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Minor Mode Cuing: Do Composers Signal Minor Mode Sooner Than Major Mode?

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Western-enculturated listeners use different tonal schemas when listening to major versus minor mode (e.g., C. L. Krumhansl and E. J. Kessler, 1982, Tracing the dynamic changes in perceived tonal organization in a spatial representation of musical keys, Psychological Review, Vol. 89, pp. 334–368). To avoid possible tonal ambiguity, one might expect composers to attempt to disambiguate or clarify the mode soon after a work begins. The major mode is the most common tonal schema in Western music, so listeners might expect that an unknown work will be in the major mode. This suggests that composers might tend to cue listeners sooner when presenting works in the (rarer) minor mode. In this article, we report on 2 studies that test the hypothesis that mode-defining pitches occur earlier for minor-mode works. Surprisingly, the studies do not support this hypothesis: in fact, mode-defining scale tones (mediant and submediant) appear significantly later in notated music than in scrambled versions of the same scores, regardless of the mode. Repercussions of the results are discussed.

Keywords: minor mode cuing, tonality, key induction, Humdrum Toolkit, expectation

Since about the 17th century, Western music has been dominated by the major/minor system in which two tonal schemas predominate. Throughout the history of the major/minor system, the major mode has been more common than the minor mode. Depending on the musical genre, between two thirds and three-quarters of works are written in the major mode. For example, in the Barlow and Morgenstern (1948) *Dictionary of Musical Themes*, 73% of nearly 10,000 thematic passages are designated by the authors as in the major mode with the remaining 27% in the minor mode.

Huron (2006) reviewed a number of empirical observations suggesting that listeners tend to assume that a newly encountered musical passage will be in the major mode. That is, the major mode appears to be a "default" listening mode for Western-enculturated listeners. Given the predominance of the major mode, this perceptual default is consistent with statistical learning, and more specifically consistent with Bayesian inference. If listeners do indeed tend to assume a "major mode default," then the switch to minor-mode listening is probably cued by one or more tonal patterns that fail to conform to the major mode. Such "disconfirming" stimuli are widely regarded as important events for activating appropriate perceptual schemata (Holland, Holyoak, Nisbett, & Thagard, 1986).

How listeners infer the tonality of a passage has attracted considerable research attention over recent decades (Brown, 1988; Brown & Butler, 1981; Cohen, 1977, 1991; Cuddy, Cohen, & Mewhort, 1981; Cuddy & Lyons, 1981; Hébert, Peretz, & Gagnon, 1995; Huron & Parncutt, 1993; Krumhansl, 1990a; Krumhansl & Kessler, 1982; Leman, 1995; Smith & Schmuckler, 2004). For monophonic passages, tonality might be inferred through the recognition of mode-defining chroma distributions, through distinctive interval patterns, via chroma-dyad distributions, or through some combination of these or other pitch-related mental representations. Successful key-inference algorithms have been devised using a variety of techniques (Aarden, 2003; Bellman, 2005; Holtzman, 1977; Krumhansl & Schmuckler, 1986; Sapp, 2008; Schmuckler & Tomovski, 1997, 2000; Takeuchi, 1994; Temperley, 2007). However, reliable key inference by machine does not necessarily mean that listeners use an equivalent mental process. The Krumhansl–Butler debate of the 1980s and 1990s (Butler, 1989, 1990; Cross, 1997; Krumhansl, 1990b, 2000; Van Egmond & Butler, 1997) can be interpreted in several ways. However, one interpretation is that the debate arose from disagreement about whether the mental representation for tonal sequences is predominantly pitch related (Krumhansl) or predominantly interval related (Butler). See Huron (2006) for an extended discussion.

