Pitch Height and Emotional Response in Musical Pieces

by

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Abstract

The current research looked at the relationship that exists between the mode of a musical piece, its pitch height, and the emotions conveyed to the listener. It was hypothesized that when transposing a minor mode piece downwards in pitch, there will be more frequent reports of negative emotions from the listeners, and when transposing a major mode piece upwards in pitch, there will be more frequent reports of positive emotions from the listeners. In order to test this hypothesis, 22 subjects listened to various musical clips that were major, minor, or atonal. Each clip was edited through Ocenaudio to create two versions of each clip separated in pitch height by one octave. Participants rated each musical clip for the intensity of fear, happiness, and sadness that it communicated. It was found that there was a significant main effect of mode and pitch for each emotion, as well as a significant interactions between pitch and mode for all emotions except sadness.

Pitch Height and Emotional Response in Musical Pieces

Listeners have long ascribed emotional qualities to music. References to the affective qualities of music appear in manuscripts written by ancient Greek philosophers over 2,000 years ago (Aristotle, 1905; Plato, 1943). This paper explores some of the possible reasons why music communicates emotion as well as the acoustic parameters by which it does so. It culminates in an empirical exploration of the role of two elements of music, mode and pitch height, in the communication of emotion.

Emotion

Emotions are adaptive responses that bias behavior (Ekman, 1992). They can be triggered by events that hold personal relevance to one's goals. Emotions are fairly discrete events that can last anywhere from a few seconds to hours, though they generally tend to be short lived. They give way to moods, which linger. Most things that elicit emotion have some personal relevance to the individual experiencing the emotion in that moment (Scherer, 2001). Therefore, it is curious that music, which should bear no relevance to one's goals, can evoke emotion.

Music has the power to both *communicate* emotion and *cause* emotional responses in listeners. For instance, a listener may recognize that the composer is trying to communicate sadness but not feel any personal sadness in response to the song. This paper is more concerned with the musical *communication* of emotion than emotional responses to music.

The Communication of Emotion

Given that emotions bias action (Ekman, 1992; Scherer, 2000), the ability to detect emotion in others may enable one to anticipate the actions of others, which, evolutionarily, would confer a survival advantage. Recognizing an individual's emotional state enables one to assess the probable outcome of interacting with that individual, enabling the detection of potential allies as well as potential sources of threat. Because failure to read these signals could imperil survival, the human species evolved perceptual mechanisms that automatically detect emotional content (Niedenthal & Showers, 1991). There are some behavioral manifestations of emotional responses, such as gestures, vocalizations, and facial expressions, that serve as fairly reliable signals that an emotion has occurred. The detection of emotion in vocal and facial expressions is rapid, automatic, and fairly accurate (Ekman & Friesen, 1971; Niedenthal & Showers, 1991).

Musical emotions are *also* recognized quickly and with a high degree of accuracy, even across cultures (Juslin & Laukka, 2003). However, there is an advantage for within-culture recognition, as research has suggested that individuals listening to musical passages from their own cultures have an easier time detecting emotion from those pieces (Balkwill, Thompson, & Matsunaga, 2004; Juslin & Laukka, 2003).

How is Emotion Communicated in Music?

The emotional "signal" of music is largely carried by the musical structure and the acoustic cues of the musical performance (for a review, see Juslin & Laukka, 2003). And though these cues are more than sufficient for the communication of emotion in music, visual cues provided during a musical performance can enhance communicative success (Vines, Krumhansl, Wanderly, Dalca, & Levitin, 2011). Music can reliably signal the two primary dimensions of emotion, arousal and valence, through sound alone (Juslin & Laukka, 2003).

