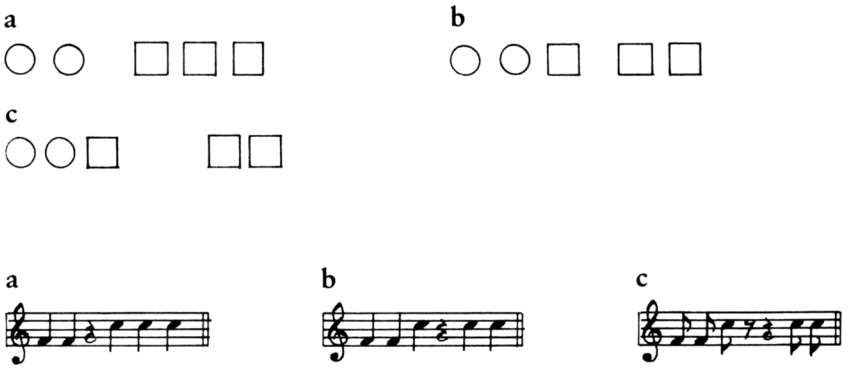
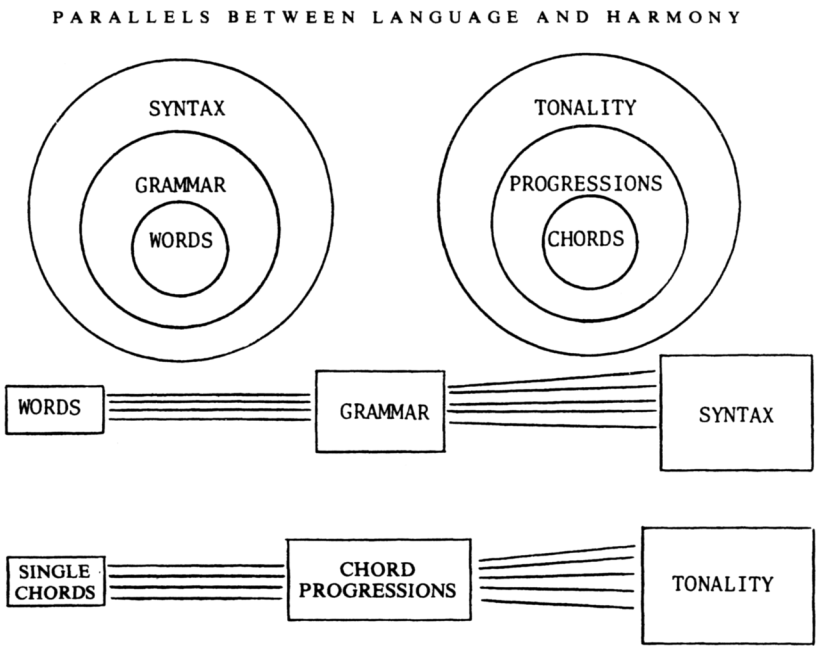
Visualizing Music
Online Supplement

Online Figure 2.3 Fred Lerdahl and Ray Jackendoff, *A Generative Theory of Tonal Music* (Cambridge, MA: MIT Press, 1983), 42.



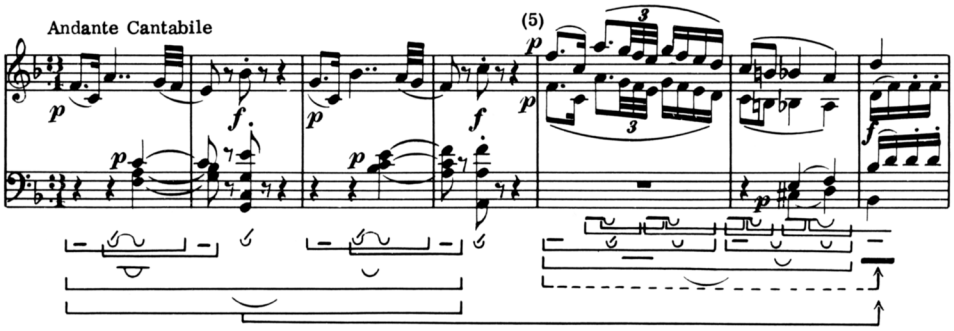
Here, spatial distance on the page serves as a metaphor for temporal "distance." Although shape *correlates* with pitch—circles represent F, and squares represent C—there is no common meaning that would elevate the mapping to *metaphor*.

Online Figure 2.4 Jan LaRue, *Guidelines for Style Analysis*, expanded 2nd ed. (Warren, MI: Harmonie Park, 2011), 40.



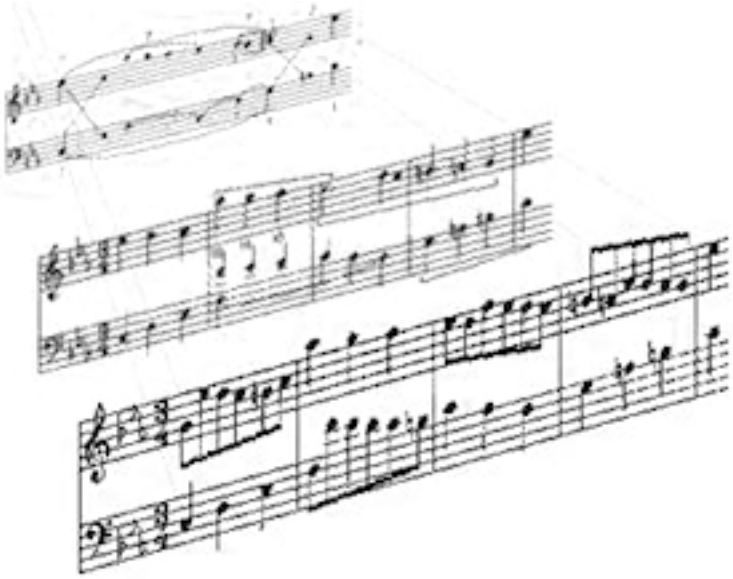
This image draws an explicit analogy between language and music, recalling Leonard Bernstein's 1973 six-lecture series at Harvard, *The Unanswered Question*.

Online Figure 2.5 Grosvenor Cooper and Leonard B. Meyer, *The Rhythmic Structure of Music* (Chicago: University of Chicago Press, 1960), 90.



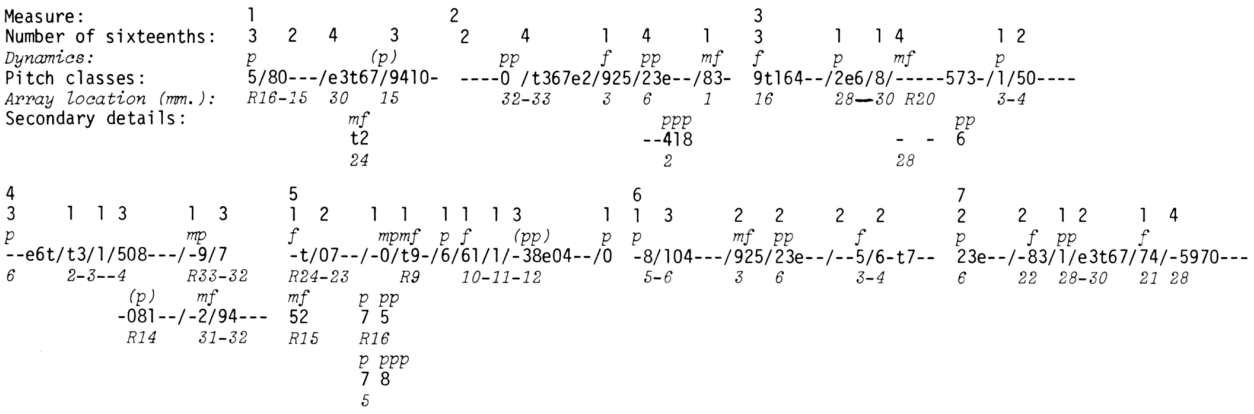
This image draws an explicit analogy between musical rhythm and poetic feet. Extending the notion of strong and weak to apply to extended musical passages lays the groundwork for the understanding of hypermeter.

Online Figure 2.7 Timothy Koozin, "On Metaphor, Technology, and Schenkerian Analysis," *Music Theory Online* 5, no. 3 (May 1999), http://www.mtosmt.org/issues/mto.99.5.3/mto.99.5.3.koozin.html.



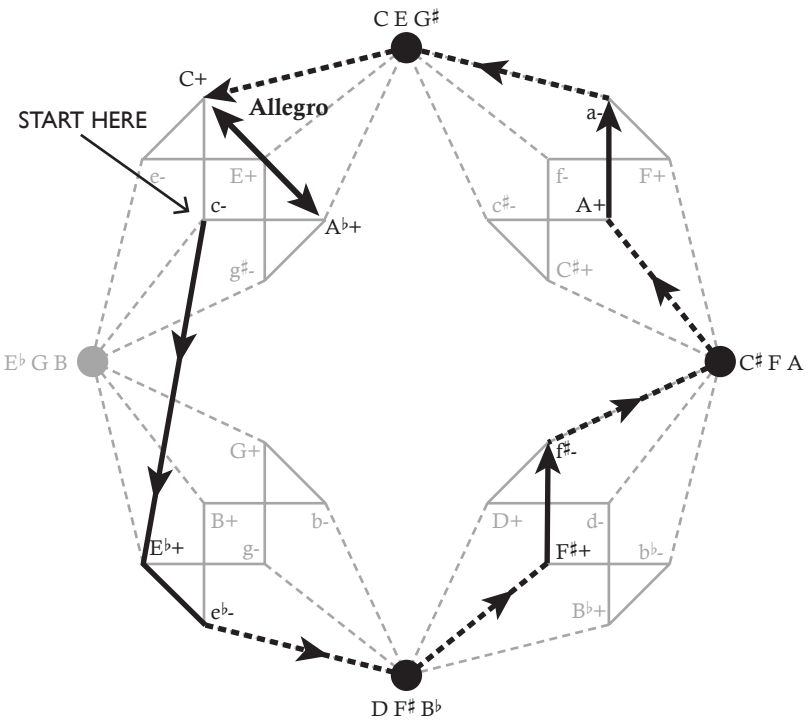
Heinrich Schenker's analytical system references foreground, middleground, and background levels. This might evoke a sense of depth perception such as that associated with perspective drawing, as depicted here.

Online Figure 3.4 Andrew W. Mead, "Detail and the Array in Milton Babbitt's *My Complements to Roger*," *Music Theory Spectrum* 5 (1983): 97, excerpt.



Here, in compact, multivariate form, four different types of information are plotted in independent rows against a fifth dimension, time, which flows from left to right. While one might design this differently today, note how effectively it conveys a large amount of information with little wasted ink. The use of roman and italic typefaces keeps the rows of information distinct, while the use of a monospaced font allows for efficient vertical alignment of temporally aligned information.

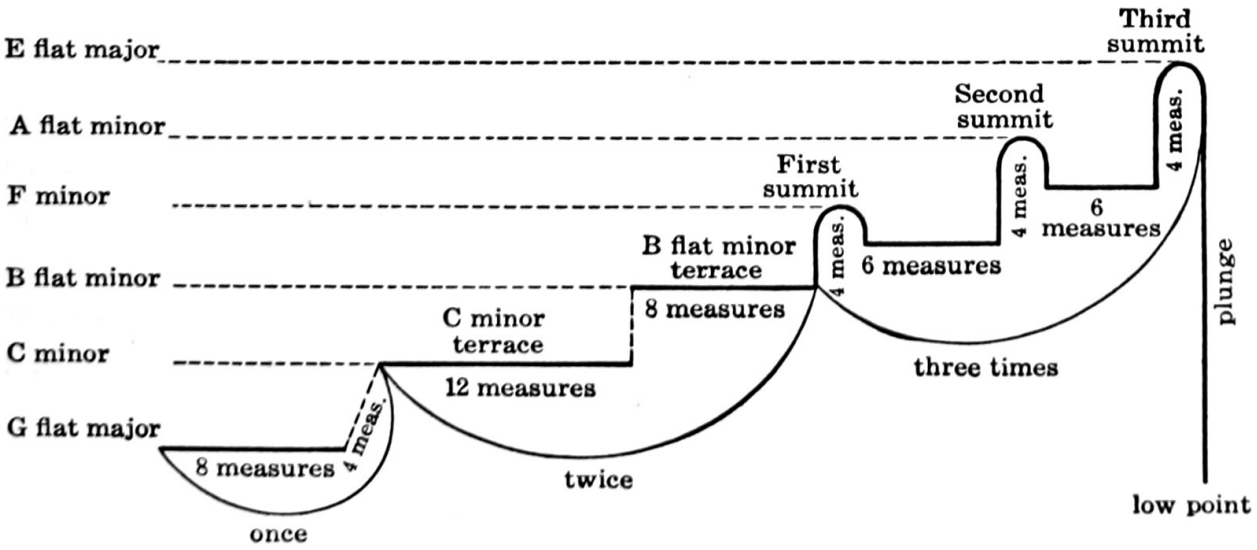
Online Figure 4.4 Richard Cohn, *Audacious Euphony: Chromaticism and the Triad's Second Nature* (New York: Oxford University Press, 2012), 87.



