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Report

Universal Recognition of Three Basic Emotions in Music

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Summary

It has long been debated which aspects of music perception are universal and which are developed only after exposure to a specific musical culture [1–5]. Here, we report a crosscultural study with participants from a native African population (Mafa) and Western participants, with both groups being naive to the music of the other respective culture. Experiment 1 investigated the ability to recognize three basic emotions (happy, sad, scared/fearful) expressed in Western music. Results show that the Mafas recognized happy, sad, and scared/fearful Western music excerpts above chance, indicating that the expression of these basic emotions in Western music can be recognized universally. Experiment 2 examined how a spectral manipulation of original, naturalistic music affects the perceived pleasantness of music in Western as well as in Mafa listeners. The spectral manipulation modified, among other factors, the sensory dissonance of the music. The data show that both groups preferred original Western music and also original Mafa music over their spectrally manipulated versions. It is likely that the sensory dissonance produced by the spectral manipulation was at least partly responsible for this effect, suggesting that consonance and permanent sensory dissonance universally influence the perceived pleasantness of music.

Results and Discussion

The expression of emotions is a basic feature of Western music, and the capacity of music to convey emotional expressions is often regarded as a prerequisite to its appreciation in Western cultures. This is not necessarily the case in non-Western music cultures, many of which do not similarly emphasize emotional expressivity, but rather may appreciate music for qualities such as group coordination in rituals. To our knowledge, there has not yet been a conclusive investigation into the universals of the recognition of emotional expression in music and music appreciation. The investigation of musical universals with Western music stimuli requires participants who are completely naive to Western music. Even individuals from non-Western cultures who have only listened to Western music occasionally, and perhaps without paying explicit attention to it (e.g., while listening to the radio or watching a movie), do not qualify as participants because musical knowledge is usually acquired implicitly and is thus even shaped through inattentive listening experience [6]. The individuals investigated in our study belonged to the Mafa, one of approximately 250 ethnic groups that make up the population of Cameroon. They are located in the Extreme North in the Mandara mountain range, an area culturally isolated as a result of a high regional density of endemic illnesses. The more remote Mafa settlements do not have electrical supply and are still inhabited by many individuals who pursue a traditional lifestyle and have never been exposed to Western music.

The investigation of the recognition of emotional expressions conveyed by the music of other cultures has only been addressed in three previous studies [1, 7, 8]. These studies aimed to investigate cues that transcend cultural boundaries, and the authors made an effort to include listeners with little prior exposure to the music presented (e.g., Westerners listening to Hindustani music). Although these studies have significantly enhanced our understanding of how cultural experience may influence music perception, the participants in these studies were exposed to the mass media and thus also inadvertently to emotional cues of the respective foreign music (for example, by the association of this music with films). To draw clear conclusions about music universals, however, it is necessary to address music listeners who are completely culturally isolated from one another. Here, we employed a research paradigm to investigate the recognition of musical emotion in two groups: Mafa listeners naive to Western music and a group of Western listeners naive to Mafa music. Experiment 1 was designed to examine the recognition of three basic emotions as expressed by Western music (happy, sad, and scared/fearful), using music pieces that had been used previously to investigate the recognition of these emotions in brain-damaged patients [9, 10].

Data from experiment 1 showed that all three emotional expressions (happy, sad, and scared/fearful) were recognized above chance level by both Western and Mafa listeners (Figure 1A, see also Supplemental Data available online for statistical evaluation; note that the Mafa listeners had never been exposed to Western music before). However, the Mafa listeners showed considerable variability in their performance, and 2 of the 21 Mafa participants performed at chance level. The mechanism underlying the universal recognition of emotional expressions conveyed by Western musical phrases appears to be quite similar for both Western listeners and the Mafas: an analysis of rating tendencies revealed that both Mafas and Westerners relied on temporal cues and on mode for their judgment of emotional expressions, although this pattern was more marked in Western listeners (see Supplemental Results and Discussion for details). For the tempo, both Westerners