The extensive research on tonality notwithstanding, to our knowledge no pertinent psychological research has been carried out regarding mode inference—that is, how a listener infers that the key is major or minor. In general, there are three accepted forms of the minor scale: the harmonic minor, melodic minor, and natural minor. Of these, the harmonic minor is typically regarded as most normative. From the perspective of music theory, what distinguishes the major and minor modes is the treatment of the third (mediant) and sixth (submediant) scale tones. Specifically, for the minor modes, the third and sixth scale degrees are lowered by one semitone compared with the major mode. The seventh scale tone is lowered in both the natural minor and the descending version of the melodic minor. The unlowered (or "raised") seventh is not considered a chromatic alteration in the harmonic minor scale. Theoretically, if a musician avoided the third and sixth scale tones, then the mode would remain ambiguous. However, with a "default major," listeners might still favor hearing the passage in the major mode. Although listeners might infer the modality of a

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work by other means, at face value, simple occurrences of a lowered third or lowered sixth scale tone might be expected to be essential cues for activating a minor-mode schema.

Depending on the aesthetic goal, composers may or may not be interested in conveying a clear sense of modality. For example, a composer may explicitly set out to create an ambiguous tonal center. However, it is reasonable to suppose that in most circumstances composers intend their works to exhibit a perceptually transparent tonality.

If we assume that composers intend to convey clear indications of a work's mode, and that it is better to convey this information early in the listening experience, and that the major mode is the default listening strategy (and so, conveying the minor mode requires special cuing), then we might predict that the third and/or sixth scale tones will tend to occur sooner in minor-mode works than the comparable scale tones in major-mode works.

Hypothesis

Formally, we may state our hypothesis as follows:

H_1. The occurrence of mode-defining pitches will occur sooner for minor mode works than for major mode works.

By "mode-defining pitches," we mean specifically the occurrence of the third and sixth scale tones. By "works," we will examine notated musical passages. By "sooner," one could be referring to the elapsed time (in seconds) from the onset of a work. Because notated music typically provides imprecise timing information, one might use commercial sound recordings to identify the exact moment when a mode-defining pitch occurs. However, for the purposes of this study, we elected to use a simpler operationalization of "sooner." In this study, we will simply count the total number of sonorities from the onset of the work, as evident in notated score.

Study 1: Comparing Major and Minor

In brief, our method involved assembling two samples of music in the major and minor modes, and counting the number of sonorities from the onset of the work to the first sonority in which the third or sixth scale degree occurs. Figure 1 provides an illustration: the work is in A minor; the third scale tone is C, and the sixth scale tone is F. As can be seen, the first occurrence of a mode-defining pitch (C) occurs at the sixth sonority.

Sample

Two musical samples were assembled for this study. One sample consisted of 1,000 randomly selected classical instrumental themes from the Barlow and Morgenstern (1948) *Dictionary of Musical Themes* (500 in major and 500 in minor). This reference dictionary includes nearly 10,000 themes spanning 1598 to 1948, with the majority of themes taken from common practice period of Western art music literature—as identified by Harold Barlow and Samuel Morgenstern. It might be regarded as representing the "canon" of classical instrumental music as understood in the United States around the middle of the 20th century. The second sample consisted of 96 keyboard preludes from works by Johann Sebastian Bach (1685–1750), Johann Nepomuk Hummel (1778–1837), and Frédéric Chopin (1810–1849). Specifically, these consisted of the 48 preludes in the *Well Tempered Clavier*, by Bach (BWV 846–893), the 24 opus 67 preludes by Hummel, and the 24 opus 28 preludes by Chopin. The first sample is monophonic whereas the second sample is multipart music. It should be noted that musical themes do not typically appear at the onset of a work, so the sample of themes from the Barlow and Morgenstern may not be representative of "how music starts."

Procedure

For each excerpt, it was important to reliably establish the mode for the work. In the case of the Barlow and Morgenstern, the authors themselves identified the mode for each thematic passage. In the sample of keyboard preludes, all of the preludes are explicitly labeled according to key and mode.