Acoustic cues are defined as properties of the acoustic signal that can be perceived and interpreted without explicit or implicit knowledge of music conventions. For example, pitch height, loudness, tempo, and timbre are all acoustic cues that communicate emotion (e.g., Nakamura, 1987). Acoustic cues are those that enable identification of emotion across cultures (e.g., Balkwill, Thompson, Matsunaga, 2004; Fritz et al., 2009). For instance, loud, fast music is used to communicate high intensity emotions across cultures (Juslin & Laukka, 2003). Beyond these universal acoustic cues, cultural associations between musical structure and emotion further shape the listener's impression of the music. For instance, there are strong cultural associations in Western music between emotion and the mode of the music. *Mode* refers to a particular combination of musical tones that are used to compose melodies. The major and minor modes are associated with the communication of positive and negative affective states, respectively (for a review, see Gabrielsohn & Lindstrom, 2001). Major scales and minor scales differ in terms of their intervals; minor scales have a flattened third, sixth, and seventh scale degree, while major scales do not (see Figure 1). Atonal music is generally associated with fear and states of uncertainty. Within an atonal scale, all notes are equally important, resulting in a 12 note scale that lacks a modal pitch (see Figure 2).

The simultaneous use of many different acoustic and structural cues may be used to firmly drive home a singular affective state through the use of cue redundancy. The extent to which communication is successful depends on whether the composer and listener share the same cultural associations with the available musical cues. Communication will be more successful when composers and listeners alike draw upon acoustic cues as well as shared cultural cues.

The extent to which the communication of emotion relies on universal acoustic cues versus culturally-specific associations with musical structure has been examined in 147 Japanese listeners who were exposed to Japanese, Western, and Hindustani music (Balkwill, Thompson, & Matsunaga, 2004). It was hypothesized that the listeners would be able to recognize emotion within the passage as a result of universal acoustic cues—those that can be perceived and interpreted without knowledge of music conventions. The musical passages provided were played on stringed instruments and flute. For each stimulus culture (Western, Japanese, Hindustani), there were three separate pieces for every emotion (joy, anger, sadness). The results demonstrated that the listeners could pick up on emotions of the Western and Hindustani music almost as well as the Japanese music, despite having more limited cultural exposure to them. When listening to musical passages from their own culture, participants had an easier time detecting emotion from those pieces than from the culturally unfamiliar music, which may be attributable to cultural variation in mode, key, and the rules surrounding melody and harmony.

Some of the musical associations between acoustic cues and emotion are also observable in human vocal expressions of emotion. Juslin and Laukka (2003) proposed that music evokes emotion due to its acoustic similarity with vocal expressions of emotion. They conducted a meta-analysis to see if human vocalizations of emotion and music communicate emotion by making similar use of the same acoustic parameters. Emotions involve changes in the somatic nervous system, thus altering the musculature for voice production and leading to different sounds depending on which emotion is being felt. Because specific physiological states lead to specific acoustic features of the voice, these vocal cues can be used to rapidly identify emotion. Juslin and Laukka found that many acoustic parameters were used similarly to communicate emotion in language and music. For instance, arousal was communicated using tempo/speech rate and sound intensity. The use of pitch appears to be an important aspect of emotional communication in both domains. It was found that with emotional vocalizations, a higher pitch is associated with some positive emotions but also the fear response, while a lower pitch was often associated with sadness and threat. Other acoustic features, when combined with pitch, can help designate between the positive and negative emotions. Juslin and Laukka's research suggests that the power of music to communicate emotion may stem from its acoustic similarity with vocal expressions of emotion and the brain's treatment of it as such.

