach and P.J. Drenth (eds) *Mental Tests and Cultural Adaptation*, pp. 349–54. The Hague: Mouton.

Poortinga, Y.H. and Foden, B.I.M. (1975) 'A Comparative Study of Curiosity in Black and White South African Students', *Psychologia Africana* (monograph), Supplement 8.

Primos, K. (2001) 'Africa', in D.J. Hargreaves and A.C. North (eds) *Musical Development and Learning: The International Perspective*, pp. 1–13. London: Continuum.

Repp, B. (1995) 'Detectability of Duration and Intensity Increments in Melody Tones: A Partial Connection between Music Perception and Performance', *Perception and Psychophysics* 57(8): 1217–32.

Rumelhart, D.E. (1980) 'Schemata: The Building Blocks of Cognition', in R.J. Spiro, B.C. Bruce and W.F. Brewer (eds) *Theoretical Issues in Reading Comprehension*, pp. 38–58. Hillsdale, NJ: Lawrence Erlbaum.

Russell, P., Deregowski, J. and Kinnear, P. (1997) 'Perception and Aesthetics', in J.W. Berry, P.R. Dasen and T.S. Saraswathi (eds) *Handbook of Cross-Cultural Psychology, Volume 2: Basic Processes and Human Development*, pp. 107–36. Boston, MA: Allyn and Bacon.

Saffran, J.R., Johnson, E.K., Aslin, R.N. and Newport, E.L. (1999) 'Statistical Learning of Tone Sequences by Human Infants and Adults', *Cognition* 70(1): 27–52.

Sampat, K.S. (1978) 'Categorical Perception in Music and Music Intervals', *Journal of the Indian Musicological Society* 9(4): 32–35.

Schaffrath, H. (1995) *The Essen Folksong Collection in Kern Format* (computer database), ed. D. Huron. Menlo Park, CA: Center for Computer Assisted Research in the Humanities.

Scherer, K.R., Banse, R. and Wallbott, H.G. (2001) 'Emotion Inferences from Vocal Expression Correlate across Languages and Cultures', *Journal of Cross-Cultural Psychology* 32(1): 76–92.

Simonton, D.K. (1984) 'Melodic Structure and Note Transition Probabilities: A Content Analysis of 15,618 Classical Themes', *Psychology of Music* 12(1): 3–16.

Smith, K.C. and Cuddy, L. (1986) 'The Pleasingness of Melodic Sequences: Contrasting Effects of Repetition and Rule-Familiarity', *Psychology of Music* 14(1): 17–32.

Snyder, J.L. (1990) 'Entropy as a Measure of Musical Style: The Influence of a Priori Assumptions', *Music Theory Spectrum* 12: 121–60.

Stobart, H. and Cross, I. (2000) 'The Andean Anacrusis? Rhythmic Structure and Perception in Easter Songs of Northern Potosí, Bolivia', *British Journal of Ethnomusicology* 9(2): 63–94.

Tekman, H.G. and Hortaçsu, N. (2002) 'Aspects of Stylistic Knowledge: What Are Different Styles Like and Why Do We Listen to Them?', *Psychology of Music* 30(1): 28–47.

Temperley, D. (2000) 'Meter and Grouping in African Music: A View from Music Theory', *Ethnomusicology* 44(1): 65–96.

Temperley, D. (2001) *The Cognition of Basic Musical Structures*. Cambridge, MA: MIT Press.

Terwogt, M.M. and Grinsven, F.V. (1991) 'Musical Expression of Moodstates', *Psychology of Music* 19: 99–109.

Thomassen, J. (1982) 'Melodic Accent: Experiments and a Tentative Model', *Journal of the Acoustical Society of America* 71: 1596–605.

Thompson, W.F. (1994) 'Sensitivity to Combinations of Musical Parameters: Pitch with Duration, and Pitch Pattern with Durational Pattern', *Perception and Psychophysics* 56: 363–74.

Todd, N.P. (1994) 'The Auditory "Primal Sketch": A Multiscale Model of Rhythmic Grouping', *Journal of New Music Research* 23: 25–70.

Toiviainen, P. and Eerola, T. (2003) 'Where Is the Beat?: Comparison of Finnish and South African Listeners', in R. Kopiez, A.C. Lehmann, I. Wolther and C. Wolf (eds) *Proceedings of the 5th Triennial Escom Conference*, pp. 501–4. Hanover: Hanover University of Music and Drama.

Toiviainen, P. and Snyder, J. (2003) 'Tapping to Bach: Resonance-based Modeling of Pulse', *Music Perception* 21(1): 43–80.