Having established the modality for each sampled work, we then counted the number of sonorities from the beginning of the work until the appearance of the third and sixth scale degrees. Having counted the number of sonorities to the occurrence of these tones, we could also determine which tone (third or sixth) represented the advent of the first mode-defining pitch. Rests were not regarded as sonorities.

The case of accaciaturas (grace notes) is perhaps ambiguous. Because these notes are very short, an argument might be made that these tones should be excluded from the sonority count. On the other hand, because grace notes are clearly sounding pitches, an argument might be made that these tones should be included in the sonority count. In the case of the keyboard preludes, a number of the works begin with accaciaturas or groupettos. To avoid reducing the sample size, we elected to include these pitches. In the case of the Barlow and Morgenstern *Dictionary of Music Themes*, however, there are many thousands of themes from which to draw a sample. Because it is not clear how accaciaturas should be treated, we a priori decided to eliminate such works from the sample of themes.

One of the assumptions in this study is that composers endeavor to establish a work's key near the beginning of the listening experience. If a chromatic tone (outside of the nominal key) occurs near the beginning of a work, this occurrence might be considered

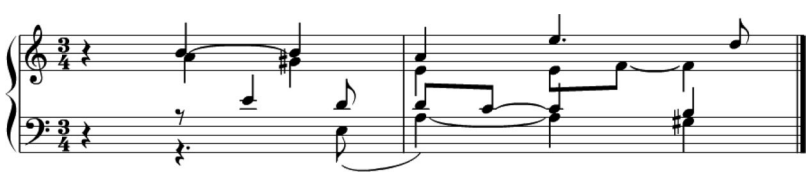

Figure 1. Illustration of the method for determining the serial position of a mode-defining pitch. In this example (in A minor), the third scale tone is C, and the sixth scale tone is F. The first occurrence of a mode-defining pitch (C) is deemed to occur at the sixth sonority.

Table 1
Mean Serial Position of First Mode-Defining Note

	Major (third and sixth)	Minor (third and sixth)
Instrumental themes	3.65 (3.03, 248)	3.91 (2.85, 246)
Preludes	2.28 (1.13, 42)	4.85 (14.22, 46)

Note. Standard deviations and numbers of themes/preludes considered are reported in brackets.

inconsistent with this assumption. That is, chromatic tones might be symptomatic of a composer's intention to render the key ambiguous. At the same time, one might argue that, because chromatic tones are sometimes present, this remains an important part of the musical arrangement or organization. Accordingly, we once again elected to treat the two subsamples differently. In the case of the Barlow and Morgenstern, we discarded from the sample any theme that contained a chromatic tone. However, in the case of the keyboard preludes, we elected to include all of the works in our sample. In the case of the seventh scale tone, we deemed that raising this pitch in the minor mode would not be considered a chromatic alteration.

All of the sampled materials are available in the Humdrum kern format. The Bach preludes were encoded by Walter Hewlett; the Hummel and Chopin preludes were encoded by Craig Sapp (see http://kernscores.org). These materials were all processed using the Humdrum Toolkit (Huron, 1995, 2002).

Results

Table 1 presents the results by sample where the third and sixth scale degrees are combined. It shows the average serial position for the first occurrence of either the third or sixth scale tones for both major and minor modalities. Separate results are shown for the two samples. In both the keyboard preludes and the instrumental themes, the average serial positions for the minor-mode works are later than for major-mode works. Without having to carry out any inferential statistics, simply on the basis of the mean values, we can conclude that the results are not consistent with the hypothesis.

Table 2 presents the same data where the serial positions for the third and sixth scale tones are separately reported. Once again, with only one exception, the means for the major mode indicate that the results are inconsistent with the hypothesis.