Pitch is used in many species to signal threat and submission. In nature, and specifically in mammals, an increase in pitch in a vocalization is often indicative of submission, either in the form of "friendliness" or fear (such as a scream), while a decrease pitch often indicates "aggression" or "threats". Following the natural order associated with pitch, Huron, Kinney, and Precoda (2006) examined the influence of pitch height on the perception of submissiveness and threat in musical passages. They hypothesized that when a musical passage was transposed down, it would be perceived as more aggressive, threatening, or dominant. Similarly, when a passage was transposed up, it would be perceived as more submissive, passive, or polite. In order to test this, the researchers presented a musical passage in three forms to participants. The first form was the normal passage, the second was the passage transposed up by 12 semitones, and the third was the passage transposed down by 12 semitones. Participants rated the submissiveness and dominance of the music on a Likert scale. The results revealed that increasing the pitch height of a piece did lead to greater interpretations of politeness and submissiveness with a decrease in "heaviness" and levels of threat. The research suggested no effect of pitch on feelings of aggressiveness or timidity. The change in emotional responses to the differences in pitch is suggestive of a potential link to the way in which emotionally charged language is delivered.

Turner and Huron (2008) proposed that the ecological associations between pitch height and the vocal communication of emotion could explain some of the emotional associations noted in music, including the affective difference between the major and minor modes. As previously mentioned, the minor mode is often used to convey feelings of sadness, solemnity, loss, and longing. In speech, utterances that are sad often exhibit a lower overall pitch than other primary emotions (Curtis & Bharucha, 2010; Juslin & Laukka, 2003). Turner and Huron points to this as a possible explanation for why the minor mode might be associated with sadness in music. Turner and Huron analyzed the average pitch that existed within a large corpus of major and minor key pieces. They found that the overall pitch height for major-themed pieces was A_4 while the overall pitch height for minor-themed pieces was $\#G_4$, a difference of one semitone. This finding is consistent with sad utterances exhibiting a lower overall pitch, but some researchers view this as a feature of sad music that results from differences in how modes are structured (the minor mode has a lower average pitch height than the major mode, even when key is controlled) and not a probable explanation for why the minor mode is associated with sadness.

Curtis and Bharucha (2010) agreed with Huron (2008) in principle about emotional speech being a possible mapping source for the major/minor emotional distinction, but found the view that this is attributable to a simple difference in average pitch to hold limited explanatory power. The perceptually defining quality of a mode seems to be the relationships between the tones of the mode, particularly the relationship between the first and third scale degree, not the average pitch height of those tones (Gabrielsohn & Lindstrom, 2001). Curtis and Bharucha (2010) provided evidence that the musical relationships that seemingly color the emotional quality of the major and minor modes are also evident in the prosodic contours of emotional speech. These findings suggest that there may be a direct mapping between the communication of emotion in speech and music and also point to the importance of mode as a carrier of the emotional signal—perhaps more important than average pitch height.

The literature indicates that pitch and mode play substantial roles in the musical communication of emotion. Pitch may be crucial for communicating emotion across cultures, and mode may enable even greater communicative specificity within a shared musical culture.

The current study was designed to examine the influence of the mode and pitch height of a musical passage on the subsequent emotion that the passage conveys to the listener. It assessed whether the reported emotional ratings of the stimuli were directly related to changes in pitch height or to the mode of the stimulus. It was hypothesized that when transposing a minor mode piece downwards in pitch there will be more frequent reports of negative emotions from the listeners, and when transposing a major mode piece upwards in pitch there will be more frequent reports of positive emotions from the listeners. This study is important to understanding the independent contributions of pitch height and mode in the communication of emotion as well as how these two features of music interact.

Methods

Participants

The participants in this experiment were 18 undergraduate students recruited from a small university in the northeastern United States. Eight of the participants reported that they played an instrument and had been doing so for an average of 8.14 years (*SD* = 3.75). Seven of the participants reported having some training in music theory. No other demographic data were collected. Each participant was compensated with credit towards a Psychology course.

Materials

All participants were given an online questionnaire through Qualtrics to collect information on their musical backgrounds/training and any music theory training. Six songs were selected as stimuli, two major, two minor, and two atonal (see Appendix A for list of songs) and were edited to create thirty-six musical stimuli: 12 major, 12 minor, and 12 atonal. Each stimulus was 30 seconds long. Pitch-shifted versions of each stimulus were included such that a comparison could be made between higher and lower pitched versions of the same clip in each of the three mode conditions.