Trehub, S., Schellenberg, E. and Hill, D. (1997) 'The Origins of Music Perception and Cognition: A Developmental Perspective', in I. Deliège and J. Sloboda (eds) *Perception and Cognition of Music*, pp. 103–28. Hove: Psychology Press.
Unyk, A.M., Trehub, S.E., Trainor, L.J. and Schellenberg, E.G. (1992) 'Lullabies and Simplicity: A Cross-Cultural Perspective', *Psychology of Music* 20(1): 15–28.

Appendix 1: list of western melodies used in Experiment 1

Collection name			
canada01	deut4130	erk0470	jugos119
czech09	deut4173	erk0586	lothr029
danmark9	deut4192	erk0704	luxemb01
deut094	deut433	erk0794	oestr022
deut111	deut4468	erk0846	romani09
deut200	deut4538	erk1038	romani26
deut259	deut4591	erk2080	suisse12
deut3076	deut5061	erk2084	sverig05
deut3609	deut5084	erk2495	sverig06
deut3769	elsass10	italia05	sverig07
deut3902	emmenth2	jugos052	sverig10
deut3945	erk0092	jugos094	sverig11
deut3960	erk0421	jugos114	ussr07

Note: All melodies are from the Essen folk song collection (Schaffrath, 1995).

Appendix 1: list of African melodies used in Experiment 2

Name			
Bašimane	Le mmone	Pela	Thereline
Demazana †	Mangwane mpulele	Pula ya na †	Thula thu' †
Dikgomo	Mapimpana	Ra šila†	Tsela di matlapa
Dinaledi	Mašilo wee	Re Bananyana	Tšhaba dimaketše
Emonti †	Mmagwe ke moloi	Sebakanyana	Tšhelete
Ge ngabe ke le	Mma Selina	Sehlekehleke	Tsoga
Ge re sila †	Mokgonyana	Serantabola	Tweba dili tharo †
Impuku nekati †	Nganginehhashi †	Silang mabele †	Uthando lwakhe †
Ke llata	Ngwana malome	Sina wee	We makoti
Ke ne ke nkile †	Nkuke	Siyanibulisa †	Wena
Lebake	O jele tamati †	Tamati sososo †	Wen' osematholeni †

Note: All melodies are from *Sina's Songs* (Kutu and van Niekerk, 1998), except those marked with †, which are from the *Spot On! Songbook* (Cock and Wood, 2001).

TUOMAS EEROLA is a senior assistant in musicology at the University of Jyväskylä, Finland. He is interested in music cognition and psychology, especially in melody perception. He is a graduate of the University of Jyväskylä, Finland and his PhD dissertation (2003) work involved dynamic aspects and cross-cultural correlates of melodic expectancy.
Address: Department of Music, University of Jyväskylä, Finland, PO Box 35, FIN-40014 University of Jyväskylä, Finland. [email: tuomas.eerola@campus.jyu.fi]

TOMMI HIMBERG is a doctoral student at the Faculty of Music at Cambridge University, UK. He is a graduate of the University of Jyväskylä, Finland. In his current research, he explores the cognitive foundations of musical interaction under the supervision of Dr Ian Cross.
Address: St. Edmund's College, Cambridge CB3 0BN, UK. [email: tijh2@cam.ac.uk]

PETRI TOIVIAINEN is a Professor of Music at the University of Jyväskylä, Finland. His research themes include tonality and beat induction using neural nets and other non-linear systems. His recent publications include articles in the *Journal of New Music Research*, *Music Perception*, *Perception*, *Musicae Scientiae* and he has contributed book chapters to *The Cognitive Neuroscience of Music* (I. Peretz and R. Zatorre (eds), Oxford University Press, 2003) and *Readings in Music and Artificial Intelligence* (E. Miranda (ed.), Harwood Academic Publishers, 2000). He also performs as a jazz pianist.
Address: Department of Music, University of Jyväskylä, Finland, PO Box 35, FIN-40014 University of Jyväskylä, Finland. [email: ptoiviai@campus.jyu.fi]

JUKKA LOUHIVUORI is a Professor of Music at the University of Jyväskylä, Finland. His research themes include cognitive ethnomusicology, music education, African music, spiritual folk hymns and variation in oral cultures. He is the head of the Pythagoras Graduate School for Music and Sound Research and has organized several international conferences. Besides studies in musicology he has pursued instrumental studies at Sibelius-Academy (Helsinki, Finland), specializing in early music and currently in Finnish folk music, especially spiritual folk hymns and shepherd's flute.
Address: Department of Music, University of Jyväskylä, Finland, PO Box 35, FIN-40014 University of Jyväskylä, Finland. [email: louhivuo@campus.jyu.fi]