The information in Tables 1 and 2 might be regarded as having limited utility, however, because it assumes that the third and sixth scale tones occur with equal frequency in both the major and minor modes. The frequencies of scale degrees are known to vary considerably (Krumhansl, 1990a). For example, in the major mode, the third scale tone accounts for 19.8% of all tones, whereas in the minor mode the third scale tone accounts for 16.9% of all tones (Aarden, 2003). Similarly, in the major mode, the sixth scale tone accounts for 8.15% whereas in the minor mode, the sixth scale tone accounts for just 4.57%. This suggests that the values in Table 1 are confounded by the simple frequency of occurrence for the different scale tones. In the minor mode, the third and sixth scale tones occur less often than their major-mode counterparts, so they would tend to appear later simply by chance. To carry out a proper comparison, we need to control for frequency of occurrence.

One way to address this confound would be to correct the values in Table 1 according to the distribution of scale tones such as the frequencies reported by Aarden (2003). A better approach would use the scale-degree distributions from the music used in our own sample.

Study 2: Scrambled Controls

A simple way to control for the different frequencies of tone occurrence is to compare the actual serial positions of mode-defining pitches with the same data when the order of the pitches is randomly reordered. By randomly reordering the pitches, we destroy only the temporal information, not the distribution of pitches themselves. In the case of multipart music, the same randomization procedure can be applied at the level of sonorities. That is, by randomly reordering vertical sonorities, we destroy the temporal relationship between sonorities, without disturbing the distribution of pitches themselves. To this end, we used the Humdrum *scramble* command to achieve these reorderings. Figure 2 illustrates the scrambling procedure.

Table 3 shows the results when comparing the actual musical excerpts with the randomly pitch-reordered excerpts. Table 3 reports the combined serial positions for scale degrees three and six.

Results

We conducted two three-way repeated-measures analyses of variance (ANOVAs) separately for our two musical samples, with Mode (major or minor), Degree (third or sixth scale degree), and Type (original or scrambled) as within-subject variables. Because the interactions were tested 15 times, the alpha-level was lowered to 0.003 for these tests (Bonferroni correction for multiple tests). For the instrumental themes (see Figure 3), we found a main effect of Degree, showing that the third scale degree occurs earlier than the sixth scale degree, $F(1, 146) = 102.23$, $p < .001$. Further, we found a main effect of Type, showing that mode-defining pitches occur later in the original themes than in the scrambled versions, $F(1, 146) = 6.65$, $p = .011$. However, this effect was qualified by

Table 2
Mean Serial Position of Mode-Defining Note by Scale Degree

	Major		Minor	
	Third	Sixth	Third	Sixth
Instr. themes	3.43 (2.97, 180)	4.23 (3.04, 68)	3.80 (2.81, 197)	4.35 (2.94, 49)
Preludes	2.98 (3.60, 42)	15.71 (13.47, 42)	5.93 (15.56, 42)	12.31 (17.80, 45)

Note. Standard deviations and numbers of themes/preludes considered are reported in brackets.

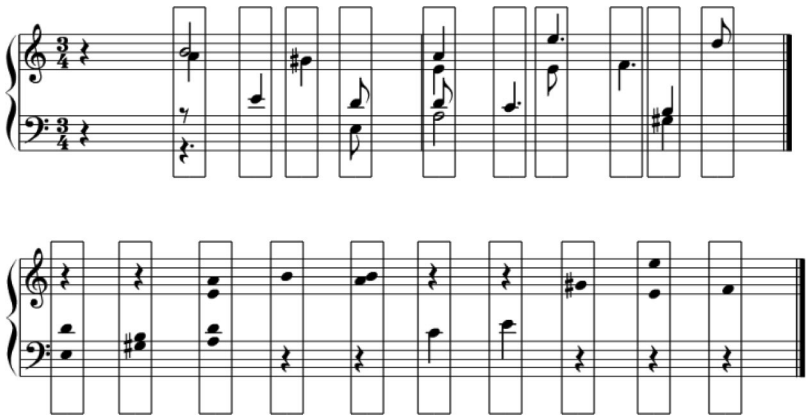

Figure 2. Illustration of randomizing procedure used in Study 2. A target passage (see Figure 1 for original notation) is parsed into successive sonorities (upper notation); the order of the sonorities is then scrambled (lower notation).

a significant interaction between Degree and Type, $F(1, 146) = 14.71$, $p < .001$, showing that the described effect of Type holds only for the sixth scale degree, $t(197) = 4.54$, $p < .001$, but that there are no differences between the original and scrambled versions regarding the third scale degree, $t(239) = -.853$, $p = .395$, n.s.

