

On the Role of Semitone Intervals in Melodic Organization: Yearning vs. Baby Steps

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ABSTRACT

A corpus study of 15,000 melodies was carried out to test various conjectures arising from the purported tending or yearning quality of the semitone interval. Several hypotheses were tested, including comparing semitone and whole-tone intervals in major-mode contexts with comparable movements in minor-mode contexts. Results failed to show the predicted relationship favoring semitone intervals for “yearning.”

In the course of this study, our analyses produced an unexpected result regarding the use of semitone intervals in melodies generally. Although whole-tone intervals are more common than semitone intervals, compared with melodies whose pitches have been randomly reordered, there is a tendency for composers to favor semitone intervals compared with whole-tone intervals. These results reinforce longstanding observations regarding pitch-proximity, but add to these observations by identifying a disposition toward using the smallest available intervals in the construction of melodies. Overall, the results call into question the conjecture that the semitone interval itself is responsible for the yearning qualia.

I. INTRODUCTION

The strong affinity between certain pitch relationships has been the topic of research by both music theorists and music psychologists. Among music theorists, pitches related by a semitone interval have attracted considerable speculation and discussion. Specifically, the semitone is commonly regarded as exhibiting inherently unstable properties. In *Ars Musica* (1296-1304), Aegidius of Zamora referred to the semitone as an “imperfect tone” that must resolve in order to reach perfection (cited in Leach, 2006, and Fuller, 2011). Boethius similarly wrote that the very term “semitone” was derived from *semus*, *sema*, *semum*, meaning imperfect (cited in Fuller, 2011). This notion of an “imperfect,” unstable semitone has been consistent throughout the history of music theory. Fétis (1844) believed that tonality was itself a consequence of the attractions from scale degree $\hat{7}$ to $\hat{1}$, and from scale degree $\hat{4}$ to $\hat{3}$. Similarly, Lussy (1874) wrote that tones exhibit higher levels of attraction depending on their relative proximity. More recently, Lerdahl (2001, 167) discussed at length “the psychological need for an unstable pitch to be assimilated to an immediately subsequent proximate and stable pitch.”

Although the purportedly unstable semitone has been a central topic in music theory for centuries, it has received empirical attention only in recent decades. Krumhansl and Shepard (1979) empirically demonstrated a hierarchy of stability for different scale tones, and showed that there is a psychological tendency for less stable tones to proceed to more stable tones. Similarly, Deutsch (1978) showed the importance of pitch proximity in processing tones. Bharucha (1984, 1996) combined the properties of both proximity and

stability in his model of melodic anchoring, stating that “two constraints characterize the process of melodic anchoring: the anchor and the anchored tones are close in pitch (proximity), and the anchor always follows the anchored tone (asymmetry)” (1996, 383). Bharucha refers to the directional expectation generated by both of these factors as the “yearning vector,” which he defined as “the psychological force pulling the [musical] event up or down” (1996, 393). He carried out a behavioral study that demonstrated that listeners perceived the distance from scale degree $\hat{7}$ to scale degree $\hat{1}$ as closer than the reverse distance of $\hat{1}$ to $\hat{7}$ (1984). More generally, listeners perceive an inherent proximity when an unstable pitch resolves to a stable one, but not the other way around. Similarly, Francès demonstrated that listeners are more likely to detect when a leading tone is too low rather than too high (1958/1988, discussed in Yeary, 2011).

At least in the case of Western music, musicians commonly refer to the “yearning” qualia of a semitone relationship. Consider the semitone relationship between $\hat{7}$ and $\hat{1}$. For Western-enculturated listeners, the “leading tone” is aptly named as it evokes a strong urging or longing feeling. But this phenomenon is not limited to the upward semitone pitch movement from $\hat{7}$ - $\hat{1}$. In certain musical circumstances the same feeling of yearning attends the movement between the fourth and third scale degrees. A related example can be found in the so-called $\hat{4}$ - $\hat{3}$ suspension, in which a downward semitone tendency is delayed—heightening the phenomenological experience of yearning. The qualia associated with different scale tones have been chronicled in studies by Huron (2006) and Arthur (2015) in which musician listeners were asked to describe the feelings evoked by various scale degrees. The leading tone was described using terms such as *inevitability*, *unstable*, *pointing*, *restless*, *uncomfortable*, *squirmy*, and *itching*. In analyzing the content of such opened-end descriptions, Huron distinguished a semantic category dubbed “stability,” and linked it to first-order probabilities in exposure. That is, when stimulus X is commonly followed by stimulus Y in the environment of exposure, then when listeners encounter stimulus X, they commonly experience a strong feeling of instability and anticipation of the ensuing occurrence of Y. However, Huron’s study focused on the qualia of scale tones and did not examine qualia related specifically to intervals. In other words, Huron’s 2006 discussion did not link yearning qualia in any way to the interval of the semitone.

