SOUND and EMOTIONAL RESPONSE

Don Ritter

DESCRIBING SOUNDS

Numerous methods exist for describing sounds, ranging from sinusoidal waves as displayed on an oscilloscope to avant-garde drawings of contemporary composers. The most common method in western civilization is the diatonic scale. This scale consists of octaves containing twelve tones. Within a single octave the notes are coded as A through G which are then repeated in the next octave. The notes within a particular octave are double the frequency of those in the next lower octave. The A note in the fourth octave, identified as A4 has a fundamental frequency of 440 Hz, while A5 in the fifth octave has a fundamental frequency of 880 hz. The notes B4 through G4 are used to describe those notes with fundamental frequencies between 440 Hz, A4, and 880 Hz, A5. The traditional staff, bar, and symbols used with the diatonic scale enable the note, the duration of a note and the length of rests between notes to be indicated.

Although the diatonic scale is widely used in music, disadvantages exist when attempting to describe simple tones. Firstly, the diatonic scale and nomenclature used require extensive learning and secondly, the technique portrays relative rather than absolute timing. In addition, the quality of the sound or timbre is not recorded because musical scores typically can be played on a variety of instruments.

Pitch. Pitch refers to the subjective perception of a particular frequency. With a pure sine wave the pitch is related to the frequency, but with a complex wave the pitch may be the envelope, the rate of growth and decay, of the various component frequencies. Although the notes A4 and A5 have different fundamental frequencies, they will sound similar because their component frequencies, harmonics, are similar.

Timbre. The timbre of a sound or music is also referred to as the quality, color or texture. All these terms refer to the perception of a fundamental frequency, a particular note, and the rate of growth and decay of that note's harmonics. The same note played on different instruments will sound similar because the fundamental frequency is the same but will sound different because different instruments have different timbres. The timbre of a cymbal, for example, displays a fast decay of harmonics while an organ has a slow decay. Besides differing in growth and decay rate of harmonics, different instruments also possess different harmonics. A flute has very few harmonics associated with its fundamental frequencies while an electric guitar has numerous. Figure 1 depicts the timbres of two hypothetical instruments playing the A4 note(f0=440 Hz). Note that different harmonics are present between the two instruments and that their harmonics change differently over time as well.

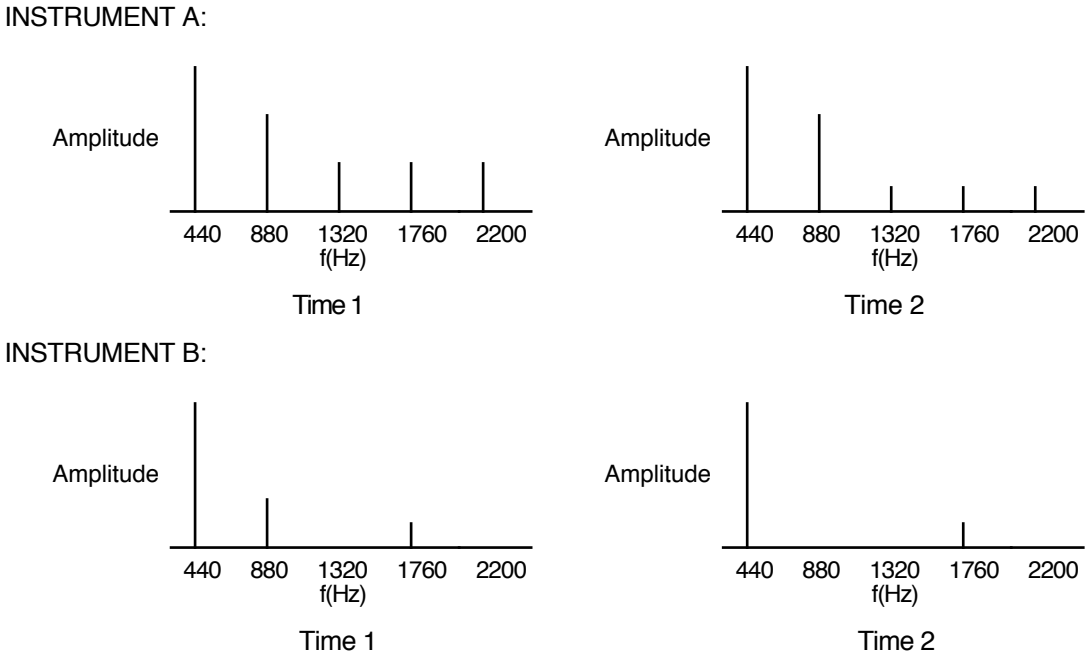

Figure 1. **Timbre of Two Different Instruments**

Temporal Structure. The temporal structure refers to changes in a sound over time. The changes may include the duration of a particular sound or component of a complex sound, rests or moments of silence between sounds, and the relationships between successive notes as to whether similar or dissimilar harmonics occur. A melody exists because of a temporal structure consisting of various notes of different duration with rests. When a melody is remembered, persons show better recall for the temporal structure than the pitch in which the melody was played(Bartlett & Dowling, 1980). If tones are to be used in a human interface, users may recall the meanings of different tones better if they differ in temporal structure rather than pitch.