For the preludes (see Figure 4), we found a very similar pattern. Again we found a main effect of Degree, showing that the third scale degree occurs earlier than the sixth scale degree, $F(1, 41) = 20.23$, $p < .001$. Further, we found a main effect of Type, showing that mode-defining pitches occur later in original themes than in scrambled versions, $F(1, 41) = 8.03$, $p = .007$. Again, we found a significant interaction, $F(1, 41) = 9.92$, showing that the main effect of Type holds only for the sixth scale degree, $t(44) = 4.17$, $p < .001$, and that there are no differences between the original and scrambled versions regarding the third scale degree, $t(41) = -.39$, $p = .704$, n.s. The interaction in this case also qualifies the main effect of Degree, showing that the sixth scale degree comes later than the third scale degree only in original versions, $t(41) = 4.00$, $p < .001$, but that there are no differences for scrambled versions, $t(41) = 1.91$, $p < .063$.

Contrary to our hypothesis, in none of the analyses did we find an effect or an interaction involving musical mode. In post hoc explorations of the subsamples, we noticed that the Chopin preludes differ notably from the Bach and Hummel preludes. Whereas the Bach and Hummel preludes exhibited similar results, nothing was significant in the Chopin preludes. Because Chopin seems to be a special case, we conducted post hoc analyses of the preludes, excluding the Chopin works (see discussion below). For the remaining sample (see Figure 5), we found main effects for Degree, $F(1, 29) = 59.69$, $p < .001$, as well as for Type, $F(1, 29) = 10.46$, $p = .003$. However, both effects were qualified by two-way interactions, Mode by Type, $F(1, 29) = 8.866$, $p = .006$, and Degree by Type, $F(1, 29) = 57.61$, $p < .001$, which in turn were qualified by a three-way interaction, $F(1, 29) = 9.04$, $p = .005$.

Table 3
Mean Serial Position of First Mode-Defining Note: Original Versus Scrambled

	Major (third and sixth)	Minor (third and sixth)
Original themes	3.65 (3.03, 248)	3.91 (2.85, 246)
Scrambled themes	3.30 (2.72, 248)	3.87 (3.19, 246)
Original preludes	2.28 (1.13, 42)	4.85 (14.22, 46)
Scrambled preludes	2.95 (2.33, 42)	3.33 (2.55, 46)

Note. Standard deviations and numbers of themes/preludes considered are reported in brackets.