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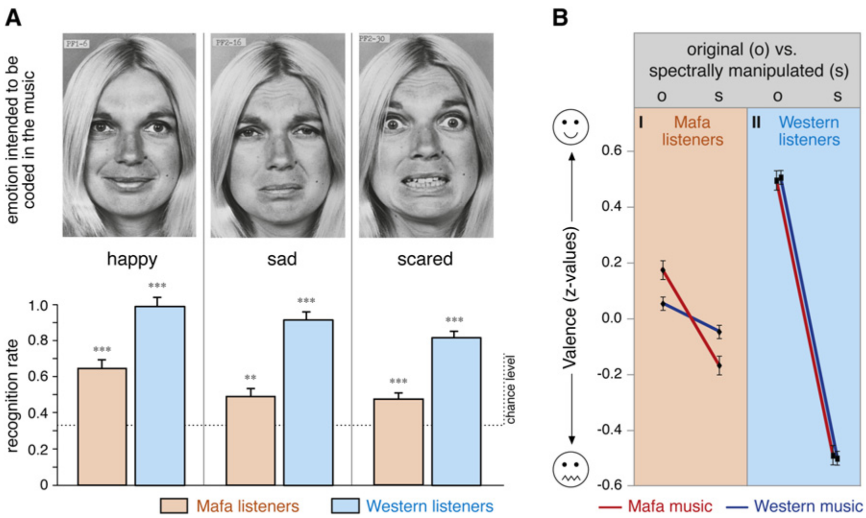

Figure 1. Main Results from Experiments 1 and 2

(A) Experiment 1: The participants listened to short piano pieces and had to decide which of three faces from the Ekman archive (depicting emotional expressions corresponding to those in the music) fitted best with the perceived music stimulus. The figure shows the mean performance in percentage for the recognition of each emotional expression in Western music excerpts, separately for Mafas (light red) and Westerners (light blue; error bars indicate SEM). The dotted horizontal line indicates chance level (1/3); stars indicate the probability that the mean value was significantly different from chance level (***$p < 0.001$, **$p < 0.05$). A MANOVA with the within-subject factor "emotional expression" (happy versus sad versus scared/fearful) and the between-subjects factor group (Mafa versus Western listeners) revealed a main effect of "emotional expression" ($F_{(2,39)} = 15.48$; $p < 0.001$): Happy music was recognized better than scared ($F_{(1,40)} = 24.52$; $p < 0.001$) and sad pieces ($F_{(1,40)} = 12.55$; $p = 0.001$) by members of both cultures. Moreover, a main effect of group ($F_{(1,40)} = 117.83$; $p < 0.001$) indicated a different recognition performance between the two groups (with Western listeners having higher hit rates than Mafa listeners).

(B) Experiment 2: Mean values of valence ratings for the main effects of *spectrum* (error bars indicate SEM), separately for Mafas (light red panel) and Westerners (light blue panel). Each panel shows the mean ratings for original excerpts (*o*; forward and backward excerpts pooled) and spectrally manipulated excerpts (*s*; forward and backward excerpts pooled). Ratings for Mafa music are connected by red lines; ratings for Western music are connected by blue lines.

and Mafas were more likely to classify pieces with higher tempo as happy and pieces with lower tempo as scared/fearful, whereas for sad pieces, no correlation with tempo was observed. The categorization of pieces was also significantly influenced by the mode of the piece, in both groups. Both Westerners and Mafas classified the majority of major pieces as happy, the majority of pieces with indefinite mode as sad, and most of the pieces in minor as scared/fearful (see Table S6).

The universal capacity to identify emotional expressions in Western music is presumably at least partly due to the universal capability to recognize nonverbal patterns of emotional expressiveness [11] such as emotional prosody: emotional prosody is mimicked by Western music as a means of emotional expression [12], and it has also previously been shown that emotional prosody can be recognized universally [13]. This interpretation is consistent with the notion that similar emotion-specific acoustic cues are used to communicate emotion in both speech and music [14, 15]. Importantly, the recognition of an emotional expression, as investigated in experiment 1, does not necessarily assume that a listener also experiences the respective emotion [16] (see also Supplemental Data for details).

Experience of emotion was investigated in experiment 2, which explored whether listeners felt that the experience of listening to music was pleasant or unpleasant. Previous evidence from developmental [17, 18] (see also Supplemental Data) and functional neuroimaging studies [19–22] have shown that Western listeners perceive consonant music as more pleasant compared to permanently dissonant music. Experiment 2 aimed to investigate whether the Mafa listeners would also do the same (the Supplemental Experimental Procedures also include data on a comparison of music played forward and music played backward). We presented original Western and original Mafa music and spectrally manipulated versions of these excerpts to both Mafa and Western individuals. Each spectrally manipulated version consisted of the original tune that was played synchronously with two pitch-shifted versions of the same tune: one version was shifted one semitone upward, and another version was shifted a tritone downward (see Figure 2 for spectrograms and Supplemental Experimental Procedures for sound examples).

