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A Comparison of Average Pitch Height and Interval Size in Major- and Minor-key Themes: Evidence Consistent with Affect-related Pitch Prosody

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ABSTRACT: An analysis of 9,788 instrumental themes shows that minor-key themes are, on average, slightly lower in pitch than major-key themes. The lower pitch is not merely an artifact of structural differences in the scales. In addition, instrumental themes in minor keys show a weak though significant tendency to use smaller pitch intervals. Both results are consistent with observations in speech prosody, where sad speakers exhibit a lower F0 and narrower pitch fluctuation compared with normal or happy speakers.

Submitted 2008 March 5; accepted 2008 March 12.

KEYWORDS: *music, minor key, sadness, pitch, speech prosody*

WESTERN music of the so-called 'period of common practice' is based on two principal scales: the *major* and *minor* scales. For whatever reason, the minor scale has become associated with sadness (Heinlein, 1928; Hevner, 1935). Of course, not all music in the minor mode has sad connotations. Traditional Bulgarian music, for example, employs four pentachordal modes (major, minor, phrygian, hijaz) and Bulgarian music specialists doubt that there is any straightforward mode/mood relationship in this repertoire (Timothy Rice, personal communication, Oct. 19, 2007). At face value, there is nothing inherently 'sad' about the Western minor scale. The most commonly held view is that the relationship between the minor mode and sadness arises from a learned association. Nothing in the present study contributes to our understanding of the purported sadness of the minor mode, nor is this study motivated by an attempt to account for this common association.

If the minor mode is associated with sadness for a large segment of Western-enculturated listeners, then composers might choose to make use of the minor mode in order to portray or evoke sad feelings in their listeners. However, this is not the only reason why a composer might elect to use the minor key. In the first instance, the minor mode has other emotional connotations: apart from sadness, music commentators have described the minor mode as being variously associated with grief, fear, anger, or seriousness. Moreover, a composer might choose to use the minor key for purposes other than evoking or portraying a particular emotion. For example, a composer might employ the minor mode to increase a compositional contrast, to add musical variety, or as a means of delineating formal divisions in a work. Or a composer might make use of the minor key merely because its use in a particular context conforms to an existing musical tradition or convention.

The purpose of this study (and the companion studies in this volume) is not to address the possible origins of the association between the minor mode and sadness. Instead, our goal is to explore other elements of musical organization (like pitch height, tempo, articulation, and dynamics) that might contribute to the purported 'sadness' evoked or portrayed by the music. In effect, an association between the minor mode and sadness will be assumed in these studies, and this association will be used as a research lever to investigate how composers might evoke or portray sadness.

Research on music-related affect has long been inspired and influenced by research in speech prosody. Juslin and Laukka (2003) reviewed 104 studies of speech-related affect and 41 studies of music-related affect, and concluded that both speech and music involve similar acoustic-affective cues and accord with the physiologically-inspired theory of Klaus Scherer (Scherer, 1986). In the case of sadness,

Fairbanks and Pronovost (1939) studied the effect of pitch on emotional speech. They found that sad utterances exhibit a lower overall pitch (mean F0) and also have smaller pitch excursion (F0 variation). Since their pioneering study, the relationship between pitch and sadness has been observed many times in a variety of experimental conditions (e.g., Banse & Scherer, 1996; Bergmann, Goldbeck & Scherer, 1988; Breitenstein, van Lancker & Daum, 2001; Davitz, 1964; Eldred & Price, 1958; Huttar, 1968; Skinner, 1935; Sobin & Alpert, 1999; Williams & Stevens, 1972). Apart from speech, the ability of low pitch and small pitch range to convey sad affect has also been demonstrated using synthesized tones (Lieberman & Michaels, 1962; Scherer & Oshinsky, 1977). Contradictory results have been reported by Erickson et al. (2006) who measured high mean F0s for two female speakers whose utterances were judged as sad. However, it is possible that the affect in question is better described as *grief* (associated with high sympathetic arousal) rather than *sadness* (associated with low sympathetic arousal).

HYPOTHESES

With respect to the evoking or representation of 'sadness' in music, at least two pitch-related hypotheses arise from the extant research on vocal prosody:

H1. Music deemed to exhibit a sad affect will tend to exhibit a lower overall pitch. Since the minor key in Western culture is commonly regarded as associated with sadness, a more specific prediction is that works in minor keys will tend to exhibit a lower overall pitch.

H2. Music deemed to exhibit a sad affect will tend to exhibit a narrow overall pitch range. Once again, since the minor key in Western culture is commonly associated with sadness, the more specific hypothesis is that works in minor keys will tend to exhibit a smaller pitch range or variance.