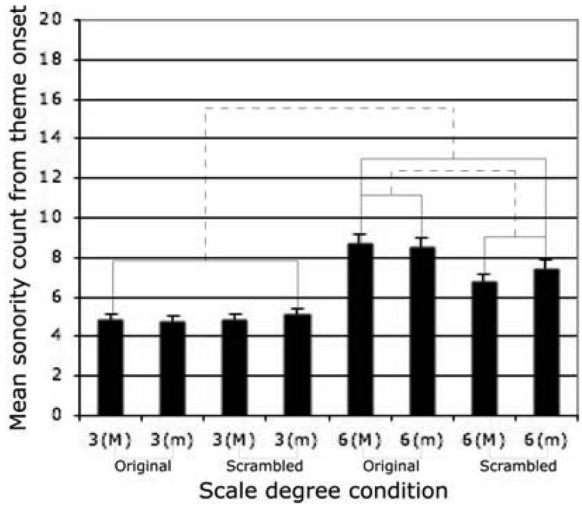

Figure 3. First occurrence of mode-defining pitches in 1,000 instrumental themes from the Barlow and Morgenstern's *Dictionary of Musical Themes*. The graph plots the average sonority count from the beginning of each theme for both original themes and randomly reordered (scrambled) versions of the same themes. Separate bars are shown for mediant (3) and submediant (6) pitches and for major (M) and minor (m) modes. By way of example, the occurrence of the third scale tone in both major and minor modes occurs around 4.8 sonorities from the onset of the theme. Statistically significant differences ($p < .003$) are indicated by dashed lines: mediant pitches occur sooner than submediant pitches; mediant pitches do not occur sooner than a chance relationship; submediant pitches occur later than would be expected by chance.

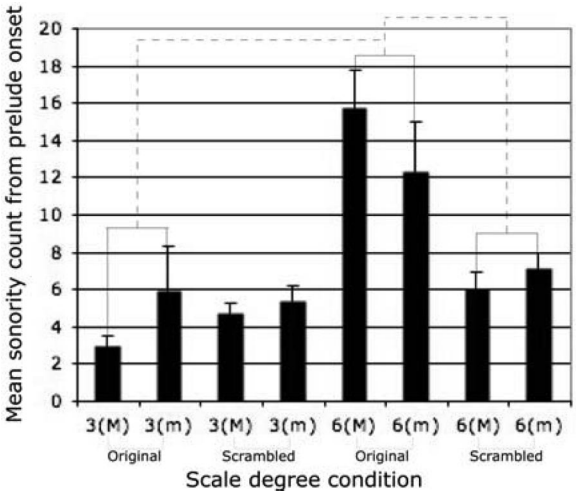

Figure 4. First occurrence of mode-defining pitches in 96 keyboard preludes by Bach, Chopin, and Hummel. The graph plots the average sonority count from the beginning of each prelude for both original and randomly reordered (scrambled) versions. Separate bars are shown for mediant (3) and submediant (6) pitches and for major (M) and minor (m) modes. By way of example, the occurrence of the sixth scale tone in the major mode occurs around 15.7 sonorities from the onset of the work. Statistically significant differences ($p < .003$) are indicated by dashed lines: mediant pitches occur sooner than submediant pitches in the original works; submediant pitches occur later than would be expected by chance.

The resulting patterns show that the sixth scale degree occurs later in original (unscrambled) major mode pieces than in the other conditions (except for the sixth scale degree in original minor mode pieces). Further, the third scale degree in original major mode pieces occurs earlier than in their scrambled counterparts, as well as earlier than the sixth scale degrees in all condition except for the scrambled sixth major mode. A last effect shows that in original minor mode pieces, the third scale degree occurs earlier than the sixth scale degree.

Discussion and Conclusion

In general, the results are contrary to the hypothesis that motivated this study. At least with regard to the methods and sample used here, the mode-defining pitches of the third and sixth scale degrees do not occur sooner in the minor mode than in the major mode. In fact, when the data for both major and minor modes are combined, mode-defining pitches (as a group) occur later in actual works than in their scrambled counterparts.

As with all negative results, there may be many reasons why a test of a hypothesis might fail. Our study might be faulted for assuming that mode-defining pitches are somehow more important than, say, intervallic implications in establishing the tonality of a passage (see, e.g., Brown, 1988; Butler, 1989). It is possible that a more sophisticated key-induction method might produce results consistent with the hypothesis.

Moreover, if we examine the third and sixth scale tones separately, a slightly different story emerges. In general, the third scale tone tends to be introduced much sooner than the sixth scale tone. This is consistent with certain theories of tonality that regard the tonic, mediant and dominant pitches as playing especially important roles (see, e.g., Lerdahl, 2004). Some researchers have suggested that these tones act as perceptual anchors (Bharucha, 1984). It may be that the relatively late appearance of the submediant is due to its subordinate tonal role, especially when compared with the mediant pitch.