This experimental manipulation increased the sensory dissonance of the music (for an explanation of "sensory dissonance," see Supplemental Discussion) with the advantage that it allowed us to manipulate both Western and Mafa music and to use original, naturalistic music excerpts (i.e., ecologically valid stimuli) for a comparison with their spectrally manipulated counterparts. However, at the same time, this experimental manipulation also increased the spectral complexity of the music (because three versions of the musical excerpt were simultaneously audible in different keys, thereby leading to a greater density of the spectral texture; a possible effect of this factor on the perceived pleasantness is discussed further below). It must be noted that an investigation of consonance or dissonance with isolated intervals [23] would have posed the problem that it would have remained unclear whether a possible preference of consonance over dissonance in Mafa listeners extends to "real" music. To our knowledge, only one study has so far addressed the appreciation of musical intervals with varying dissonance in different cultures [24]. However, that study [24] was not designed to investigate music universalities because it addressed groups of participants who, while having grown up in different countries, shared an overlapping music culture through the mass media.

Results revealed that both Mafa and Western listeners rated the original excerpts as being more pleasant than the spectrally manipulated ones, for both their own music ($p < 0.001$ for both groups; see also Table S4) and for the music of the respective other music culture ($p < 0.001$ for Westerners listening to Mafa music, $p = 0.022$ for Mafas listening to Western music; see also Figure 1B, Table S4, and Supplemental Statistical Evaluation). It is likely that the difference in sensory dissonance contributed to the difference in pleasantness ratings. Therefore, our findings presumably reflect that

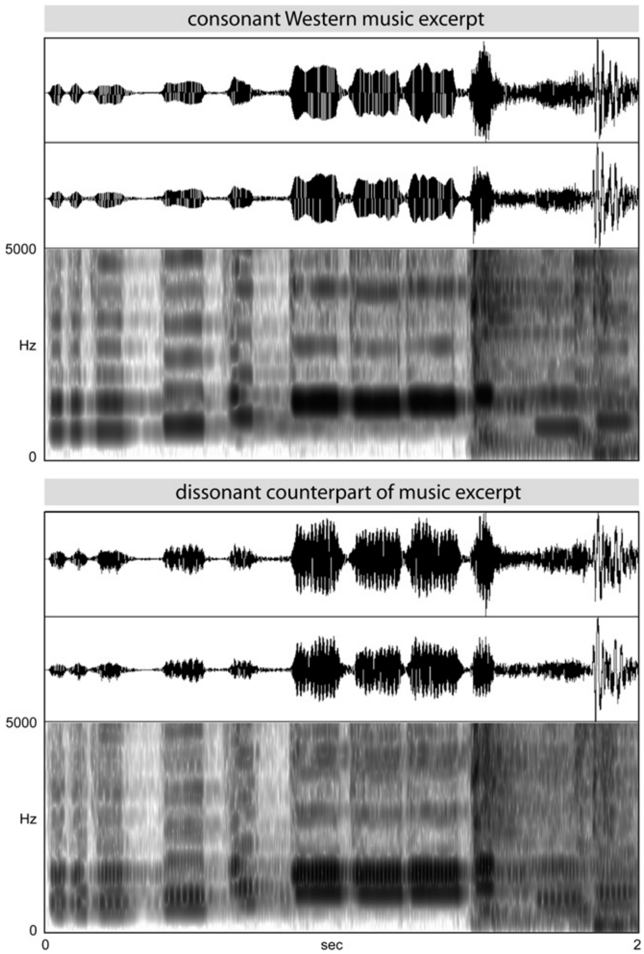

Figure 2. Envelopes and Spectrograms of an Original Western Music Piece and Its Spectrally Manipulated Counterpart

consonance is universally perceived as being more pleasant than permanent sensory dissonance. However, it is also likely that dissonance was not the only factor that contributed to the results. This is because the original stimuli also differed from the spectrally manipulated stimuli in that more frequencies were simultaneously audible in the manipulated versions, increasing their spectral complexity and possibly rendering the stimuli more unpleasant.

However, it is likely that the difference in pleasantness ratings observed between the original and manipulated musical excerpts in the Mafas was at least partly due to a preference for more consonant music compared to permanently dissonant music: to the Mafas, the spectrally manipulated versions probably sounded as if more instruments were playing at the same time than in the original versions, and the Mafas prefer music in which more instruments are played simultaneously because this indicates more powerful performances of multiple players (see Supplemental Discussion). This preference renders it unlikely that the increased spectral complexity of the manipulated versions was perceived as unpleasant. Experiment 2 also showed that the difference in pleasantness ratings between the original and manipulated versions was greater in Western than in Mafa listeners (see also Figure 1B, Figure S2, and Table S2: "spectrum × subgroup"). This group difference is discussed in the Supplemental Discussion.