This image clearly conveys the tonal narrative of the opening of a Franz Schubert overture through the Cube Dance. Dark arrows guide our steps through an intricate background maze of potential voice leading. The lovely dance metaphor was proposed by Douthett and Steinbach (1998).

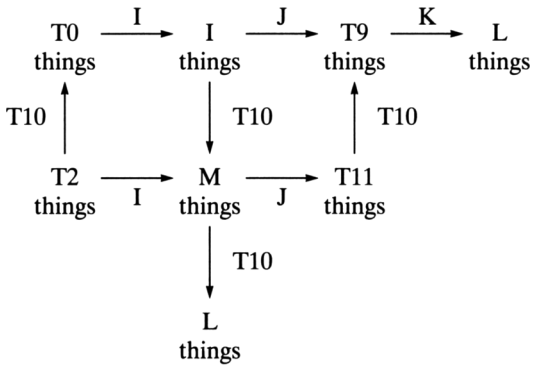
Rogers and Buchler (2003) employ a square dance metaphor to delightful effect.

Online Figure 4.5 Hugo Leichtentritt, *Musical Form* (Cambridge, MA: Harvard University Press, 1951), 385.



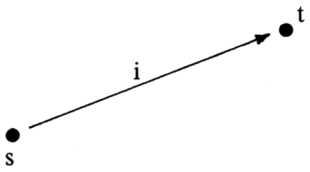
While many images use arrows to convey directionality, if an image can do without, all the better. In this reading of the development of Anton Bruckner's Symphony no. 8, movement 1, a left-to-right time-directional reading combined with the climb to ever higher terraces—and then summits—renders arrows unnecessary.

Online Figure 4.7 David Lewin, *Musical Form and Transformation: 4 Analytic Essays* (New Haven, CT: Yale University Press, 1993), 77.



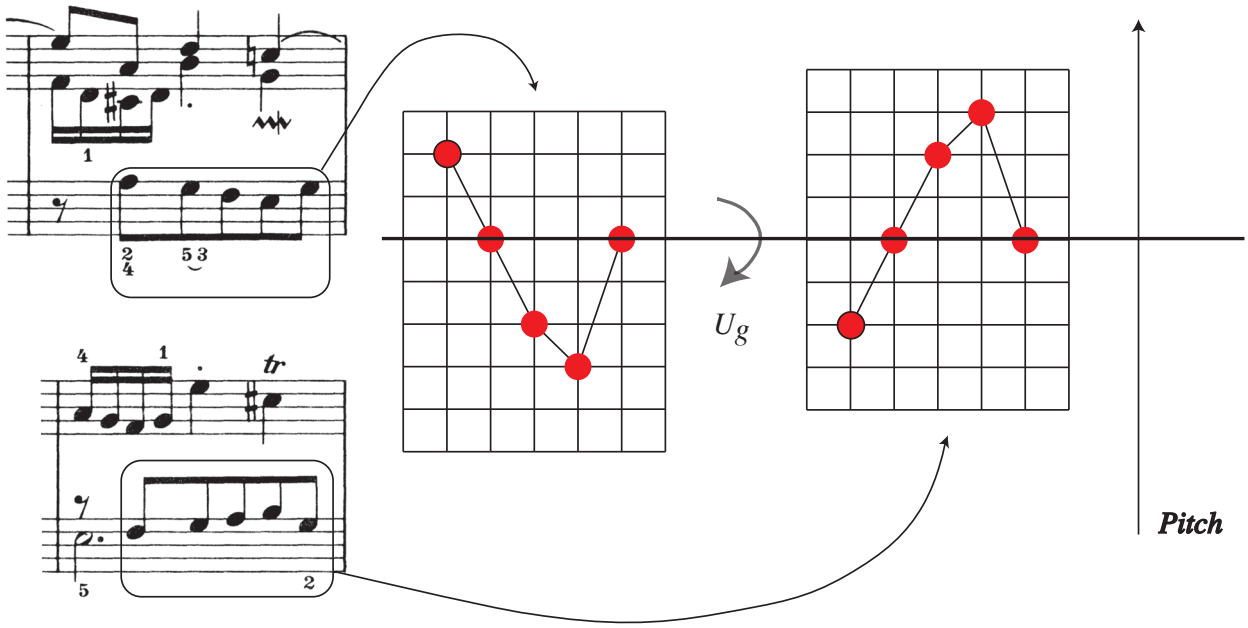
This image tells the story of Anton Webern's *Five Pieces for Orchestra*, op. 10, no. 4. Referencing "things" explained in an earlier example in the source, it is a tale of T0 things being transformed by a contextual inversion operation *I* into I things, which are transformed by a different contextual inversion operation *J* into T9 things, which are finally transformed by a third contextual inversion operation *K* into L things. As the original caption notes, this basic story is "elaborated by T10-relations and the I,J 'subplot'" involving T2, M, and T11 things (Lewin 1993, 77). Note the explicit reference to a narrative motivation for the image. Listing all the T10 transformations vertically and all the inversion transformations (*I*, *J*, *K*) horizontally neatly untangles a complex web of interactions in the music itself.

Online Figure 4.8 David Lewin, *Generalized Musical Intervals and Transformations* (New Haven, CT: Yale University Press, 1987), xi.



The genesis of figures like online figure 4.7 is Lewin's own iconic image, a schematic representation of an interval. Whereas an interval is a static measure of distance between two things—emphasizing the objects themselves (how music "is," in Westergaard's formulation). Lewin proposes shifting the focus from interval to transformation (how music "goes"). Measuring intervals is not necessarily inappropriate, but if it is possible to add a narrative component, an image will be more compelling.

Online Figure 5.1 Guerino Mazzola, Stefan Göller, and Stefan Müller, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhauser, 2002), 141.



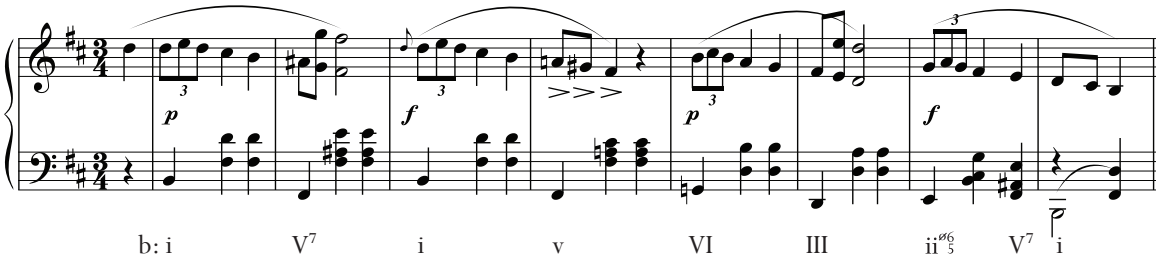
In music, the staff serves a function similar to that of a ruler—allowing us to see the relative (diatonic) distance between pitches. Grids akin to graph paper can serve the same function for measuring distance in chromatic space.

Online Figure 5.5 David Huron, *Sweet Anticipation: Music and the Psychology of Expectation* (Cambridge, MA: MIT Press, 2006), 273.

Chord	Expectedness	Tendency	Valence	Other
#VI	novel, futuristic, bold, conventional	stable, settled, complete, final, leading, urging, pushy	upbeat, energetic, bright	whole, heightened, strong, simple, uncomplicated, plain
#vi	surprising, challenging	confident, resolute, enticing, incomplete, stable, established, shifty, open-ended	weighty, airy, serious, majestic	melodious, strident, expansive, solid
vi	unexpected, different, newness, abrupt, eccentric		mysterious, cheerless, somber, dark, tragic, despairing, death, depressed	
#III	surprising, edgy, sudden	transitional, falling, promising, temporary, committed, directed, suggestive, drawing in, settled, resolved	satisfying, positive,	simple, plain, hollow, crisp
#iii	surprise	restful, resigned	somber, sad, mysterious, serious, solemn, stately, solid, melancholic	whimsical, light
iii	surprising, unprepared	compelling, foreboding, insistent, leading, tentative	dark, ominous, murky, solemn, mysterious, ethereal, disturbed, anxious	rich, fuzzy, cozy, sensitive, detached

Tables are inherently comparative. Here, reported descriptors of four different qualities are given for six chromatic mediant chords. Reading across paints an increasingly detailed picture of each chord's characteristics. Reading down draws attention to the ways in which they differ.

Online Figure 5.6 Mitchell S. Ohriner, "Grouping Hierarchy and Trajectories of Pacing in Performances of Chopin's Mazurkas," *Music Theory Online* 18, no. 1 (2012): ex. 12a, http://mtosmt.org/issues/mto.12.18.1/mto.12.18.1.ohriner.php.



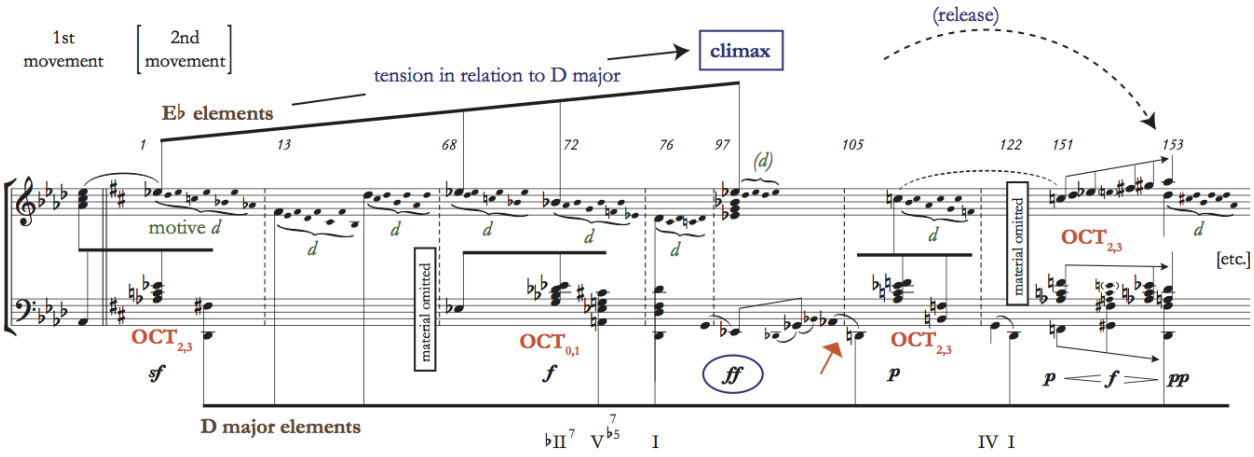
Evidence for two-measure grouping: thematic repetition, descending fourths in the bass, dynamic contrast, slurring, long notes

Evidence for four-measure grouping: registral shift of first melodic note, textural break in melody, introduction of novel harmony.

Evidence for eight-measure grouping: absence of $V^{\sharp}$ half cadence in measure 4

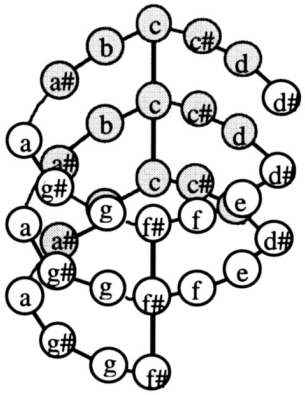
This image simply but effectively makes conceptual comparison among three possible metrical groupings in a Frédéric Chopin Mazurka. Parallel use of a boldface font ("Evidence for . . .") triggers the comparison impulse.

Online Figure 7.4 Blair Johnston, "Modal Idioms and Their Rhetorical Associations in Rachmaninoff's Works," *Music Theory Online* 20, no. 4 (December 2014): ex. 8d, http://www.mtosmt.org/issues/mto.14.20.4/mto.14.20.4.johnston.html.