In the Chopin preludes, the appearance of mode-defining pitches is much later (12.4 sonorities) than for either the Bach (7.2) or Hummel (9.7) preludes. In one of the Chopin preludes, for example, neither the third or sixth scale tones occurred until the 98th sonority. One might speculate that this difference implies that Chopin aimed to evoke greater mode or key ambiguity, perhaps in accordance with a more Romantic musical aesthetic. Prelude no. 2 provides an especially apt example. The work ends in A minor but begins in a manner suggestive of E minor; the nominally key-defining pitches of C and F do not appear until measures 12 and 16 (respectively) in a work that is only 22 measures in length. Moreover, there are a number of C#s and F#s that appear prior to the appearance of the lowered versions, contributing to the ambiguity of the ultimate key. If we regard Chopin as an exception, and exclude his data from the analysis, then the third scale tone does indeed appear earlier than would be expected by chance in both the major and minor preludes. This observation is statistically significant; however, only if no correction is made for multiple tests.

The above interpretation is consistent with other research suggesting that the Romantic period is special with respect to the use of the minor mode. Post and Huron (2009) found that the associ-

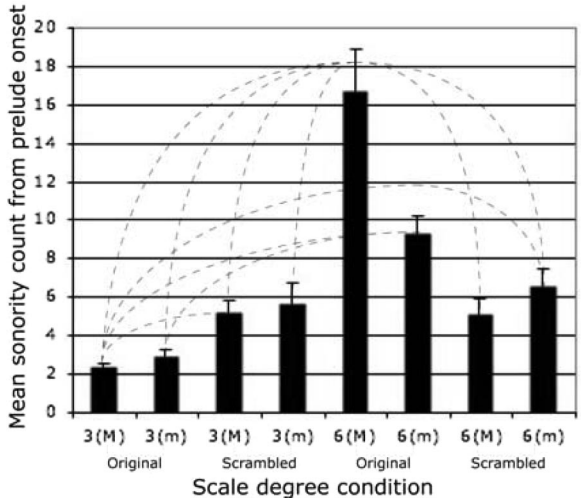

Figure 5. First occurrence of mode-defining pitches in 72 keyboard preludes by Bach and Hummel (Chopin excluded). The graph plots the average sonority count from the beginning of each prelude for both original and randomly reordered (scrambled) versions. Separate bars are shown for mediant (3) and submediant (6) pitches and for major (M) and minor (m) modes. Statistically significant differences ($p < .003$) are indicated by curved lines: the sixth scale degree occurs later in original major mode pieces than in any other condition (except for the sixth scale degree in original minor mode pieces); the third scale degree in original major mode pieces occurs earlier than in their scrambled counterparts, as well as earlier than the sixth scale degrees in all conditions except for the scrambled sixth major mode; in original minor mode pieces, the third scale degree occurs earlier than the sixth scale degree.

ation of the minor mode with slow tempo is reversed in 19th century music. Similarly, Ladinig and Huron (2010) found that the association of the minor mode with quiet dynamic levels is reversed for music in the 19th century. That is, 19th century minor-mode music is, on average, both faster and louder than major-mode music from the same century. Ladinig and Huron speculated that this change might be related to the "passionate" expressive language that came to epitomize musical Romanticism. It may be that tonal ambiguity (at least in the case of Chopin) might be another feature of this stylistic change.

Future research might focus on music prior to the 19th century to reduce the potential confounding effect of the pursuit of tonal ambiguity. A broader and more representative sample of music would be warranted, perhaps focusing on prominent composers, excluding more marginal figures like Hummel. In addition, a more refined methodology might weight sonorities by duration or position in the metric hierarchy rather than giving each sonority equal weight as was done in the current study. Finally, perceptual experiments might be carried out to determine the moment when listeners typically identify the tonal center and mode; the ensuing perceptual data could then be used to test the assumption that the appearance of the third and sixth scale tones provides important modality-resolving information.

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