METHOD

In order to test these hypotheses, a convenience sample of music was used—a digital database consisting of instrumental themes assembled by Harold Barlow and Sam Morgenstern (1948). The first edition of the Barlow and Morgenstern *Dictionary of Musical Themes* contains some 9,788 instrumental themes deemed by the authors to represent the canonical repertoire of the Western European classical tradition. Each theme is notated in its original key and at the original octave of the first appearance of the theme in its respective work. In an accompanying index, Barlow and Morgenstern explicitly interpreted the mode (major or minor) for each of the 9,788 themes. In total, the authors deemed 7,170 themes to be in major keys and 2,618 themes to be in minor keys (i.e., 73% in major keys).

In order to use this sample, it must be assumed that musical themes are representative of the works from which they are extracted. More specifically, it must be assumed that isolated musical themes retain the emotional character or general affective tone of the works from which they are drawn, at least with regard to expressions of sadness or depression. In many cases, one might expect the principal emotional quality to be better conveyed by the accompaniment rather than by the theme. However, most music scholars would consider it a reasonable to assume that musical themes commonly echo the affective character of the musical work as a whole.

Calculations were carried out using the Humdrum Toolkit (Huron, 1995, 2002). In order to test Hypothesis 1, the mean pitch for each theme was calculated. Averages were calculated in semitones with respect to middle C (=0). Tied notes were treated as a single note; note durations were ignored so grace notes were given equivalent weight to whole notes. In total, some 187,532 notes were involved. In order to test Hypothesis 2, the pitch range (in semitones) was determined for each theme.

RESULTS

In the case of Hypothesis 1, grand averages were calculated from the means of all major and minor themes. The average for major-key themes was 8.902 semits above middle C (s.d. = 5.476) and the average for minor themes was 7.823 (s.d. = 5.914). That is, the average pitch height for major-key themes was near A4 whereas the average pitch height for minor-key themes was near G#4. Although this difference in

average pitch is small (about 1.1 semitones), it is nevertheless statistically significant (t=8.443; df=9.786; p<0.000001).

While this result is consistent with Hypothesis 1, it is appropriate to consider possible confounds that might suggest an alternative interpretation. One potential confound is the effect of scale structure. Conceptually, one might distinguish the overall pitch of a melody from local pitch-height effects arising from the scale itself. The minor scale might be regarded as an altered form of the major scale. For the harmonic minor scale, the third and sixth scale tones are lowered by one semitone compared with the major scale. For the natural minor scale, the third, sixth, and seventh tones are lowered.

If all seven scale tones were equally likely, the average pitch for a tone sequence in the harmonic minor mode would be 2/7ths of a semitone lower than for a parallel rendition in the major mode. Similarly, the average pitch for a sequence in the natural minor mode would be 3/7ths of a semitone lower than for a parallel rendition in the major mode. If we use the natural minor scale as a conservative base, then one could arguably 'correct' the average pitch for the major-key measure by subtracting 3/7 (0.428571) of a semitone. This reduces the average pitch for major scale themes from 8.90181 to 8.47324, and so reduces the difference between average major and minor key pitch heights to 0.65 semitones.

Of course, one might argue that this purported confound is not a confound at all, and that the lowering of particular scale tones is an integral part of the compositional manipulation by which a musical passage can be made to sound 'sadder.' However, the most conservative test would dismiss this interpretation and carry out the data analysis using the proposed pitch correction. Even after this correction is introduced, however, a t-test shows that the difference in the mean pitch heights for major-key and minor-key themes remains statistically significant (t=5.088; df=9.786; p<0.000001).

In addressing this hypothetical confound, we have assumed that all scale degrees are equally probable. However, this assumption is baseless. If the 3rd, 6th, and 7th scale degrees occur more frequently than other scale tones, then a correction of 3/7ths of a semitone would be insufficient. In the major mode, the 5th scale tone (dominant) is the most common tone, followed by the 3rd (mediant) and then the 1st (tonic). In the minor mode, scale degrees 1 and 5 are equally prominent followed by the 3rd scale tone (Aarden, 2003; see also Huron, 2006, pp.148–149). Considered as a group, the frequency of scale degrees 3, 6, and 7 represent 33.4% of all tones in the major mode and 33.7% of all tones in the minor mode (including both raised and lowered variants of 6 and 7). Both of these values are below the 3/7th (42.9%) assumed in the equiprobable case. Hence, the above corrected test can still be regarded as conservative.