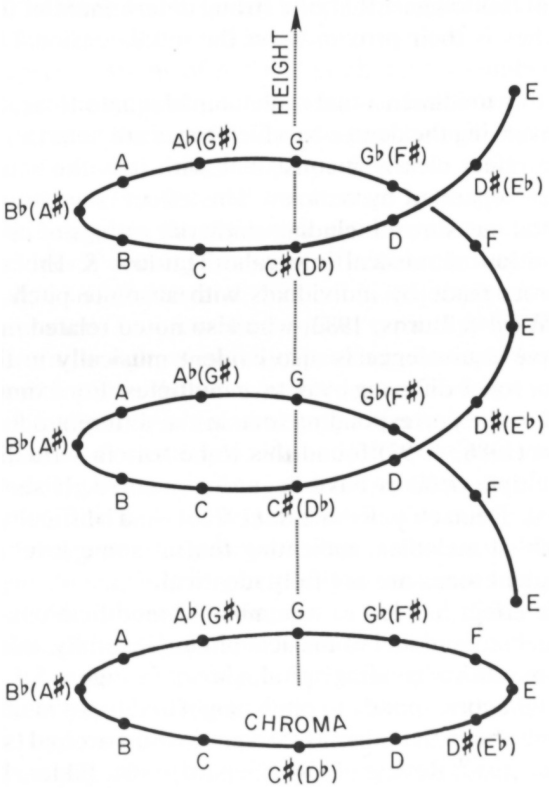


This image paints a richly layered picture of Rachmaninoff's *The Bells*, integrating into one image elements of collection, long-range tonal design, motivic unity, and dramatic shape. Structurally significant pitches drawn from E♭ and D major collections are given long stems and beamed together. Stemless elaborating notes have smaller noteheads. A label showing a recurring motive uses a different font style (*italic*) and color (green) than the rest of the text. Octatonic collections are labeled in another color (red). A third color (blue) marks the dramatic structure of the movement. The combination of unique color, font, and function in each layer makes it easy to jump among the elements within that layer. Dynamic markings and chord labels appear in their own spaces near the bottom of the image, while the informationally insignificant, but referentially necessary, measure numbers are presented in a smaller font in their conventional location. The image is beautifully rendered, with each layer made visually clear and the various elements given enough space to breathe.

Online Figure 8.6 *Left*, Tuire Kuusi, "Set-Class and Chord: Examining Connection between Theoretical Resemblance and Perceived Closeness," Studia Musica (Helsinki: Sibelius Academy, 2001), 17; *right*, Carol L. Krumhansl, *Cognitive Foundations of Musical Pitch* (New York: Oxford University Press, 1990), 114.

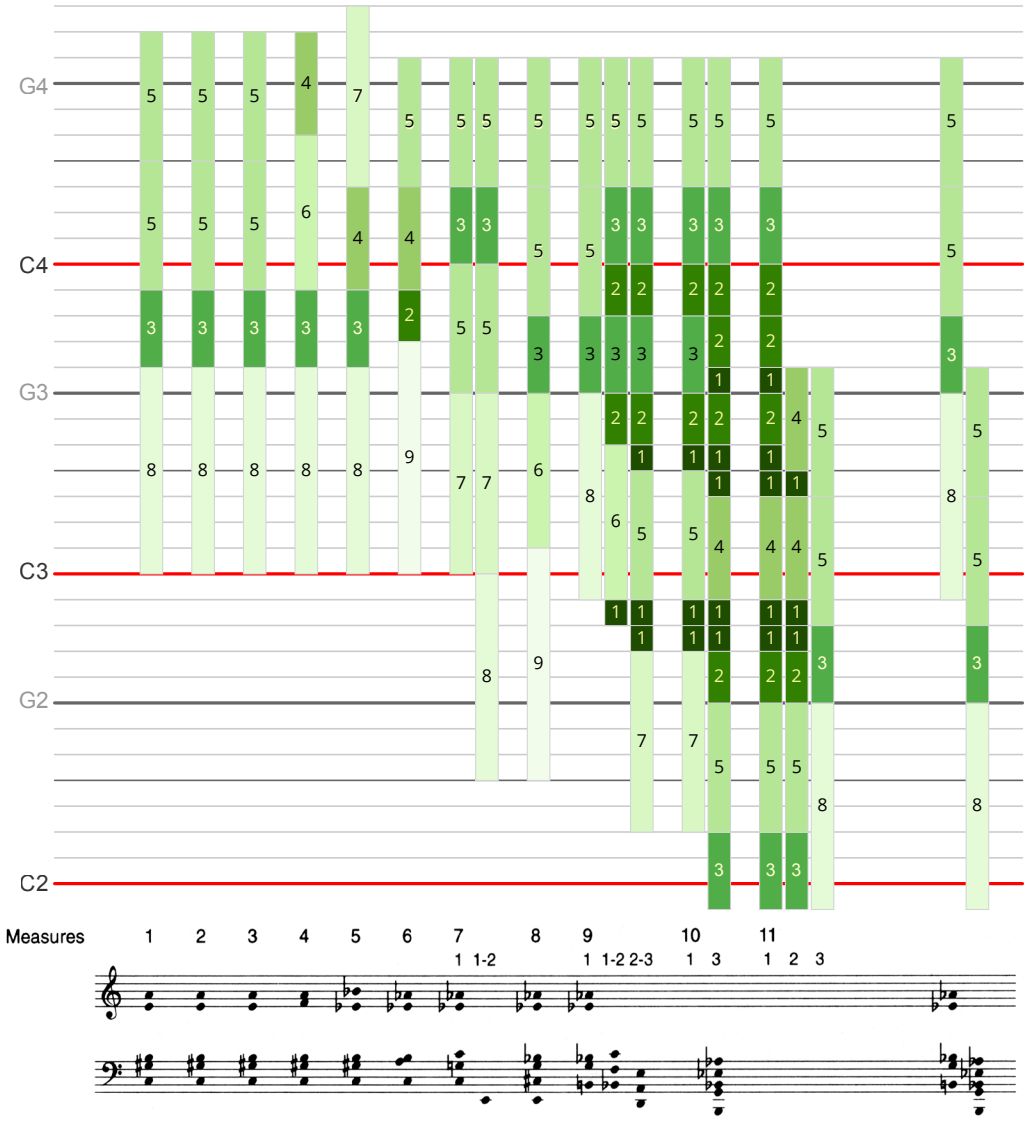


The pitch helix



In the left image, unnecessary circles around the note names only distract from what can be seen more clearly in the right image. The right image wastes little ink. However, more prominent note names relative to the helix would improve it.

Online Figure 8.10 Redrawing of fig. 8.9.



This redrawing of figure 8.9 replaces the various line styles depicting different intervals with bars that express the interval sizes in both number and color. It also greatly subdues the grid. The vertical alignment of the bars above the chords they represent eliminates the need for vertical gridlines. Horizontal lines still mark off semitones, but reference lines drawn in different thicknesses and colors replace the reference pitches that appeared at the left in the original. The visual focus is squarely on the information itself.

Online Figure 9.3 *Above*, Nathan Hesselink, "Rhythm and Folk Drumming (P'ungmul) as the Musical Embodiment of Communal Consciousness in South Korean Village Society," in *Analytical and Cross-Cultural Studies in World Music*, ed. Michael Tenzer and John Roeder (New York: Oxford University Press, 2011), 283; *below*, redrawing.

Soe	O		o	O		o	O		o	⊃	o	
Changgo (stick side)	l		'	l		'	l		l	O	l	'
Changgo (mallet side)	O			O			O					
Puk	O			O			O			o		

Soe	O	O		O		o	O		o	⊃	o	
Changgo (stick side)	l	l	'	l		'	l		l	O	l	'
Changgo (mallet side)	O	O		O			O					
Puk	O	O		O			O			o		

Key

Soe (small gong) strokes	*Changgo* (hourglass drum) strokes	*Puk* (barrel drum)
O = loud stroke	O = mallet stroke	O = loud stroke
o = weaker stroke	l = stick stroke	o = weaker stroke
⊃ = damp sound with hand holding gong	' = stroke by tip of stick	

Soe	O		o	O		o	O		o	⊃	o	
Changgo stick side	|		'	|		'	|		|	O	|	'
Changgo mallet side	O			O			O					
Puk	O			O			O					

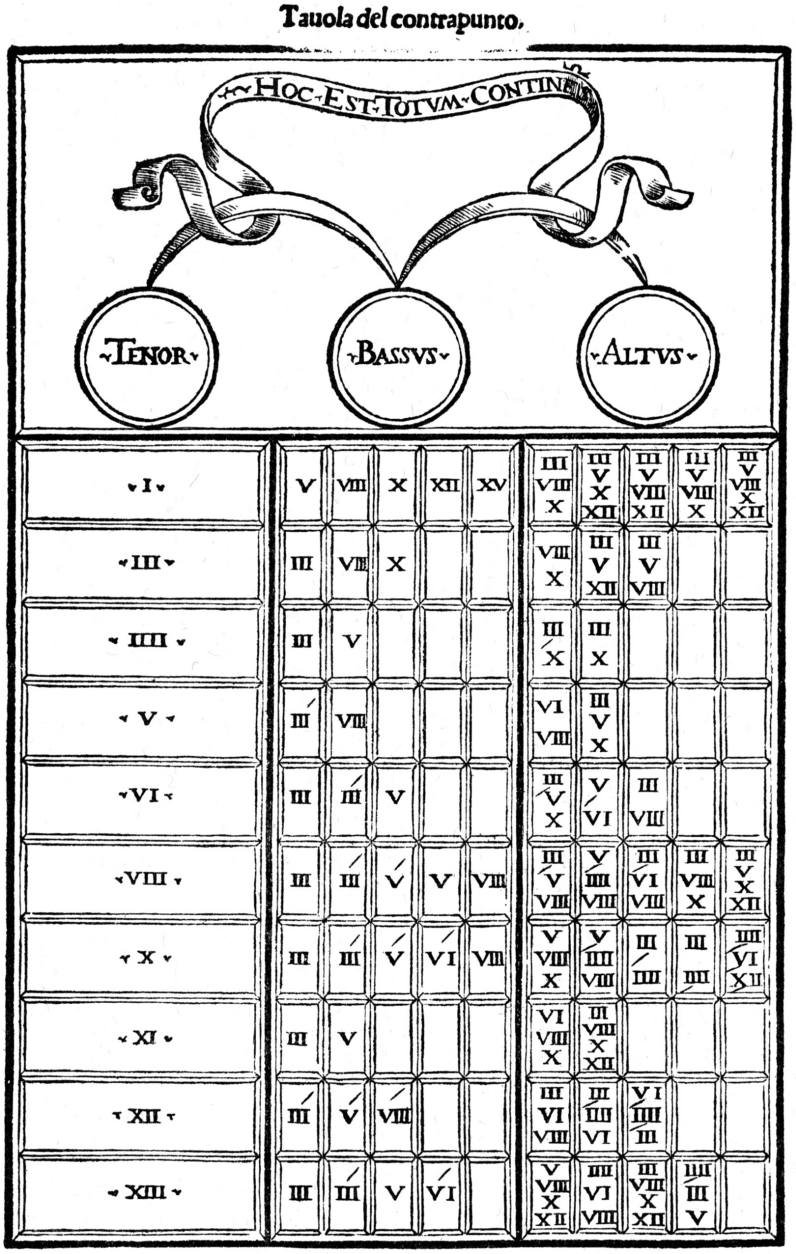
Soe	O	O		O		o	O		o	⊃	o	
Changgo stick side	|	|	'	|		'	|		|	O	|	'
Changgo mallet side	O	O		O			O					
Puk	O	O		O			O			o		

Key

Soe (small gong) strokes	*Changgo* (hourglass drum) strokes	*Puk* (barrel drum)
O = loud stroke	O = mallet stroke	O = loud stroke
o = weaker stroke	| = stick stroke	o = weaker stroke
⊃ = damp sound with hand holding gong	' = stroke by tip of stick	

A table's contents can be entirely symbolic. In the upper image in online figure 9.3, textual symbols represent different drum strokes used in a Korean rhythmic pattern. In a nice touch, the symbols are evocative rather than arbitrary. Round *O*s represent mallet heads, with a larger letter representing a loud stroke and a smaller letter a weak stroke. A straight line looks like a stick, and the ‘ symbol resembles the end of the stick. Finally, the ⊃ symbol resembles a hand. As often happens in tables, the grid here is too loud, though in this case it cannot be dispensed with altogether: the vertical gridlines are temporal markers, and their thickness distinguishes bar lines from internal beats. The horizontal lines carry no meaning, though they separate the *Soe* and *Puk* from the two sides of the *Changgo*. The redrawing below removes unnecessary gridlines and reduces the prominence of those that remain, bringing the important information to the fore. The redrawing also reformats the instrument names slightly.

Online Figure 9.7 Pietro Aron, *Toscanello in musica*, book 2 (Venice: M. Sessa, 1539), cap. XXX.



Aron's "table of counterpoint," an extreme example of an overly imposing grid, imprisons the data in double reinforced walls. These walls aren't needed.