Four different Likert scales were used to assess the degree to which each clip communicated happiness, sadness, and fear. Subjects rated levels of emotions for each stimulus on a Likert scale.

Design

This experiment used a 3x2 within-subjects design (three modes, two pitch heights). The dependent variables for this research were the emotions that are reported by the listener. Three different Likert scales were used to assess the degree to which each clip communicated happiness, sadness, and fear.

Procedure

Subjects completed a questionnaire asking for information regarding musical experience. Subjects were then asked to listen to 36 musical stimuli in the same order. After listening a stimulus, the subject was asked to rate the levels of fear, happiness, and sadness communicated by the piece on a Likert scale from 1 to 7 before listening to the next stimulus. Once the subject completed the experiment, they were debriefed and compensated.

Results

The data were analyzed using a 3x2 (mode x pitch) repeated-measures ANOVA with three measures: fear, happiness, and sadness ratings. Conditional means are displayed in Table 1. There were significant main effects of mode on all three measures. There was a significant effect of mode on fear, F (2, 34) = 32.93, $p < .001$, such that atonal (M = 3.91, SD = 2.10) and major (M = 4.14, SD = .82) were perceived as communicating higher degrees of fear than the minor mode (M = 2.53, SD = .69). There was a significant effect of mode on happiness, F (2, 34) =

9.10, *p* = .001, such that minor (*M* = 3.18, *SD* =.42) and major (*M* = 3.04, *SD* = 1.13) were perceived as communicating higher degrees of happiness than atonal (*M* = 2.46, *SD* = .78). There was a significant effect of mode on sadness, *F* (2, 34) = 10.71, *p* < .001, such that minor (*M* = 3.70, *SD* = .32) and atonal (*M* = 3.94, *SD* = .95) were perceived as communicating higher degrees of sadness than major (*M* = 3.17, *SD* = .38).

There was a significant effect of pitch on fear, *F* (1, 17) = 31.96, *p* < .001, such that higher pitched songs (*M* = 4.05, *SD* = 1.89) communicated higher levels of fear than lower pitch songs (*M* = 3.00, *SD* = 1.57). There was a significant effect of pitch height on happiness, *F* (1, 17) = 10.47, *p* = .005, such that lower pitched songs (*M* = 3.24, *SD* = 1.17) communicated higher levels of happiness than higher pitch songs (*M* = 2.54, *SD* = 1.40). There was no significant effect of pitch height on sadness, *F* (1, 17) = .423, *p* = .524; lower pitched songs (*M* = 3.66, *SD* = 1.40) and higher pitch songs (*M* = 3.55, *SD* = 1.21) communicated similar levels of sadness.

There was a significant interaction between mode and pitch height on fear, *F* (2, 34) = 39.39, *p* < .001. High pitch was strongly associated with fear in the atonal condition (*M* = 5.40, *SD* = 1.32), whereas low pitch was not (*M* = 2.43, *SD* = 1.18). A similar, though less divergent pattern was noted in the major mode (high pitch: *M* = 4.72, *SD* = 1.18; low pitch: *M* = 3.56, *SD* = 1.56). The pattern flipped for the minor mode (high pitch: *M* = 2.04, *SD* = .97; low pitch: *M* = 3.02, *SD* = 1.39).

There was a significant interaction between mode and pitch height on happiness, *F*(2, 34) = 17.47, *p* < .001. Low pitch was more associated with happiness in the atonal condition (*M* = 3.01, *SD* = 1.31) than high pitch was (*M* = 1.91, *SD* = .65). A similar pattern was noted in the major mode (low pitch: *M* = 3.84, *SD* = 1.39; high pitch: *M* = 2.24, *SD* = .79). The pattern flipped for the minor mode (low pitch: *M* = 3.48, *SD* = 1.36; high pitch: *M* = 3.93, *SD* = .95).