A number of theoretical ideas have been proposed to explain the possible origins for what might be dubbed “the yearning semitone.” For example, it is possible that the operative principle is that when you are close to something important, central or expected, there is a strong sense that one should move to that something. An alternative view might be

that there is nothing inherent to small intervals that would lead to this yearning quality. It may simply be that scale degrees $\hat{7}$ and $\hat{1}$ have a strong attachment, and that scale degrees $\hat{3}$ and $\hat{4}$ have similarly strong attachments independent of the semitone relationship. The implicit learning view posits no special function for the semitone: any pitch might accrue yearning qualia simply by its statistical tendency to be followed by some other pitch. For example, the dominant might evoke feelings of anticipation for the tonic, simply because in Western music, many dominants are followed by the tonic.

These speculations aside, the purpose of the present study is not to resolve the issue of origins, but to empirically test the existence of the phenomenon. That is, our aim is to determine whether musical organization is indeed consistent with the special role of the semitone in such a yearning or tending relationship. Accordingly, we might propose the following conjecture:

Scale degrees separated by a semitone are more likely to cleave together than scale degrees separated by a larger distance (e.g., whole tone).

In testing this conjecture we face at least two potential confounds. The first difficulty relates to compositional intent. Without resorting to a perceptual experiment, how might we operationalize the notion of “cleaving” or “yearning”? If one tone tends to cleave to another tone, evidence consistent with this relationship might minimally involve a statistical tendency for the one tone to be followed by the other tone. Of course, in real music, composers might aim to increase tension or engage in deception by interposing a third tone between a purported “yearning” pitch and a purported “yearned-for” pitch. So a simple tally of the number of X followed by Y may be necessary but not sufficient evidence consistent with a purported “cleaving” or “yearning” qualia. Nevertheless, we may reasonably suppose that evidence of a purported “cleaving” quale would minimally involve an elevated likelihood that one of the tones will have a high probability of being followed by the other tone.

A second potential confound relates to the relative stability of different scale tones. Musical melodies are not simply successions of intervals. Melodies are also salient successions of scale degrees, and some scale tones are more important than others. For example, scale degrees $\hat{1}$, $\hat{3}$ and $\hat{5}$ are known to be more stable than other scale tones. These differences are empirically evident, for example, in the key profiles assembled by Krumhansl and Kessler (1982). Unstable tones are simply attracted to more stable tones. This suggests that the tendency for $\hat{7}$ to move to $\hat{1}$, and for $\hat{4}$ to move to $\hat{3}$ might simply be a manifestation of unstable-to-stable movement, and that the semitone relationship between the pitch pairs is merely coincidental.

Fortunately, the dual-scale system of major and minor modes offers an opportunity to control for this confound. Although the scale-tone hierarchies are regarded as similar between the major and minor scales, the positions of the semitones differ between the two scales. Specifically, in the major scale, semitone relationships exist between $\hat{3}$ and $\hat{4}$ and between $\hat{7}$ and $\hat{1}$. In the harmonic minor scale, semitone relationships exist between $\hat{2}$ and $\hat{3}$, between $\hat{5}$ and $\hat{6}$, and between $\hat{7}$ and $\hat{1}$. The contrasting placement of semitones in

these two modes allows us, at least to some extent, to be able to examine semitone pitch movements relatively independently of the hierarchical importance of the different scale tones. That is, the contrast between the major and minor scales affords the opportunity to test our conjecture independent of the effect of scale degree.

II. HYPOTHESIS

In light of this background, we might propose the following specific hypothesis:

H. There is an association favoring semitone movement so that movement between $\hat{3}$ and $\hat{4}$ is favored in the major mode over the minor mode, while movement between $\hat{2}$ and $\hat{3}$ is favored in the minor mode over the major mode.

III. METHOD

In general, our method involves calculating the frequency of successions for various scale tones in a sample of major and minor-mode works.

A. Sample

Since our hypotheses relate to tone successions, an important sampling criterion is to focus on musical materials for which the linear succession of tones is not contentious. That is, we need to ensure that there is no ambiguity or dispute that tone X is followed by tone Y. Of the various musical textures, the least contentious would be musical melodies. Accordingly, in selecting our musical materials, we aimed to sample unambiguous musical melodies or thematic material.

For the purposes of this study, we employed two convenience samples. Specifically, we made use of two existing monophonic musical databases:

1. A random sample of 7,704 major and 768 minor-mode songs from the Essen Folksong Collection (Schaffrath & Huron, 1995).
2. A random sample of 7,171 major- and 2,618 minor-mode themes from the Barlow and Morgenstern *Dictionary of Musical Themes* (1948).

In both of these databases, the determination of the mode for each musical passage was made by the database authors. We have no information about the provenance or method by which these determinations were made. For the purposes of this study, we simply accepted the major and minor designations as encoded by the database authors.