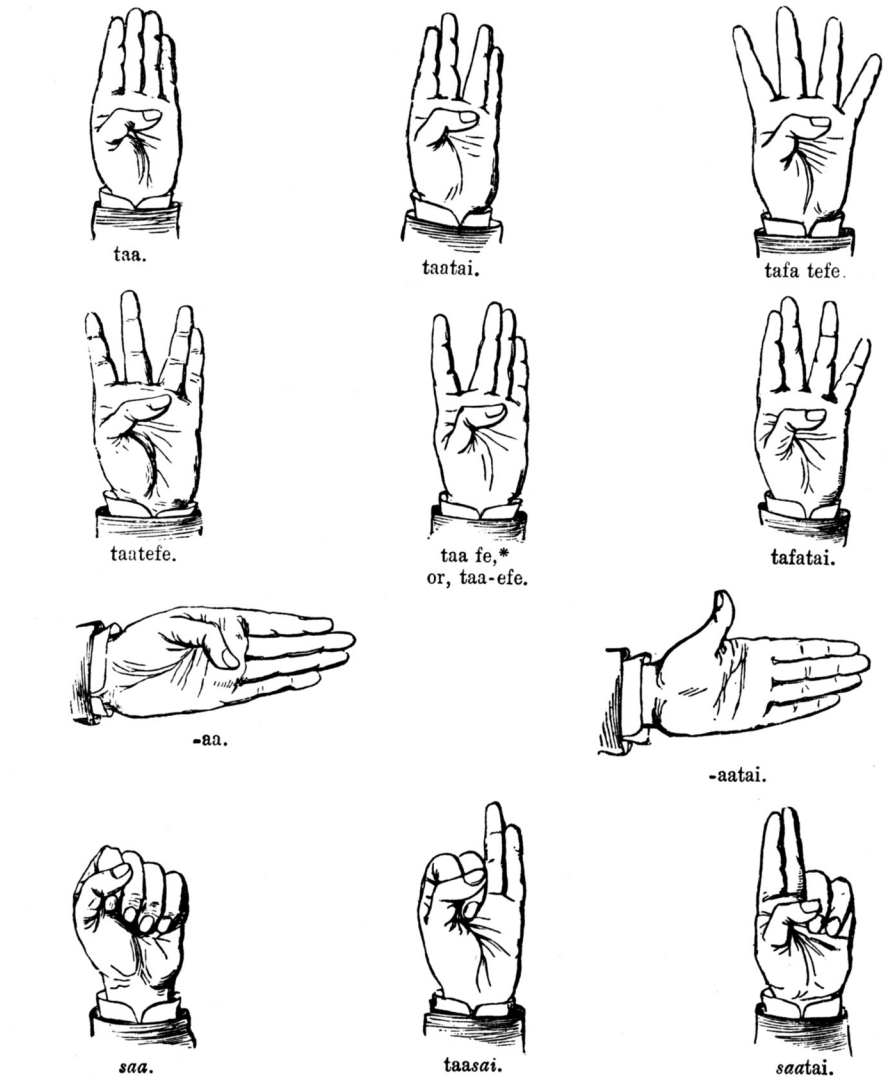
Online Figure 9.9 Miguel A. Roig-Francolí, "From Renaissance to Baroque: Tonal Structures in Tomás Luis de Victoria's Masses," *Music Theory Spectrum* 40, no. 1 (2018): 31, excerpt.

Masses	*Model*	*Model Tonal Type and Mode*	*Mass Tonal Type*	*Mass Movements and Cadences*			*Mass Mode*	*Comments*
				Mov.	*Final*	*Internal*		
1576								
1. *Ave maris stella* a 4	*Ave maris stella* chant, *LU* 1259	N/A 1	♭–g2–G	*Kyr.* *Glor.* *Credo* *Sanc.* *Ben.* *Agnus*	G G G G G G	C, G, D, F G, D, C, F, B♭ (Mostly G, D) G, D, A, F, C (Mostly G, D) G, C, D, F G, F G, D, F, B♭	1	Tonal type and structure: Clearly mode 1
2. *Simile est regnum cælorum* a 4	Guerrero, *Simile est...* (*Septuagesima* motet a 4)	♮–g2–G 8	♮–g2–G	*K.* *G.* *C.* *S.* *B.* *A.D.*	G G G G G G	G, C, D C, G, D C, G, D, (E), A G, C C, G G, C, D	8	Tonal type and structure: Clearly mode 8
3. *De beata Maria virgine* a 5	Plainchant Mass IX and *Credo* I	*Kyrie* IX: mode 1 *Gloria* IX: mode 7 *Credo* I: mode 4 *S./B.* IX: mode 5 *A.D.* IX: mode 5	♭–g2–G ♮–g2–G ♮–g2–E ♭–g2–F ♭–g2–F	*K.* *G.* *C.* *S./B.* *A.D.*	G G E F F	G, D, B♭ C, G, D G, D, A C, F, B♭ F, C	1 7 4 5 5	Each movement follows mode of corresponding paraphrased chant. Only conflict: *Credo*, tonal type typical of mode 3, cadences of mode 4.
4. *Gaudeamus* a 6	Morales, *Jubilate Deo* a 6	♭–c1–G 2	♭–c1–G	*K.* *G.* *C.* *S.* *B.* *A.D.*	G G G G G G	A, D, G, B♭ D, G, B♭ G, C, B♭, D, F D, C, G, B♭ D, G, C, B♭ G, B♭, D	2	Tonal type and structure: Clearly mode 2
5. *Dum complerentur* a 6	Own motet a 5	♭–g2–G 1	♭–g2–G	*K.* *G.* *C.* *S.* *B.* *A.D.*	G G G G G G	D, G G, D, B♭, A D, G, B♭ D, G, A D, G G, D, C, B♭	1	Tonal type: mode 1 Structure: ambiguous 1/2 (3 movs. include B♭ cadences)

EXAMPLE 3. *Victoria's Masses*

This excerpt from a much larger table lists modes used in Tomás Luis de Victoria's masses. As in figure 9.8, the tabular format allows one to find information about a particular work but also facilitates comparison among multiple works. The image appropriately eschews the gridlines found more often than necessary in tables. Here, the slightly greater white space between works than in figure 9.8 guides the eye across the table.

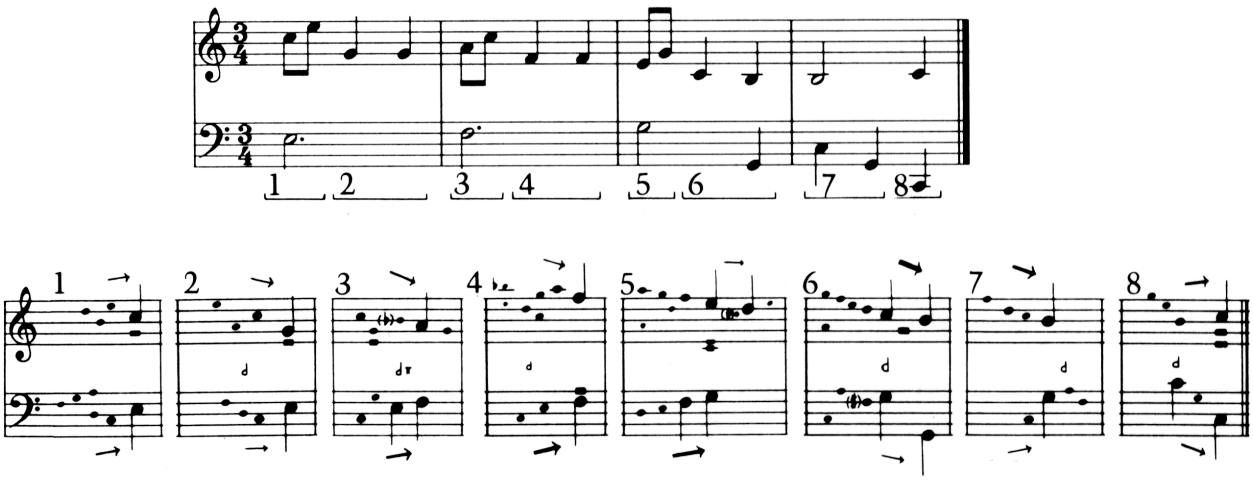
Online Figure 10.2 John Curwen, *The Teacher's Manual of the Tonic Sol-Fa Method* (London: Curren, 1875), 149.



An image from the nineteenth century shows the syllables and corresponding hand symbols for a rhythmic solfège system. The graphic serves as a lookup reference, but the small-multiple format also facilitates comparisons between different hand positions and their corresponding syllable patterns.

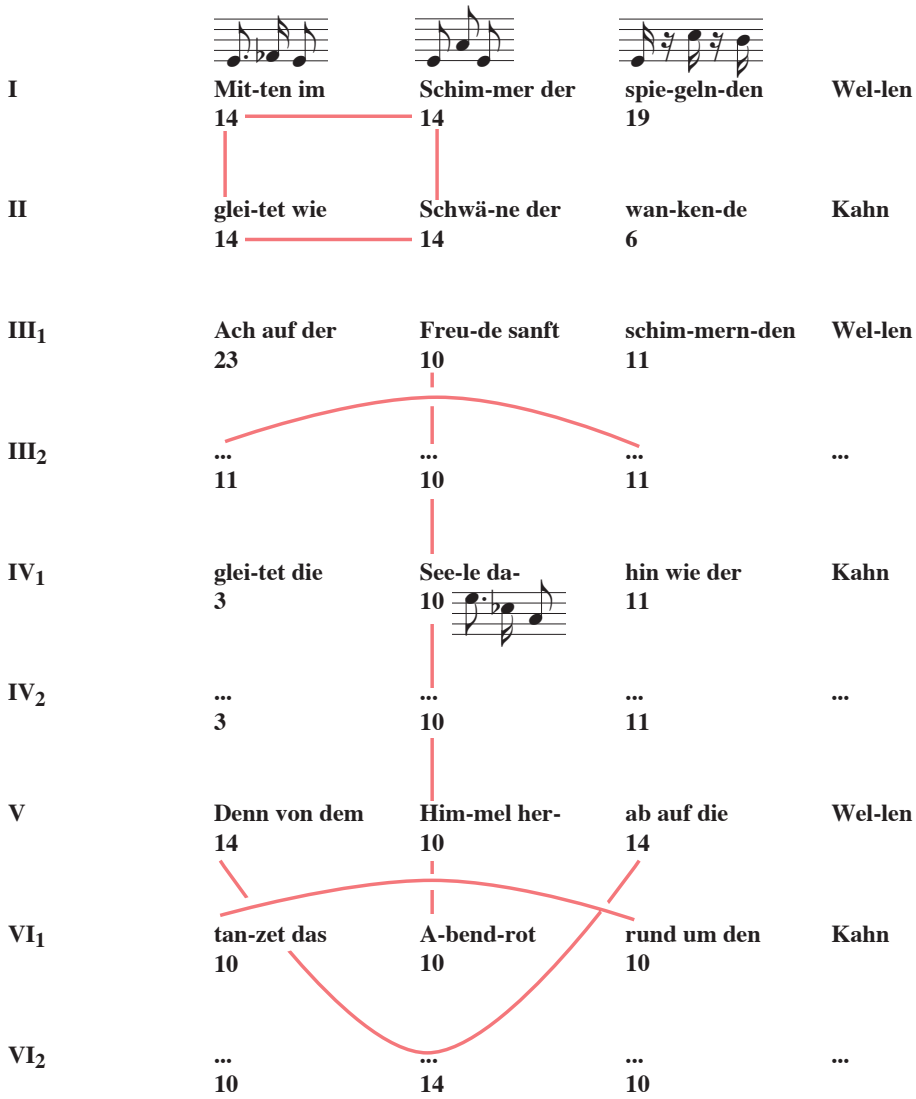
Online Figure 10.4 Redrawing of fig. 10.3.

KV2, measures 21–24



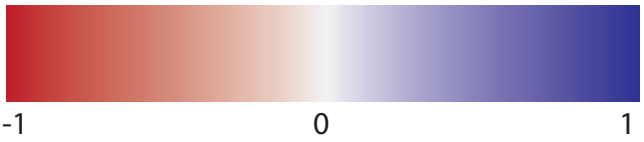
The original image (fig. 10.3) staggered the "memory" traces labeled 1 through 8, so the even-numbered traces were in a second row. This allowed the traces to roughly align with the music notation. Putting them in a single row, however, makes it easier to "listen" to them in sequence from beginning to end.

Online Figure 11.1 Guerino Mazzola, Stefan Göller, and Stefan Müller, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhauser, 2002), 265.



This image shows the recurrence of "motive classes" in Schubert's setting of "Lied auf dem Wasser zu singen, für meine Agnes." (Different motive classes are represented by different arabic numerals.) Colored lines highlight symmetries in the use of these motive classes. The red color causes the lines to pop out from the visual texture. As a result, they sit in a different conceptual layer from the rest of the image. If we wish, we can ignore the red lines and focus on the information below them, or we can follow them with our eyes, as they draw attention to and comment on key features of the underlying image.