Another potential confound relates to preferred key signatures. Musicians typically prefer key signatures with relatively few accidentals. For example, the key of G major (1 sharp) is more common than E major (4 sharps); similarly, the key of D minor (1 flat) is more common than F minor (4 flats). If we assume that simple key signatures are equally preferred in both the major and minor modes, then we might predict that *relative* key relationships will be preferred. That is, C major would be preferred, as would its relative minor, A minor (both having no sharps or flats); G major would be preferred as would its relative minor, E minor (1 sharp each), and so on. If a major-key theme were rewritten in the minor mode, it is possible that composers would tend to transpose it to the relative minor rather than the parallel minor in order to maintain the simplicity of the key signature. In rewriting the theme in the minor, it is possible that composers would tend to transpose the theme *down* a minor third (rather than transposing the theme *up* a major sixth). Although speculative, the combination of all these tendencies might conspire to lower the average pitch of minor-key themes. Unfortunately, it is not clear how one might test for the presence of this proposed confound; nor is it clear how one might control for the effect, were it present.

Another possible confound might arise if the major and minor scale tones are used differently. What if the difference in pitch height is somehow attributable to the distributions of the various scale tones for major and minor modes? For example, perhaps melodies in minor modes simply tend to employ more pitches in the lower half of the scale compared with major mode melodies. Unfortunately, this confound cannot be addressed. The lowest and highest pitches in a theme do not coincide with the lowest and highest pitches in a scale, so the effect of preferences for different scale degrees cannot be separated from the so-called *ambitus*—that is, the relationship between thematic range and the positioning of that range within the scale.

Turning to Hypothesis 2, the pitch ranges were measured for all of the themes in the Barlow and Morgenstern. For the major-key themes, the average pitch range was 13.131 semitones (s.d. 5.17803)—a little more than an octave. For the minor-key themes, the average pitch range was 13.0348 semitones (s.d. 5.24988). The difference in range is less than a tenth of a semitone (0.094 semitones). Although this difference points in the predicted direction, the difference is not statistically significant

(t=0.8088; df=9,783; p=0.27). Prima facie, this result is inconsistent with the hypothesis that the minor mode is associated with a narrower pitch range.

A more sensitive measure of pitch excursion might focus on pitch variance rather than pitch range. Accordingly, a post-hoc analysis of the pitch variance was carried out. For the major-key themes, the average standard deviation in the pitches was 3.8286 (s.d. 1.59161). For the minor-key themes, the average standard deviation in the pitches was 3.8113 (s.d. 1.58304). Again, while this difference is skewed in the predicted direction, the difference is not statistically significant (t=0.4767; df=9,786; p=0.1832).

Both range and pitch variance are summary statistics that are insensitive to order. Randomly reordering the tones within a theme will not change the range or pitch variance. Arguably, the most important aspect of pitch change is not the overall range but the local tone-to-tone intervals. An alternative way of construing 'narrow pitch range' is as small pitch intervals. As a further post-hoc test of Hypothesis 2, an analysis of the average interval size was carried out. Accordingly, the distributions of intervals in the major- and minor-key themes were investigated. Melodic intervals were calculated in semitones. Intervals were not tabulated across notated rests. For the major key themes, 128,248 intervals were considered. The mean interval size was 2.47274 semitones (s.d. 2.38526). For the minor key themes, only 47,117 intervals were available. The mean interval size for the minor-key themes was 2.41567 semitones (s.d. 2.46052). Although the means differ by only 1/100th of a semitone, the difference proved significant (t=4.404; df=175,363; p=0.00001).

DISCUSSION AND CONCLUSION

At face value, the results of this study are consistent with both Hypotheses 1 and 2. That is, instrumental themes in minor keys are lower in overall pitch than themes in major keys, and melodic intervals in minor keys are smaller than intervals in major keys. These patterns are consistent with prosodic cues for sad or depressed vocal affect. Unfortunately, the small effect sizes warrant considerable skepticism—especially in the case of Hypothesis 2. When sample sizes are large, statistically significant differences are nearly inevitable. Small differences in large samples can arise through innumerable artifacts. Hence, the tiny effect size for Hypothesis 2 is hardly a resounding affirmation.

Since the minor key is also used to convey grief, fear, anger, and seriousness, it is possible that the presumed effect of sadness on pitch has been diluted. Future avenues for research might focus on segregating the themes according to their perceived affect before carrying out the statistical analyses.

Finally, we must reiterate the caveat noted earlier that a composer's use of the minor mode may be motivated by many concerns that have nothing to do with the presumed goal of representing or evoking a particular emotion such as sadness. The use of the minor mode may be motivated by innumerable other goals, such as the pursuit of compositional contrast, the need for variation, efforts to delineate formal divisions, traditional compositional conventions, or any of a host of other musical and extramusical goals. Moreover, even if the composer's intention is to evoke a specific emotion, as already noted, the minor key in Western music is also associated with other affects, such as grief, fear, anger, and seriousness.

These caveats notwithstanding, the results of this study are consistent with a weak association between 'sad' music and both lower overall pitch and smaller melodic intervals.

NOTES

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