Although a musical work might be nominally “in the major mode” or “in the minor mode,” it is common for works to exhibit various deviant passages. In the minor mode, for example, it is common to encounter so-called “modal mixture” in which the major and minor modes co-mingle.

In addition, chromatic alterations are common in both major- and minor-mode passages. These modifications might introduce unanticipated confounds that could skew the results in various ways. It would be appropriate, therefore, to establish criteria by which certain musical works might be excluded from the sample.

Of particular concern would be those alterations that render a nominally major-mode work to more closely resemble the minor mode, or a nominally minor-mode work to more closely resemble the major mode. For example, any nominally major-mode melody that contains $\flat 3$, or any nominally minor-mode melody that contains $\natural 6$ would be suspect.

The main differences between the major and (harmonic) minor modes are found in scale degrees $\hat{3}$ and $\hat{6}$. Scale tone $\hat{7}$ is more problematic. In the minor mode, both $\flat 7$ and $\natural 7$ regularly appear and so it may be inappropriate to exclude any nominally minor-mode melody or theme either because it employs $\flat 7$ or because it employs $\natural 7$.

As a result, we resolved to exclude any nominally major-mode melody or theme that exhibits either $\flat 3$, $\flat 6$ or $\flat 7$, and to exclude any nominally minor-mode melody or theme that exhibits either $\natural 3$ and $\natural 6$. Employing this criterion, 389 of the original 7,704 major-mode melodies and 205 of the original 768 minor-mode melodies were excluded from the Essen Folksong collection. Similarly, 1,547 of the original 7,171 major-mode themes and 704 of the original 2,618 minor-mode themes were excluded from the Barlow and Morgenstern collection. Hence, our final sample included 7,315 major- and 563 minor-mode songs from the Essen Folksong Collection Procedure, and 5,624 major- and 1,914 minor-mode themes from the Barlow and Morgenstern *Dictionary of Musical Themes*.

All of the sampled materials are available in the Humdrum “kern” format. The data were processed using the Humdrum Toolkit (Huron, 1994). Specifically, each melody was translated to a scale-degree representation, and then all of the scale-degree transitions were tallied. Since rests often indicate grouping boundaries, the relationship between pitches separated by a rest appears to be perceptually less salient. Accordingly, scale-degree transitions spanning a rest were omitted. In the Essen Folksong collection, phrases are explicitly notated. For the same reason, we omitted transitions occurring at phrase boundaries for this sample. That is, we did not consider the last note of one phrase to be “connected” to the first note of the ensuing phrase.

IV. RESULTS

Recall that our hypothesis predicts an association favoring semitone movement so that movement between $\hat{3}$ and $\hat{4}$ is favored in the major mode over the minor mode, while movement between $\hat{2}$ and $\hat{3}$ is favored in the minor mode over the major mode. Tables 1a and 1b present the pertinent tallies. Both tables show the total number of instances of movement between $\hat{2}$ and $\hat{3}$ and between $\hat{3}$ and $\hat{4}$. Table 1a pertains to the Essen Folksong collection; Table 1b pertains to the Barlow and Morgenstern themes.

Table 1a. Comparison of frequency of movement between $\hat{2}$ and $\hat{3}$ and $\hat{3}$ and $\hat{4}$ in the Essen Folksong collection.

	Major	Minor
$\hat{2} \leftrightarrow \hat{3}$	39,637	2,815
$\hat{3} \leftrightarrow \hat{4}$	19,685	2,515

Table 1b. Comparison of frequency of movement between $\hat{2}$ and $\hat{3}$ and $\hat{3}$ and $\hat{4}$ in the Barlow and Morgenstern themes.

	Major	Minor
$\hat{2} \leftrightarrow \hat{3}$	9,345	3,643
$\hat{3} \leftrightarrow \hat{4}$	8,014	2,544

The hypothesized association would predict that major/ $\hat{3} \leftrightarrow \hat{4}$ and minor/ $\hat{2} \leftrightarrow \hat{3}$ would exhibit higher tallies than major/ $\hat{2} \leftrightarrow \hat{3}$ and minor/ $\hat{3} \leftrightarrow \hat{4}$. An appropriate statistical test for this association is the chi-square test for contingency tables. In the case of the Essen Folksong Collection the results are not consistent with the hypothesis. In fact, there is a significant reverse relationship, $\chi^2(1) = 424.67, p < .01$; Phi = .08, Yates’ continuity correction applied. Similar reverse results are evident in the Barlow and Morgenstern themes, $\chi^2(1) = 46.79, p < .01$, Phi = .05. In both cases the effect size is very small however.

