A biological basis for musical tonality

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Abstract

Like other sensory qualities, the human ability to perceive tonal sound stimuli has presumably evolved because of its utility. Although a variety of tonal sounds are present in the human auditory environment, the vocalizations of other humans are the most biologically relevant and the most frequently experienced. It is thus reasonable to assume that our appreciation of tonal sounds has arisen primarily for the benefits that accrue from this conspecific information. It follows that the structure and function of the tonal sounds produced by the human vocal apparatus may provide the key to understanding how and why we perceive tonality in music the way that we do. Here we consider recent evidence that bears on this idea.

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1. Introduction

Tones are periodic sound stimuli perceived as having a pitch. In nature, such stimuli are produced by objects that resonate at frequencies humans can hear when acted on by a force, most commonly by animal species that generate such sounds for social communication (e. g., the sounds of stridulating insects, the vibrations produced by the songbird syrinx, and the vocalizations of many mammals). Although many such stimuli are present in the human auditory environment, the vocalizations of other humans are the most biologically relevant and frequently experienced (Ter-

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hardt 1984; Schwartz et al. 2003; Gill and Purves 2009). The prevalence and importance of vocal stimuli suggests that an appreciation of tonal sounds in music is linked to human vocalizations.

The merits of understanding musical tonality based on vocalization depend on explaining why we hear musical tones the way we do. To date, this framework has been successfully applied to a variety of phenomena including perception of the missing fundamental (Terhardt 1974; Schwartz and Purves 2004), the fundamental root of musical chords (Terhardt 1984), pitch shift of the residue, spectral dominance and pitch strength (Schwartz and Purves 2004), musical interval preferences (Schwartz et al. 2003; Ross et al. 2007), and scale preferences (Gill and Purves 2009). The work described here focuses on this framework as a way to explain the characteristic affective impact of major and minor music (Bowling et al. 2010).

2. The emotional effects of major and minor music

The affective impact of music depends on many factors including, but not limited to, intensity, tempo, rhythm and the tonal intervals used. For most of these factors the way emotion is conveyed seems intuitively clear. If, for instance, a composer wants to imbue a composition with excitement, the intensity tends to be forte, the tempo fast and the rhythm syncopated. Conversely, if a more subdued effect is desired, the intensity is typically piano, the tempo slower, and the rhythm more balanced (Cohen 1971; Bernstein 1976; Juslin and Laukka 2003). These effects on the listener presumably occur because in each case the characteristics of the music accord with the ways that the corresponding emotional state is expressed in human behavior. The reason for the different emotional impact of the tones used in music, however, is not clear.

Much music worldwide employs subsets of the chromatic scale, which divides each octave into 12 intervals defined by the frequency ratios shown in Fig.1A. In Western music over the last few centuries the most commonly used subsets are the diatonic scales in Fig.1B, the Ionian and the Aeolian scales in particular (Pierce 1962; Bernstein 1976; Randel 1986; Burns 1999; Burkholder et al. 2006). These two scales are usually referred to simply as the major and the minor scale, respectively (Fig.1C) (Aldwell and Schachter 2003). Other things being equal, music using the intervals of the major scale tends to be perceived as relatively excited, happy, bright or martial, whereas music using minor scale intervals tends to be perceived as more subdued, sad, dark or wistful (Zarlino 1558; Hevner 1935; Cooke 1959; Crowder 1984; Krumhansl 1990; Gregory et al. 1996; Peretz et al. 1998; Burkholder et al. 2006). There has been no agreement, however, about how and why these scales and the intervals that differentiate them elicit distinct emotional effects (Heinlein 1928; Hevner 1935; Crowder 1984).

3. Major vs. minor music compared to speech

Given the roots of the human tonal sense (see Introduction), an attractive hypothesis is that musical tones take on their affective qualities by mimicry of emotions expressed vocally. This general idea is supported by several observations. First, voiced speech sounds are harmonic, and has often been