There was a significant interaction between mode and pitch height on sadness, $F(2, 34) = 11.50$, $p < .001$. Low pitch was more associated with sadness in the atonal condition ($M = 4.61$, $SD = 1.39$) than high pitch was ($M = 3.27$, $SD = .99$). The reverse pattern was noted for the major mode (low pitch: $M = 2.90$, $SD = 1.46$; high pitch: $M = 3.44$, $SD = 1.16$) as well as the minor modes. (low pitch: $M = 3.48$, $SD = 1.03$; high pitch: $M = 3.93$, $SD = .95$).

Discussion

It was hypothesized that when transposing a minor mode piece downwards in pitch there would be more frequent reports of negative emotions from the listeners, and when transposing a major mode piece upwards in pitch there would be more frequent reports of positive emotions from the listeners.

Pitch height and mode interact in complex ways. Contrary to this study's hypothesis, shifting pitch up or down did not increase the level of any of the emotions in a specific way for all modes, even though a main effect of pitch height was evident for all three measures. For instance, though high pitched stimuli were perceived as communicating fear more so than low pitched stimuli, this was not true of all three modes—only for atonal and the major mode. And mode did not communicate emotion in the straight-forward manner suggested by previous literature. According to these results, there is no mode that can be characterized as the "sad mode," "happy mode," or "fear mode." Each mode interacts with pitch height in different ways to communicate emotions.

Fear was best communicated by atonal pieces that had a high average pitch. Atonal pieces that had a low pitch, however, did not reliably communicate fear, and were perceived to align more closely with sadness than with either of the other emotions described. Fear was also communicated by pieces in the major mode that had a high average pitch.

Happiness was best communicated by major mode pieces with a lower average pitch and minor mode pieces in the higher pitch condition. Sadness was best communicated by atonal pieces in the lower pitch condition and minor mode pieces in the higher pitch condition.
The results suggest that the changes in reported levels of emotion communicated by music are influenced by both the pitch height of the musical piece as well as the mode of the piece.

The results from the current study are similar to what was found in research conducted by Curtis and Bharucha (2010) that found a connection between the communication of sadness in speech and the use of the minor second and minor third, two musical intervals that are phenomenologically salient in atonal music and in the minor mode. Curtis and Bharucha found that these intervals are used predominantly in a low vocal register when communicating sadness, which is consistent with the current results that atonal music communicates sadness in a low pitch range but not in a higher pitch range. When compared to the research that was conducted by Huron, Kinney, and Precoda (2006), we see that the results from the current study differ in that the raising of the pitch height of a piece in fact did not communicate a more "polite" or "submissive" emotion. The current study did not find a distinction for happiness and sadness in major and minor mode pieces. This could have been due to the emotional intensity of a piece being more strongly associated with the pitch height of the piece as opposed to the mode itself. The lack of a distinction between major and minor may also have been influenced by the emotional intensity of the atonal pieces that preceded them. The atonal pieces that were heard prior to some of the major and minor pieces may have had a stronger emotional charge to the listener, resulting in a weaker rating for such emotions when listening to the major and minor pieces.

Some of the results of this study may not generalize beyond the stimuli that were selected. The pieces chosen were instrumental, containing no lyrics. There may have been aspects of their unique compositional structures that interacted with the factors that were manipulated in this experiment. Although tempo was not manipulated across conditions, it was also not examined as a variable in this experiment. Tempo interacts with pitch and mode, so the results of this experiment may be unique to the specific tempi of the songs in this study. Similarly, there were other aspects of the musical performances that we did not measure or control for; sound intensity and other dynamic factors, genre, the number of instruments, and the overall stimulus complexity, for example, could have influenced the communication of emotion. Additionally, the stimuli tended to feature string instruments, because these instruments had a low susceptibility to distortion under pitch shifting, making them good candidates for the digital manipulation required for this experiment. It is unknown whether the manipulation of mode and pitch in music featuring string instruments in particular may have different affective qualities than, say, altering these qualities for brass instruments would. Moreover, this research used a relatively small sample size. The results would have undoubtedly been more generalizable with a larger sample size.