V. DISCUSSION

We predicted an association favoring semitone movement so that movement between $\hat{3}$ and $\hat{4}$ in the major mode would be more common than $\hat{3}$ and $\hat{4}$ in the minor mode, while movement between $\hat{2}$ and $\hat{3}$ would be favored in the minor mode over the major mode. However, our results showed a significant (though very small) reverse association. Instead, activity between $\hat{2}$ and $\hat{3}$ tends to always be greater than activity between $\hat{3}$ and $\hat{4}$. In light of these results, the yearning theory appears to be weak.

In the course of this study, our analyses produced an unexpected result regarding the use of semitone intervals in melodies generally. In both the Barlow & Morgenstern and the Essen Folksong Collection, the most commonly sought-out intervals are the conjunct intervals of major and minor seconds. Descending seconds appear to be more sought-out than ascending seconds, and minor seconds are sought-out more than major seconds. Unisons also occur more frequently than a chance level, although to a lesser extent. A detailed comparison of the use of unisons, minor seconds, and major seconds in actual and scrambled melodies is presented in Tables 3a-d.

Table 3a. Comparison of semitone and whole-tone frequencies in scrambled and unscrambled melodies: Essen Folksong Collection, major mode.

Interval	Actual (%)	Scrambled (%)	Difference	Increase (%)
Unison	21.8	16.8	+ 5.0	29.8
Ascending minor second	6.2	3.3	+ 2.9	87.9
Descending minor second	8.3	3.3	+ 5.0	151.5
Ascending major second	13.3	10.1	+ 3.2	31.7
Descending major second	21.5	10.1	+ 11.4	112.9

Table 3b. Comparison of semitone and whole-tone frequencies in scrambled and unscrambled melodies: Essen Folksong Collection, minor mode.

Interval	Actual (%)	Scrambled (%)	Difference	Increase (%)
Unison	18.5	16.4	+ 2.1	12.8
Ascending minor second	9.1	4.3	+ 4.8	111.6
Descending minor second	12.4	4.3	+ 8.1	188.4
Ascending major second	16.4	9.9	+ 6.5	65.7
Descending major second	21.9	10.0	+ 11.9	119.0

Table 3c. Comparison of semitone and whole-tone frequencies in scrambled and unscrambled themes: Barlow and Morgenstern, major mode.

Interval	Actual (%)	Scrambled (%)	Difference	Increase (%)
Unison	14.7	13.9	+ 0.8	5.8
Ascending minor second	9.0	3.7	+ 5.3	143.2
Descending minor second	9.9	3.9	+ 6.0	153.8
Ascending major second	15.0	8.4	+ 6.6	78.6
Descending major second	18.3	8.5	+ 9.8	115.3

Table 3d. Comparison of semitone and whole-tone frequencies in scrambled and unscrambled themes: Barlow and Morgenstern, minor mode.

Interval	Actual (%)	Scrambled (%)	Difference	Increase (%)
Unison	14.7	13.6	+ 1.1	8.1
Ascending minor second	11.2	5.0	+ 6.2	124.0
Descending minor second	13.4	5.0	+ 8.4	168.0
Ascending major second	13.0	7.3	+ 5.7	78.1
Descending major second	16.1	7.2	+ 8.9	123.6

In general, there are more whole-tone steps than semitone steps in melodies. However, compared with scrambled reorderings of tones, in actual melodies semitone intervals are favored more than whole-tone intervals. In all four samples (Tables 3a-3d) the percentage increase for ascending and descending semitones is greater than the corresponding increase for whole-tone intervals. This implies that close pitch proximity is favored.

VI. CONCLUSION

We investigated some 15,000 melodies and themes from the Essen Folksong Collection and the Barlow and Morgenstern *Dictionary of Musical Themes* in order to test whether there is an association favoring movements between scale degrees $\hat{3}$ and $\hat{4}$ (semitone) over $\hat{3}$ to $\hat{2}$ (whole-tone) in the major mode, compared with movements between scale degrees $\hat{3}$ and $\hat{4}$ (whole-tone) over $\hat{3}$ to $\hat{2}$ (semitone) intervals

in the minor mode. The results were not consistent with the “yearning semitone” theory and failed to show the predicted relationships.

However, *post-hoc* observations show that while whole-tone intervals outnumber semitone intervals, composers nevertheless exhibit an even stronger affinity for using semitone intervals in general. By way of summary, our results are not consistent with the “yearning semitone” theory, but our study does offer *post-hoc* evidence consistent with an alternative theory—what might be called the “baby steps” theory: the smallest pitch movements appear to be favored whether or not these movements are linked to tonally more stable pitches. These results reinforce longstanding observations regarding pitch-proximity, but add to these observations by identifying a disposition towards using the smallest available intervals in the construction of melodies.

Of course these observations may not generalize beyond the specific repertoires studied. Further study is warranted to establish whether “baby steps” are preferred in other styles of Western melody, and whether the theory might apply to melodies from non-Western cultures.

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