Loudness. Loudness is the subjective perception of the intensity of a sound. Variations in loudness can occur for a note or for a sub component of a note. Tremolo refers to a quick raising and lowering of a note's loudness.

AFFECTIVE RESPONSES TO MUSIC

Physiological Changes. Music has been found to cause changes in blood pressure, heart rate, respiration and GSR. Physiological reactions are more likely to occur during melodic or vigorous passages. Loud music tends to increase breathing rate and decrease regularity, while soft music increases regularity. The greatest change in GSR was found with unpleasant music and this change was noticed even in persons who did not view music as being important (Lundin, 1967). Music also may lead to skeletal movement such as foot tapping or clapping of hands. Frances & Bruchon-Schweitzer(1983) claim that the music which leads to muscular movement has a similar motor scheme as that manifested. Dissonant chords, notes having slightly different harmonics, are perceived as cues of tension, while consonant chords, notes having the same or drastically different harmonics, are perceived as cues of release.

Factors which may effect reactions to a piece of music are: the selection of music or melody presented, the instrument or timbre of the music, the emotional state of the listener, and the characteristics of the listener(music knowledge, nationality, gender).

Subjective Reactions. To determine subjective reactions to music, subjects are presented with a piece of music and asked to indicate verbally or on paper how they feel about a particular tone or sequence of tones. This approach could supposedly produce a limitless number of reactions, but major categories of responses have been identified. Farnsworth(1958) derived the following ten categories of reactions to music using factor analysis:

A	**B**	**C**	**D**	**E**
cheerful	fanciful	delicate	dreamy	longing
gay	light	graceful	leisurely	pathetic
happy	quaint	lyrical	sentimental	plaintive
joyous	whimsical		serene	yearning
bright			soothing	
merry			tender	
playful			tranquil	
sprightly			quiet	

F	**G**	**H**	**I**	**J**
dark	sacred	dramatic	agitated	frustrated
depressing	spiritual	emphatic	exalting	
doleful		majestic	exciting	
gloomy		triumphant	exhilarated	
melancholic			impetuous	
mournful			vigorous	
pathetic				
sad				
serious				
sober				
solemn				
tragic				

This approach of subjectively rating music has found that strong physiological changes correspond with subjective reports indicating strong reactions. Subjective reactions were found to be similar regardless of subjects' intelligence, musical aptitude, musical training, or age if the person was above the sixth grade. Farnsworth(1958) suggests that more subtle reactions to music would be dependent on experience and personal associations of a person. The major subjective reactions to music are listed below:

minor chords: grief and melancholy
major chords: joy and happiness
loud chords: rarely judged as soothing
fast tempos: happy or gay, excitement
slow tempos: dignified, serene and calm
high pitch: sprightly-humorous
low pitch: sad qualities, vigorous-majestic, dignified-serious
firm rhythm: dignified, spiritual, lofty
repeated listening: generally repeated listening results in increased pleasure, although this is more true for classical music than popular tunes

REFERENCES

Bartlett, J.C. & Dowling, W.J. 1980 Recognition of transposed melodies: a key-distance effect in the developmental perspective. Journal of Experimental Psychology, 6(3), 501-515

Caelli, T. & Porter, D. 1980 On difficulties in localizing ambulance sirens. Human Factors, 22(6), 719-724

Cuddy, Lola L., Cohen, Annabel J. & Mewhort, D. J. K. 1981 Perception of structure in short melodic sequences. Journal of Experimental Psychology, 7(4),869-883

Deutsch, Diana & Feroe, J. 1981 The internal representation of pitch sequences in tonal music. Psychological Review, 88(6), 503-522

Deutsch, Diana 1982 The Psychology of Music. New York:Academic Press

Dewar, R. E. & Ells, J.G. 1977 The semantic differential as an index of traffic sign perception and comprehension. Human Factors, 19, 183-189

Frances, R. & Bruchon-Schweitzer, M. 1983 Musical expression and body expression, Perceptual and Motor Skills, 57, 587-595

Hantz, Edwin 1984 Studies in musical cognition: comments from a music theorist. Music Perception, 2(2), 245-264

Farnsworth, Paul 1958 The Social Psychology of Music.

Idson, Wendy L. & Massaro, Dominic W. 1978. A bidimensional model of pitch in the recognition of melodies. Perception and Psychophysics, 24(6), 551-565

Lundin, Robert W. 1967 An Objective Psychology of Music.

Lazarus, H. & Hoge, H. 1986 Industrial safety: acoustic signals for danger situations in factories. Applied Ergonomics, 17.1, 41-46

Molino, John A., Zerdy, Gerald A., & Frome, Francine S. 1974 Toward a more musical foghorn. Human Factors, 16(6), 567-575

Morrongiello, Barbara A., Trehub, Sandra E., Thorpe, Leigh A. & Capodilupo 1985 Children's perception of melodies: the role of contour, frequency, and rate of presentation. Journal of Experimental Child Psychology, 40, 279-292

Szlichcinski, K.P. 1979 The art of describing sounds. Applied Ergonomics, 10.3, 131-138

Winckel, Fritz. 1963. The Psycho-acoustical analysis of structure as applied to electronic music. The Journal of Music Theory, 7(2), 194-246