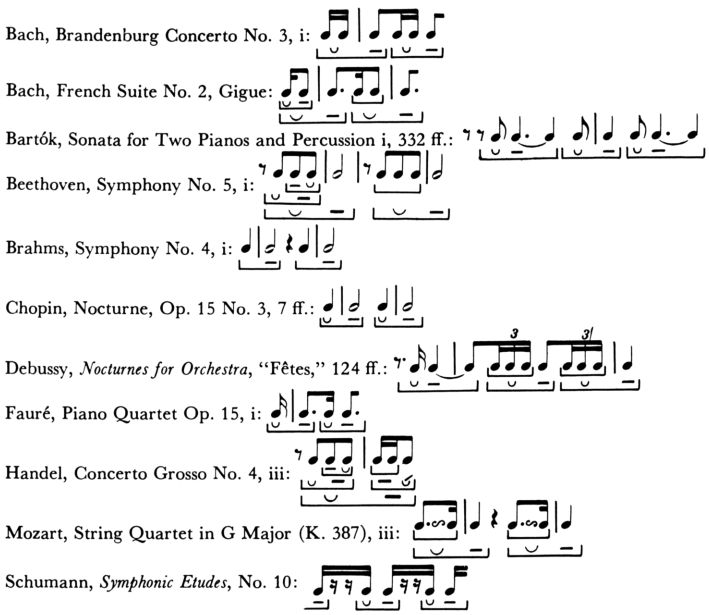
Online Figure 11.10 Three-color gradient.

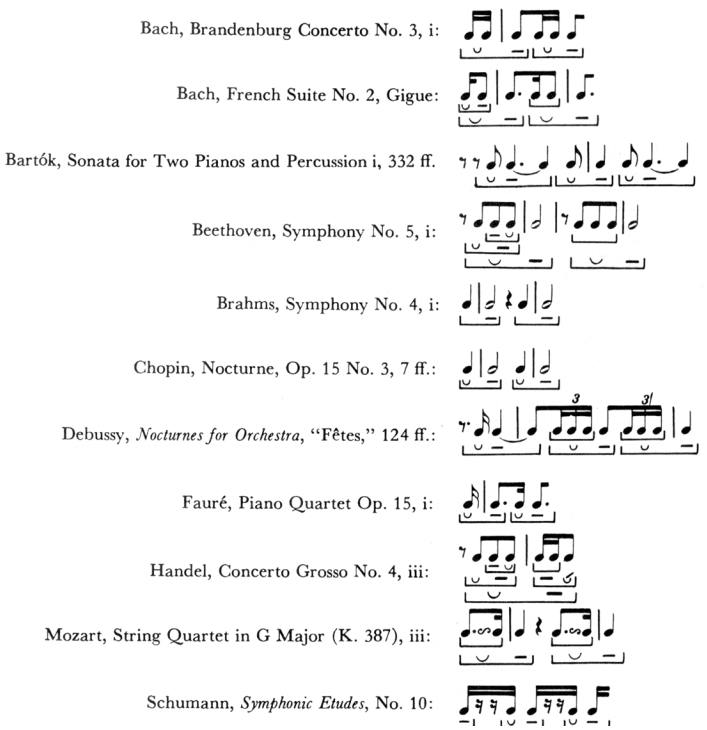


When using a three-color gradient scale, color intensity can convey number ranges that include both positive and negative numbers. The central white represents zero while the other two colors represent the opposing polarities.

Online Figure 12.2 *Above*, Grosvenor Cooper and Leonard B. Meyer, *The Rhythmic Structure of Music* (Chicago: University of Chicago Press, 1960), 48; *below*, redrawing.

The alignment principle applies any time there is parallel information. In the image above, iambic rhythmic figures jump left and right like a child playing hopscotch. The information is essentially tabular, however, and is better displayed as such. Because the rhythmic features are more central than the titles of the works they are drawn from, one can more easily scan examples aligned as in the resetting of the image (*below*).





Online Figure 12.3 Werner Breckoff, *Musik Aktuell: Informationen, Dokumente, Aufgaben* (Kassel: Bärenreiter, 1971), 138.

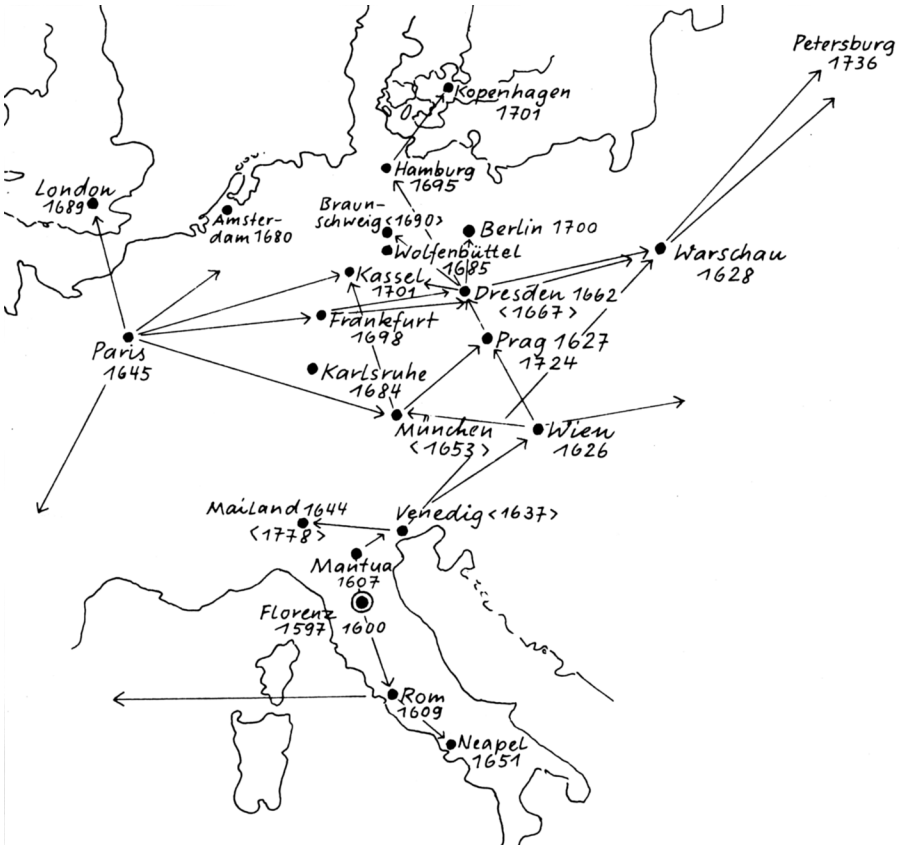
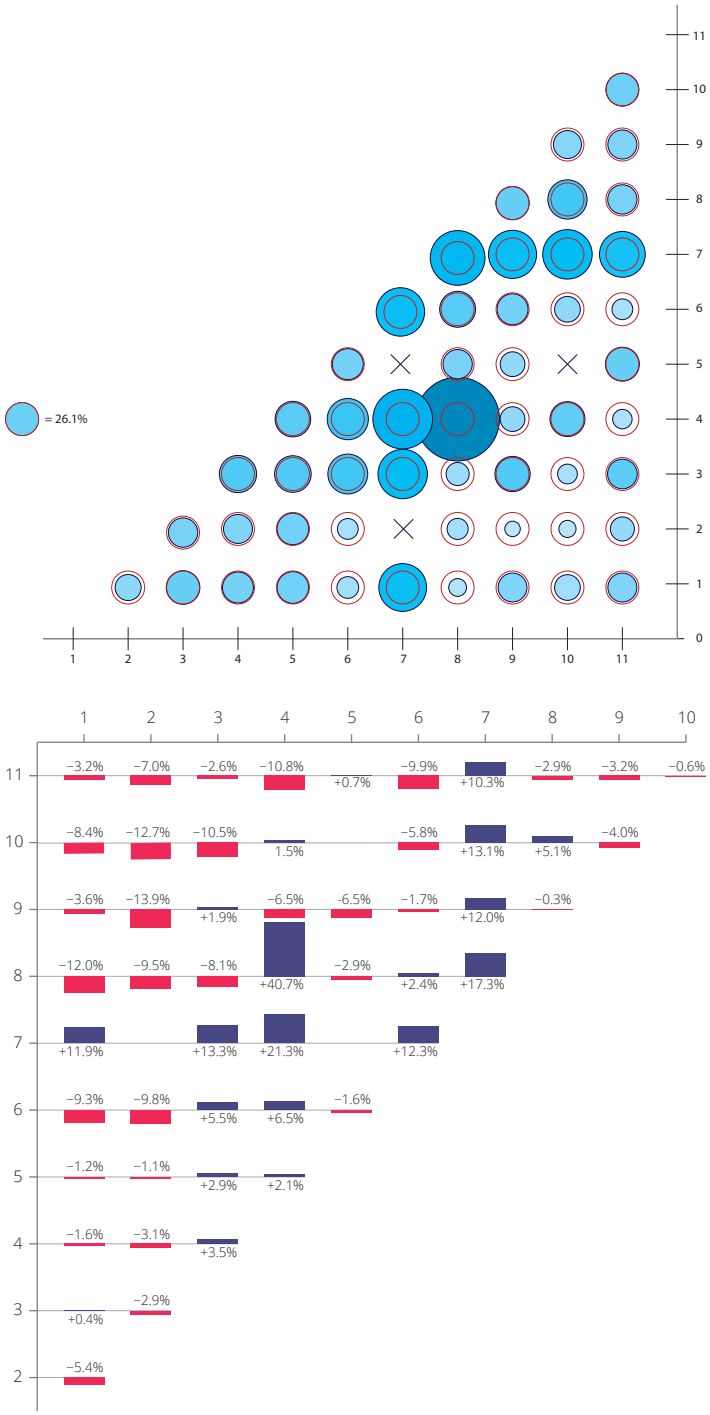


Figure 12.1 and online figure 12.2 emphasize the importance of keeping parallel information aligned. Sometimes other factors override this. This depiction of opera's spread from Florence in 1597 correctly renders the city names adjacent to the dots that indicate their location and does not force them into a grid.

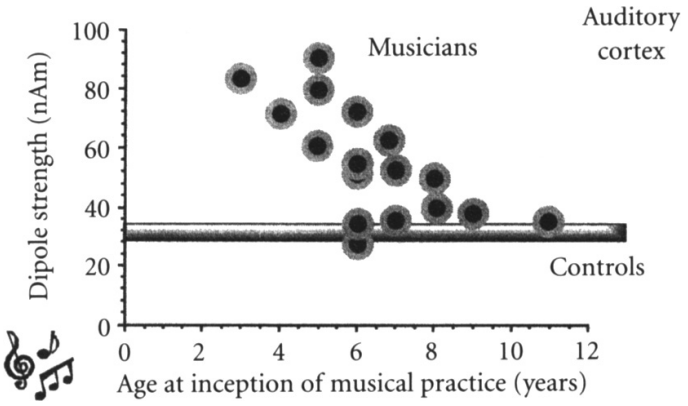
Online Figure 12.5 Two redrawings of fig. 12.4, one (*above*) an unpublished image by John Heilig (2016).

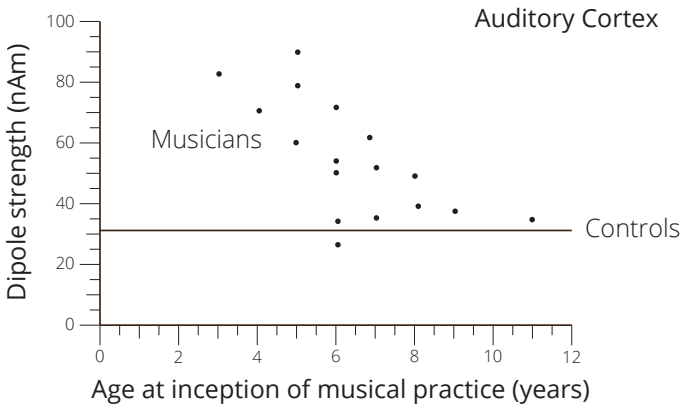
Here are two redrawings of figure 12.4. The first retains the basic design of the original but addresses some of its shortcomings. The redrawing eliminates the upper left half of the image, which mirrored the lower right portion. A red circle, repeated in each position, marks the average against which each value is measured. The direction and magnitude of the deviations from this average are indicated by differences in area (rather than implied volume).

The lower redrawing graphs deviation from the mean in only one dimension (vertical). It shows the specific amount of deviation by bar height but also by integration of the numerical data itself. It shows the direction of the deviation in three ways: color (blue for positive, red for negative), the direction of the bar from the baseline, and the explicit use of plus and minus signs in the value. The image also eliminates a redundant half of the image, though it chooses the upper left diagonal.



Online Figure 12.6 *Above*, C. Pantev et al., "Representational Cortex in Musicians," in *The Cognitive Neuroscience of Music*, ed. Isabelle Peretz and Robert J. Zatorre, 382–95 (New York: Oxford University Press, 2003), 390; *below*, redrawing.