Future research should look into atonal pieces if looking at the general effect of pitch height on reported emotions. Atonal pieces would allow for the clearest look at the relationship that exists between pitch height and reported emotions as it isolates aspects of the music. Atonal pieces would control for the influence of mode on the reported emotions allowing for a clearer understanding of the relationship between the pitch height and emotional response. Similarly, the research should look at the relationship between pitch height and reported emotion as determined by the timbre of the instruments on which the pieces are played. Instruments that have a higher timbre may communicate certain emotions in a stronger manner than instruments with a lower timbre. In addition, future research should examine how pitch height and modes interact with other factors, including other aspects of the musical stimulus, to communicate emotion. And since music is often paired with external stimuli, such as visual imagery, how does the addition of visual imagery interact with musical properties to influence the communication of emotion?

The results from the current study suggest that the relationship between the pitch height and the mode of a piece are what influence the overall emotional charge of a piece. Information about how to communicate emotion through music can be used in aspects of everyday life that do not necessarily strictly pertain to musicians and composers. Instead, this information can be used in marketing and advertisement campaigns to influence emotional responses to messages and products, by technology and software companies to enhance the experience of customers and user, and perhaps most importantly, in aspects of education to create atmospheres that cater to the highest levels of comfort that are conducive to learning.

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Appendix A

STIMULI

Minor

- Keyboard concerto in D minor: Adagio, composed by J.S. Bach
- Domestic Pressures, composed by Johann Johannsson

Major

- Flight from the City, composed by Johann Johannsson
- Unaccompanied Cello Suite No. 1 in G Major, BWV 1007, composed by J.S. Bach

Atonal

- Steps, Volume 1: No 1. Greeting, composed by Peter Seabourne
- Scenes Before a Crucifixion, composed by Peter Seabourne

Table 1

Means and standard deviations of ratings

Emotion	Mode	Condition	Means	Standard Deviations
Fear	Atonal	High	5.39	1.32
Fear	Atonal	Low	2.43	1.18
Fear	Major	High	4.72	1.18
Fear	Major	Low	3.56	1.56
Fear	Minor	High	2.04	.97
Fear	Minor	Low	3.02	1.39
Happiness	Atonal	High	1.91	.65
Happiness	Atonal	Low	3.01	1.31
Happiness	Major	High	2.24	.79
Happiness	Major	Low	3.84	1.39
Happiness	Minor	High	3.48	1.03
Happiness	Minor	Low	2.88	1.09
Sadness	Atonal	High	3.27	.99
Sadness	Atonal	Low	4.61	1.39
Sadness	Major	High	3.44	1.16
Sadness	Major	Low	2.90	1.46
Sadness	Minor	High	3.92	.95
Sadness	Minor	Low	3.48	1.37

Figure 1. The major and minor modes. The two modes differ at the 3rd, 6th, and 7th scale degrees.

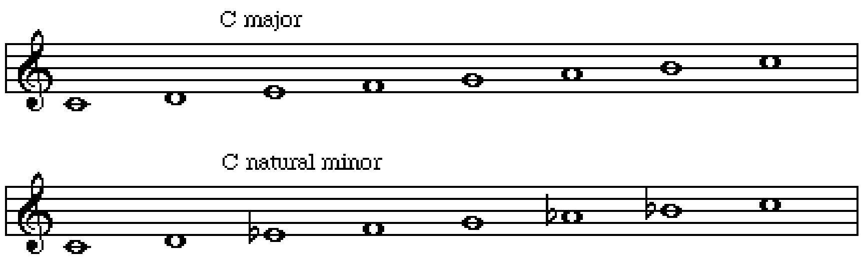

Figure 2. Atonal music treats all notes as equally-likely to occur. All 12 tones of the chromatic scale are used in atonal music.