In conclusion, both Mafa and Western listeners showed an ability to recognize the three basic emotional expressions tested in this study (happy, sad, and scared/fearful) from Western music above chance level. This indicates that these emotional expressions conveyed by the Western musical excerpts can be universally recognized, similar to the largely universal recognition of human emotional facial expression [25] and emotional prosody [13]. Furthermore, both Mafa and Western listeners perceived original music as being more pleasant than spectrally manipulated versions of this music. Although this manipulation did not only increase the sensory dissonance of the stimuli, it is likely that the difference in consonance or dissonance contributed at least partly to the difference in perceived pleasantness between original and manipulated stimuli. Therefore, the present findings support the notion that consonance and permanent sensory dissonance universally modulate the perceived pleasantness of music, although the extent of this modulation appears to be influenced by cultural experience.

Experimental Procedures

Participants

Twenty-one Mafas (13 males, ~37 to ~90 years old, M = 62.3 years) and 20 Westerners (nonmusicians, ten males, 40 to 68 years old, M = 52.4 years) participated in experiment 1 (testing the recognition of musical emotion expression). Criteria for the selection of Western listeners were that they were not familiar with African music and matched the age range of the Mafa participants approximately.

In experiment 2, 22 Mafas (ten of whom also participated in experiment 1 (four males, ~37 to ~70 years, M = 56 years) rated how pleasant or unpleasant they perceived Western music and its counterparts (Figure 1B; ten males; ~35 to ~75 years, M = 58.0 years) Twenty-one Mafas also rated how pleasant or unpleasant they perceived Mafa music and its counterparts to be (Figure 1B; 12 males, ~35 to ~100 years old, M = 62.3 years). Twenty Westerners participated in experiment 2 (Figure 1B; ten males, 40 to 68 years old, M = 52.9 years) of whom 18 (ten males, 40 to 68 years old, M = 52.9 years) had also participated in experiment 1, Criteria for the selection of Western listeners were as for experiment 1.

Stimuli and Experimental Design

In experiment 1, stimuli were computer-generated piano music excerpts with durations of between 9 and 15 s, which were specifically designed to express the emotions happy, sad, and scared/fearful according to Western conventions in that they varied with respect to mode, tempo, pitch range, tone density, and rhythmic regularity [9, 10]. Fourteen stimuli from each category (42 in total) were presented with a CD player and headphones (two pseudorandomized sequences). During the experiment, the stimuli were only audible to the participant over headphones to avoid response biases caused by the experimenter.

In experiment 2, the stimulus material included 14 Western music pieces and ten Mafa music recordings and also their spectrally manipulated and reversed (played-backward) counterparts, with four stimulus categories included in both experiments: (1) original, (2) reversed original, (3) spectrally manipulated, and (4) reversed spectrally manipulated. We performed spectral manipulation by rendering a multitrack arrangement using the software "Ableton Live," in which three versions of the music excerpt, one in original pitch, one pitched a semitone higher, and one pitched a tritone lower (but all with the original tempo) were played simultaneously (see Figure 2 for spectrograms).

The stimuli varied in their duration (2, 10, and 30 s.). In total, the Mafa music experiment comprised 120 trials, and the Western music experiment comprised 168 trials. Stimuli and instructions were presented with Presentation software (version 0.70; www.neuro-bs.com) on a laptop (charged by a mobile solar electricity facility).

Western and Mafa music included instrumental pieces. The Mafa music was recorded during Mafa rituals involving flute playing (see Figure 3, Figure S1, and Supplemental Experimental Procedures). The Western music included joyful instrumental dance music from the past four centuries (acoustic examples in additional online material) that have been successfully utilized as stimulus material in previous studies [20, 21]. The participants

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Figure 3. Mafa Flutes

The Mafa flutes consist of two functional components, a resonance body made out of forged iron and a mouthpiece crafted from a mixture of clay and wax. The flute is an open tube which is blown like a bottle, and has a small hole at its bottom end with which the degree to which the tube is opened or closed can be controlled. The depicted set of Mafa flutes is "refined" with a rubber band.

were asked to indicate their appreciation or dislike of the music on a continuous scale with a slider interface (see Figure S6 and other Supplemental Data).

Supplemental Data

Supplemental Data include seven figures, six tables, Supplemental Results, Discussion, and Experimental Procedures, and eight audio files and can be found with this article online at http://www.current-biology.com/supplemental/S0960-9822(09)00813-6.

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