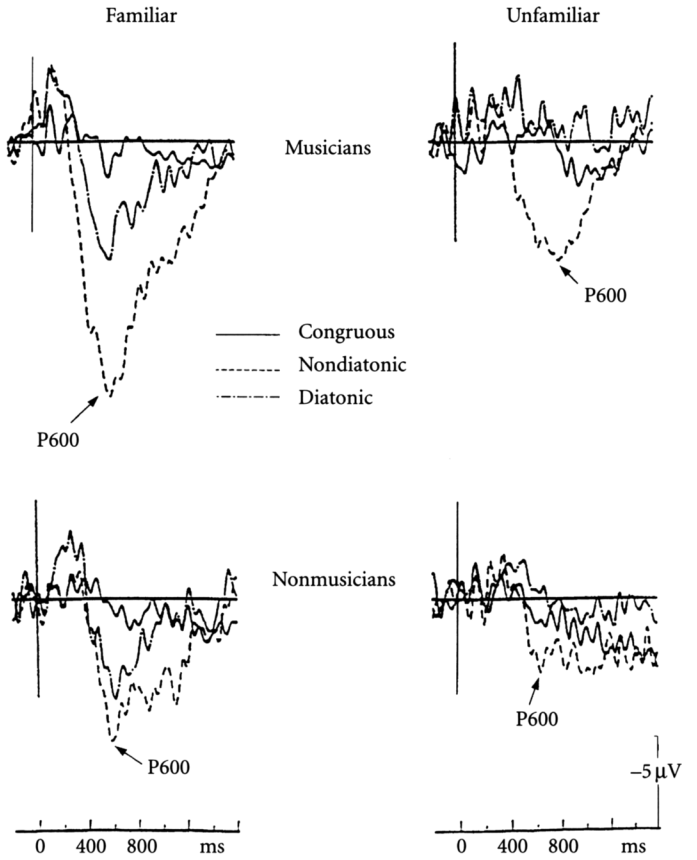




Like figure 12.4, this image suffers from the use of symbols with more dimensions than appropriate. A shaded line intended to show a single value for control subjects looks like a section of rebar and appears to span a range of values from 28 to 34 nAm. This line should be thin, effectively one-dimensional, so it reflects the actual figure. The bull's-eye data "points" for musician subjects are even wider (about 10 nAm) and suggest ages within a range of about nine months per subject. It is also unclear what the gray outer circle on each point implies. Presumably, the authors had the actual ages and could have plotted the data with small dots. A trend line would tell a more coherent story about the relationship between certain readings in musicians' brains (obtained through functional magnetic source imaging) and the age at which the musicians started to practice. The clip art in the lower left adds nothing to the image's information content or its credibility.

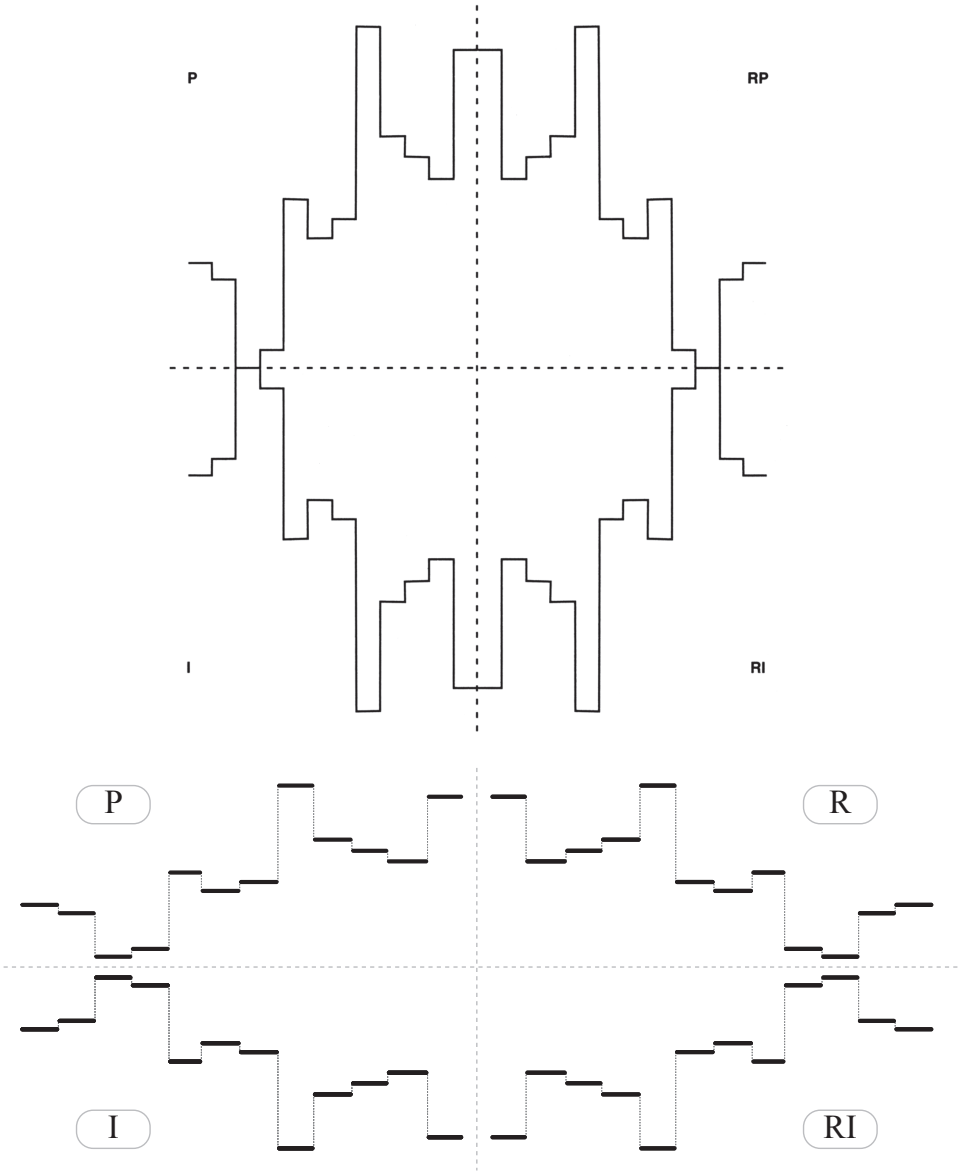
The redrawing addresses some of these concerns. Among other minor changes, tick marks along the vertical axis are spaced five units apart rather than four and the writing appears in a more legible sans serif font.

Online Figure 12.9 Mireille Besson and Daniele Schön, "Comparison between Language and Music," in *The Cognitive Neuroscience of Music*, ed. Isabelle Peretz and Robert J. Zatorre, 269–93 (New York: Oxford University Press, 2003), 280.



When graphing multiple lines, one must ensure that the data are sufficiently distinguishable. Patterned lines should be different enough from each other that viewers can distinguish between them at a distance. Here, the lines are so close together both stylistically and spatially that they run together. A combination of solid thin and solid thick (easily distinguished from each other) plus dotted (easily distinguished from the solid) lines would be better. Vertical and horizontal scales should also be provided for each graph.

Online Figure 12.12 *Above*, J. Kent Williams, *Theories and Analyses of Twentieth-Century Music* (Fort Worth: Harcourt Brace, 1997), 279; *below*, redrawing.



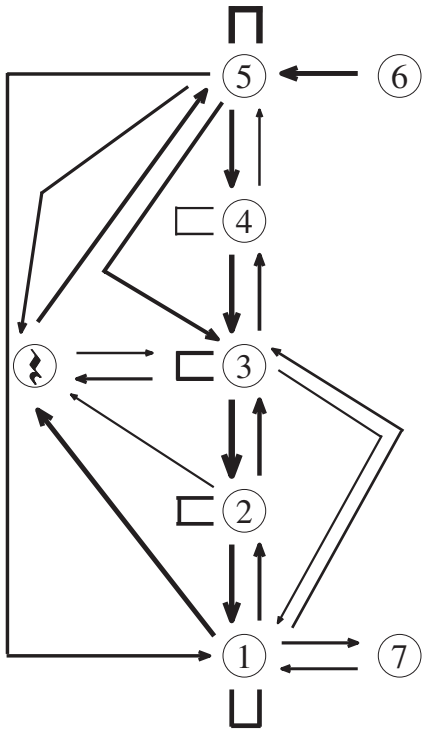
Like figure 12.10, the upper image, a representation of a twelve-tone row in its four serial transformations, represents pitch on the vertical axis, and as in figure 12.10, the vertical scale is higher than necessary: the average implied slope is approximately 5.6, not the more desirable 1.0. The redrawing below stretches the graph horizontally. It also separates the four quadrants with light, dashed lines; differentiates pitch (thick line) from connector (thin); and more clearly labels the four serial transformations.

Online Figure 12.18 David Huron, *Sweet Anticipation: Music and the Psychology of Expectation* (Cambridge, MA: MIT Press, 2006), 158 (*above*), 160 (*below*).

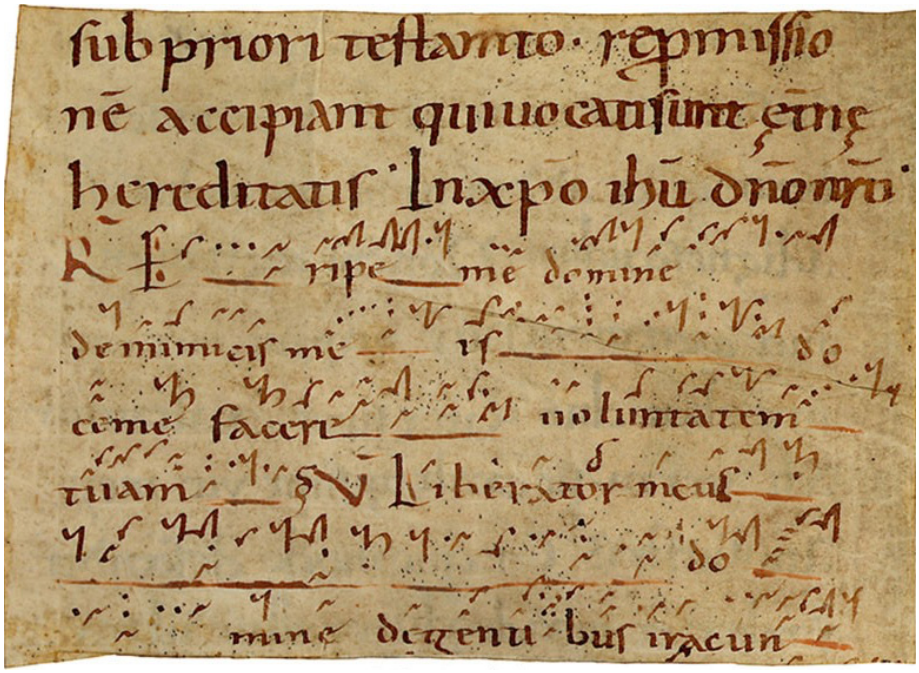
		Consequent state							
		$\hat{1}$	$\hat{2}$	$\hat{3}$	$\hat{4}$	$\hat{5}$	$\hat{6}$	$\hat{7}$	rest
Antecedent state	$\hat{1}$	0.03416	0.02806	0.01974	0.00210	0.01321	0.00839	0.02321	0.03678
	#$\hat{1}$	0	0.00042	0.00004	0	0	0.00003	0.00002	0.00002
	♭$\hat{2}$	0.00004	0	0.00001	0	0	0	0	0
	$\hat{2}$	0.04190	0.02632	0.03282	0.00678	0.00825	0.00201	0.00586	0.01521
	#$\hat{2}$	0	0.00000	0.00018	0	0	0	0	0.00000
	♭$\hat{3}$	0.00030	0.00108	0.00001	0.00071	0.00010	0	0	0.00017
	$\hat{3}$	0.01555	0.04865	0.03142	0.02644	0.02365	0.00281	0.00029	0.02357
	#$\hat{3}$	0	0	0.00000	0	0	0	0	0
	$\hat{4}$	0.00054	0.01260	0.04127	0.01506	0.01712	0.00441	0.00125	0.00537
	#$\hat{4}$	0.00003	0.00016	0.00037	0.00010	0.00257	0.00040	0.00003	0.00013
	$\hat{5}$	0.02557	0.00530	0.02854	0.03653	0.04835	0.02076	0.00369	0.02284
	#$\hat{5}$	0	0	0.00001	0.00001	0.00000	0.00027	0.00003	0.00002
	♭$\hat{6}$	0.00001	0.00000	0.00001	0.00003	0.00021	0	0	0.00002
	$\hat{6}$	0.00238	0.00168	0.00065	0.00342	0.03642	0.01261	0.00854	0.00410
	♭$\hat{7}$	0.00062	0.00003	0.00001	0.00003	0.00043	0.00119	0.00000	0.00025
	$\hat{7}$	0.02025	0.00510	0.00035	0.00029	0.00323	0.01327	0.00448	0.00275
	rest	0.01974	0.01096	0.01644	0.00706	0.03082	0.00487	0.00241	—

The table above provides data on scale degree successions from a collection of German folk songs, presented in a simple tabular format. The series captions "Antecedent state" and "Consequent state" make clear which way to read the directed motion. As with figure 12.16, the significance of the data does not immediately jump off the page when presented numerically.

The meaning of the information becomes much clearer when realized graphically. Whereas figure 12.17 plots its data on an *x*-*y* grid, this image presents an interpretation of the data. The rows and columns of the table above have become arrows identifying scale degree successions that reach a minimum threshold. The third dimension, the numerical magnitude, is realized through the relative thickness of the arrows. Although we cannot perceive exact differences in width, paired with the tabular data for the curious, this graphical representation is narrative and very effective.

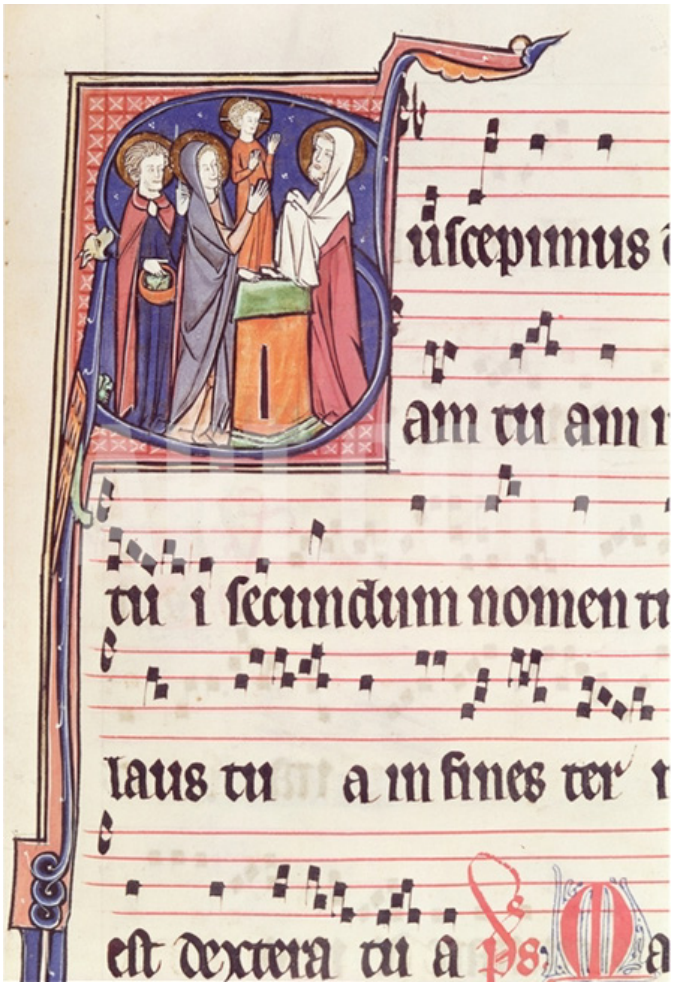


Online Figure 13.2 Schøyen Collection, MS 1275/19, Metz linear staffless neumes, France [or Germany?], ca. 950, https://www.schoyencollection.com/music-notation/metz-messine-neumes/missal-linear-staffless-neumes-ms-1275-19.



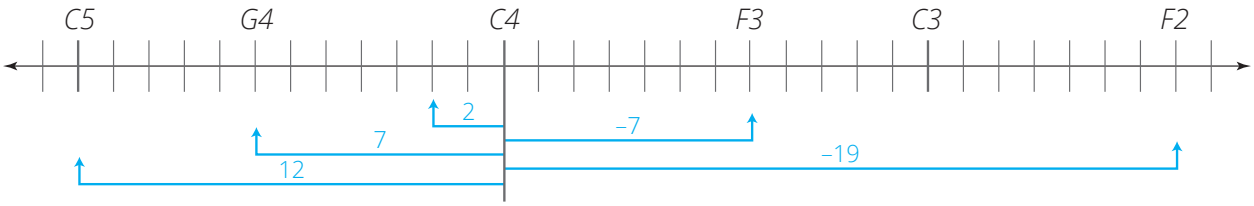
The origin of the five-line staff is found in the mid-ninth century (this image is from the mid-tenth century). Shapes called *neumes* are thought to represent gestural information associated with the recitation of chant. The neumes thus served as a memory aid.

Online Figure 13.3 Historiated initial *S* depicting the Presentation of Jesus at the Temple, from the antiphonal for the consecration of the Abbey of Vauclair (1257). MS 241 f.144, Bibliotheque Municipale, Laon, France.



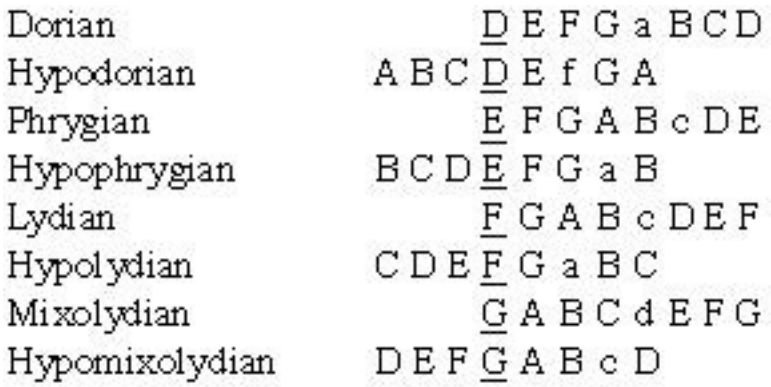
The four-line staff and clef symbol identifying a reference pitch added a great deal of precision to the notation of pitch in the Middle Ages.

Online Figure 14.4 Pitch space, oriented horizontally but with direction reversed.



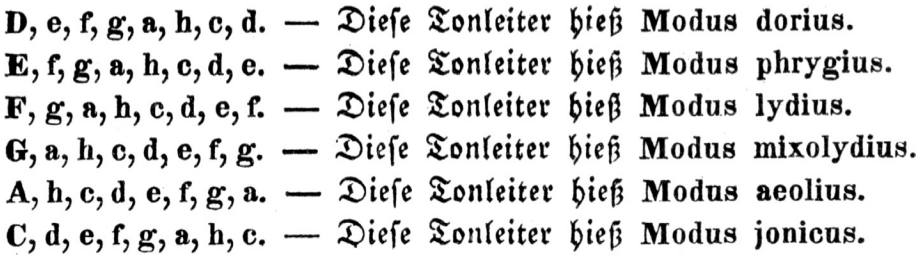
This reproduction of figure 14.3 with the orientation reversed illustrates the difficulty of reading left to mean higher and right to mean lower. The image also illustrates how the use of contrasting color to signal a different information layer helps distinguish content (pitch space) from commentary (intervals within that space).

Online Figure 15.2 *Encyclopaedia Britannica*, s.v. "Church Mode," last modified February 15, 2016, http://www.britannica.com/art/church-mode.



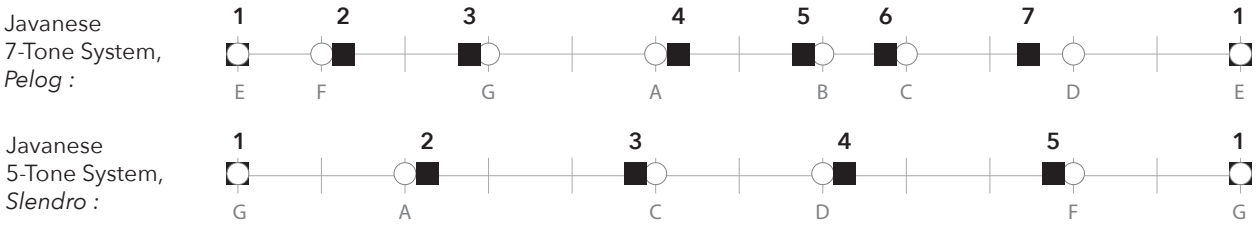
This simple representation of the eight-mode system lists the pitches of each mode in the upper case, with the finals vertically aligned and underlined. The layout draws attention to the fact that all of the plagal (hypo-) modes extend a fourth below and a fifth above the final, while the authentic modes extend an octave above the final. As a result, however, it is not obvious that the modes are rotations of one another. Curiously, the image highlights the tenors (that is, the psalm reciting tone associated with each mode) by deemphasizing them; it renders them in the smaller lower case. Where figure 15.1 shows the modes' common details, this image emphasizes the common macrostructure of authentic versus plagal. In the end, it is an information-poor image. Online figure 15.3 is a historical precedent.

Online Figure 15.3 Johann Georg Albrechtsberger, *J. G. Albrechtsberger's sämmtliche Schriften über Generalbaß, Harmonie-Lehre, und Tonsetzkunst, zum Selbstunterrichte*, ed. Ignaz Ritter von Seyfried, 2nd ed. (Vienna: Tobias Haslinger, 1837), 2:7.



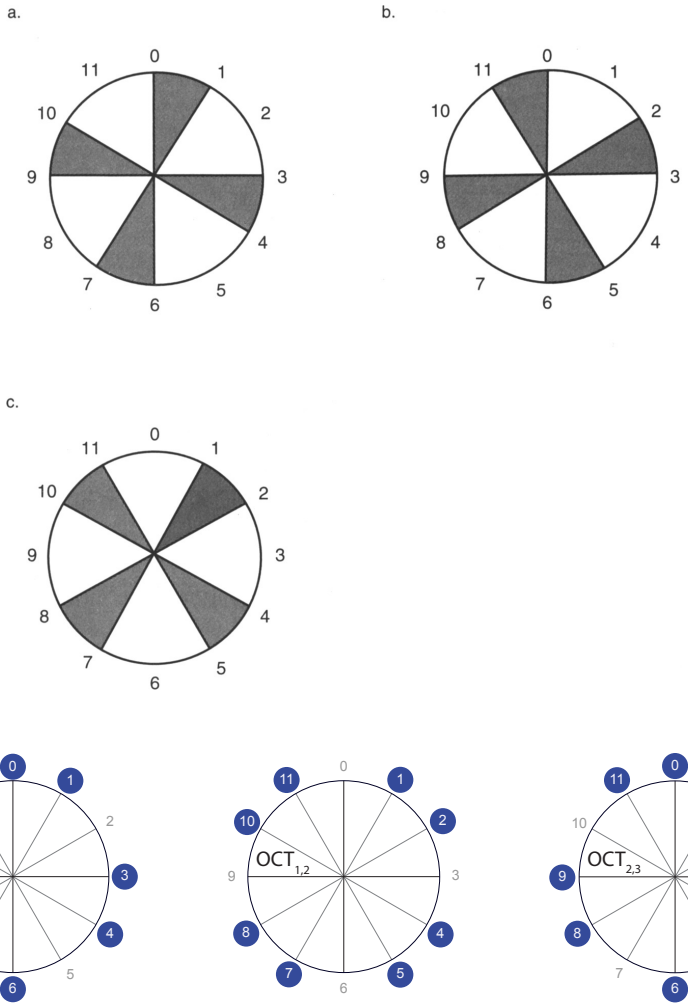
This image from the late eighteenth century is a simple representation of the six authentic modes. Like online figure 15.2, it is information poor. It also suffers from the needless repetition of the phrase "Diese Tonleiter Hieß Modus" and the unnecessary commas between pitch names.

Online Figure 15.9 Redrawing of fig. 15.8.



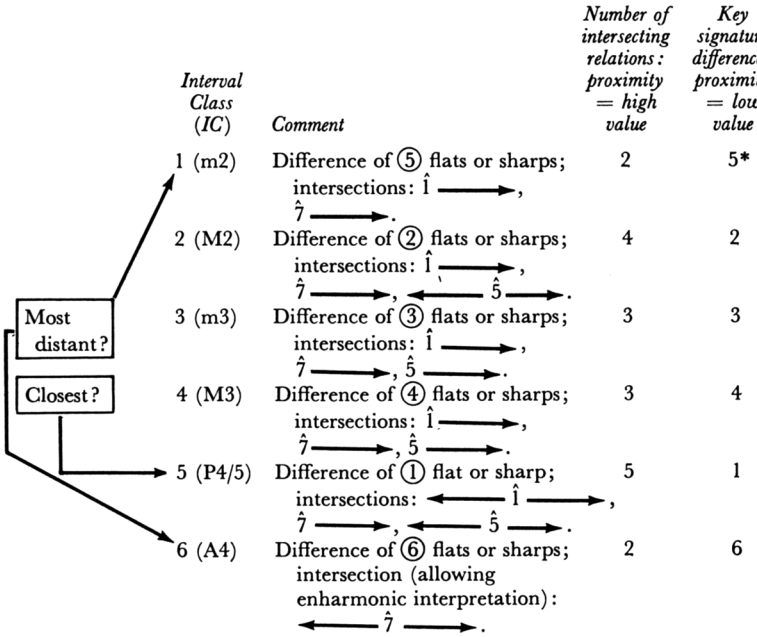
This redrawing of figure 15.8 facilitates an understanding of the Pelog and Slendro scales by representing them literally beside the nearest white-note diatonic and pentatonic scales, rather than comparing them to the chromatic scale as in the original. The chromatic is still present in the grid, which is greatly backgrounded.

Online Figure 15.12 *Above*, J. Kent Williams, *Theories and Analyses of Twentieth-Century Music* (Fort Worth: Harcourt Brace, 1997), 204; *below*, redrawing.



The image above, which shows the three octatonic collections, suffers from a figure-ground problem. First, the image draws attention to the filled-in pie wedges rather than the pitch classes that make up the collections. Second, the wedges, which connect the eight notes of each collection—two-thirds of the aggregate—end up occupying only one-third of each pie. The redrawing below offers a possible improvement. It emphasizes the notes themselves, which are set in a highly contrasting way. It retains the spokes of the original but mutes them substantially. Rendering the 0–6 and 3–9 axes more boldly makes the rotation clearer, since there are reference points. Finally, the image puts all three collections on a single line, better facilitating comparison, and adds appropriate labels.

Online Figure 15.16 *Above*, Wallace Berry, *Structural Functions in Music* (New York: Dover, 1987), 83; *below*, redrawing.



	Interval class		Intersections						Number of intersections	Key signature difference
			Degree in lower key occurs in higher key			*Degree in higher key occurs in lower key*				
	Size	*Name*	1̂	5̂	7̂	1̂	5̂	7̂	*closer = high values*	*closer = low values*
most distant? →	1	m2	•					•	2	5*
	2	M2		•	•	•	•		4	2
	3	m3	•	•				•	3	3
	4	M3			•	•	•		3	4
closest? →	5	P4/5	•	•		•	•	•	5	1
most distant? →	6	A4			•			•	2	6

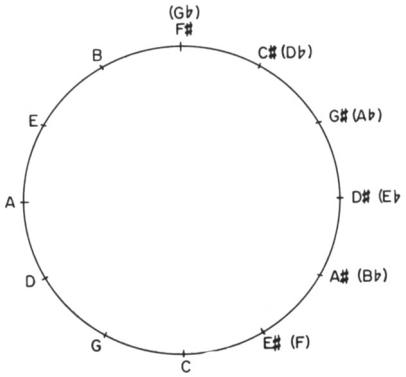
* uses the shorter distance around the circle of fifths (e.g., 5 sharps rather than 7 flats)

The image above distills some of the information present in figure 15.15 to posit the relative closeness of keys. For any pair of major keys separated by any of the six possible interval classes, it indicates whether the strongest key-defining scale degrees of one of the keys (1̂, 5̂, 7̂) is present in the other, counts these, and also lists the difference in their key signatures. The information is worthy of study, but the layout is awkward. The scale degree intersections appear in paragraph form, which requires reading rather than scanning. Those paragraphs list the differences in the key signatures, information that is redundant with the right-most column of the

image. And the meaning of the arrows' directions is inconsistent. If an intersection goes only one way, a forward arrow is used, regardless of whether the intersection goes from the lower key to the higher key or vice versa, and if a given scale degree intersects in both directions, then an arrow is shown in both directions.

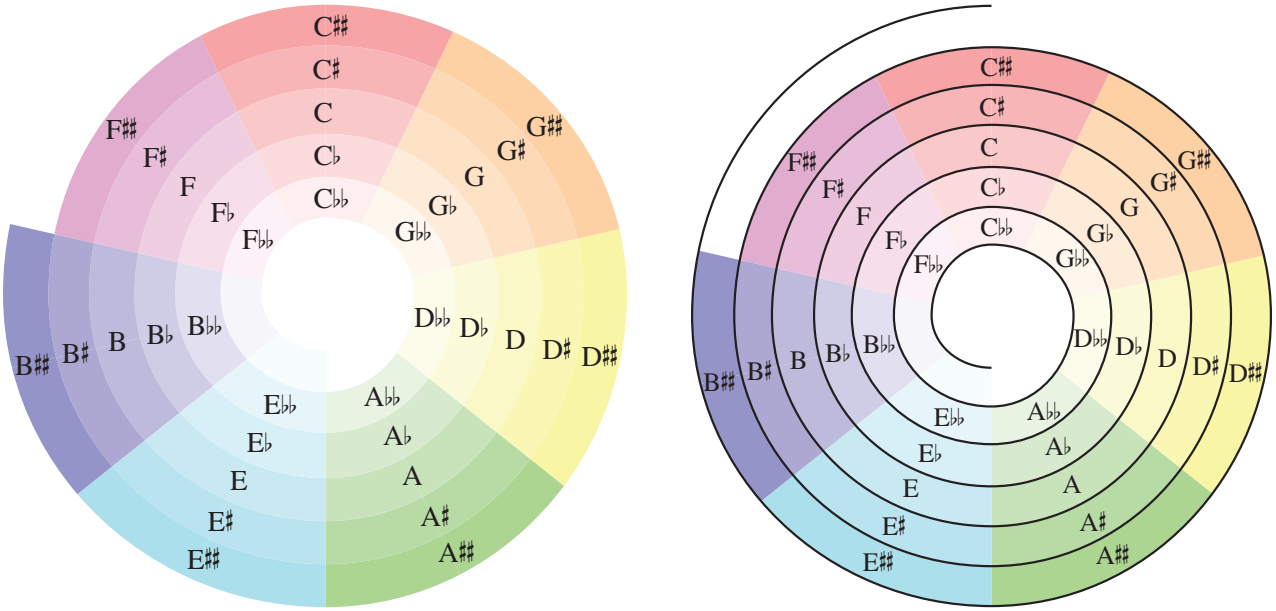
The layout in the redrawing below retains all the information from the original but improves comprehension. It makes more explicit whether the intersection is from the lower key to the higher, from the higher key to the lower, or both, and it arranges this information in tabular form, which allows one to see the number of intersections without counting arrows.

Online Figure 16.2 Howard Hanson, *Harmonic Materials of Modern Music: Resources of the Tempered Scale* (New York: Appleton-Century-Crofts, 1960), 3.



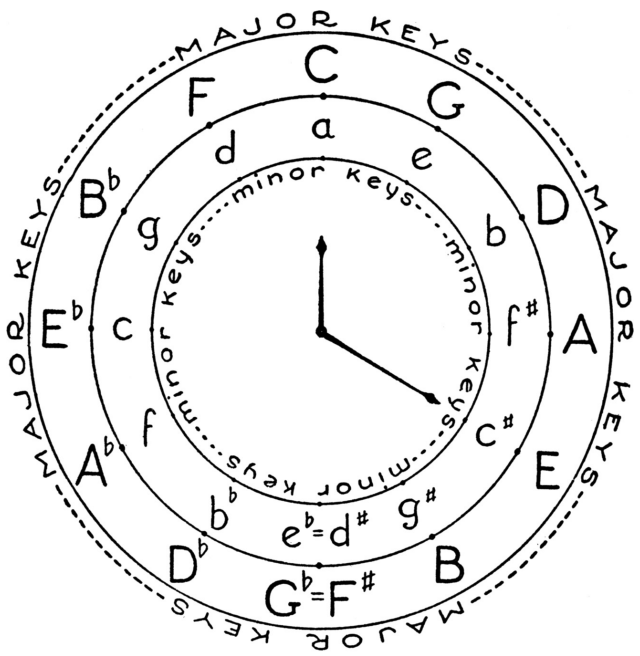
While C is almost always in the twelve o'clock position in circle-of-fifths images, here it is at the bottom. That pitch is clearly still privileged: the primary labels follow the series of perfect fifths from C moving clockwise, with the curious result that F is listed parenthetically as the enharmonic equivalent of E♯, not the other way around. Since we can process information more quickly when it adheres to a convention, one should only depart from convention if doing so would demonstrably strengthen an image. Here it doesn't; C should be at the top in circle-of-fifths images. (The right parenthesis is missing from E♭ in the original.)

Online Figure 16.4 Julian Hook, unpublished.



The idea of pitch chroma is enhanced when rendered as in these images. Each of the seven pitch chroma (C, D, E, etc.) is associated with a different hue, with different saturation levels distinguishing the chromatic variants of each. Each trip around the spiral leads to the same pitch name, but a half step higher (if spiraling outward) or lower (if spiraling inward), with the implication that the path could continue infinitely. The right image makes the possibility of infinite continuation, both outward and inward, more explicit by separating individual spirals with a light-gray line that extends beyond them slightly. The line also eliminates the fluting effect that occurs at the boundaries between colors of similar hue, as in the left image. The light boundaries that most people see between arms of the left image aren't really there.

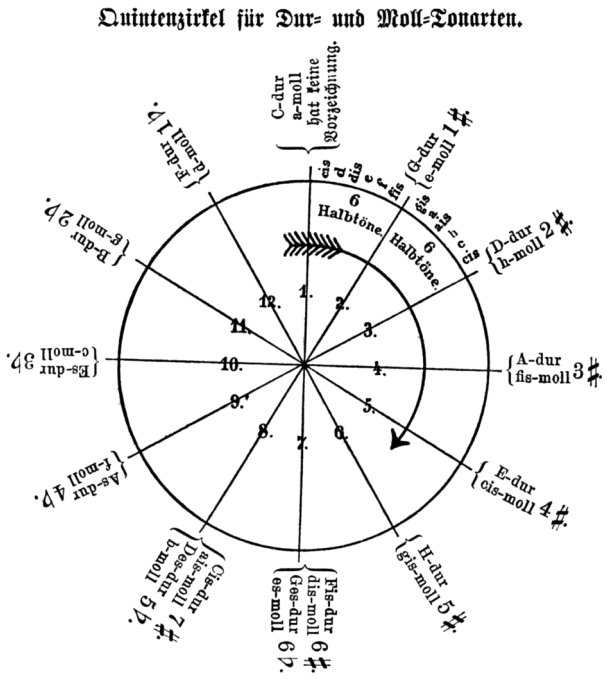
Online Figure 16.6 Nicolas Slonimsky, *The Road to Music*, rev. ed. (New York: Dodd, Mead, 1960), 41.



THE MODULATION CLOCK

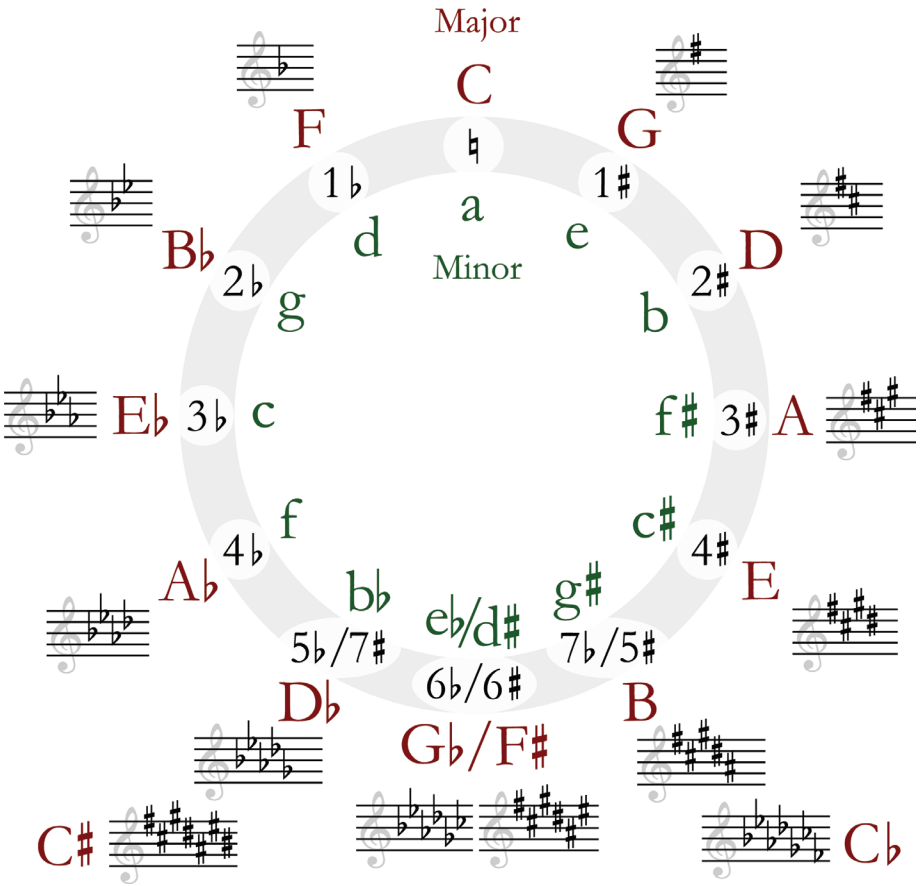
This image, which makes explicit the clock metaphor for the circle of fifths, comes from a book aimed at a general audience, hence the playful tone. As in figure 16.5, upper- and lowercase letters distinguish major and minor keys, a convention the image reminds the viewer of four times (each). This picture eschews references to key signatures and, curiously, omits the keys with seven sharps and flats. The hands, which help invoke the clock metaphor, are otherwise superfluous. Also superfluous are the circles themselves and the dashed/dotted lines connecting the redundant "major/minor keys" indicators. The latter text rotates with its bottom oriented to the center of the circle, while the key names remain oriented relative to the viewer, who, it is apparently assumed, will not be rotating the image.

Online Figure 16.8 C. A. Herm. Wolff, *Kurzgefasste Allgemeine Musiklehre* (Leipzig: P. Reclam, 1894?), 55.



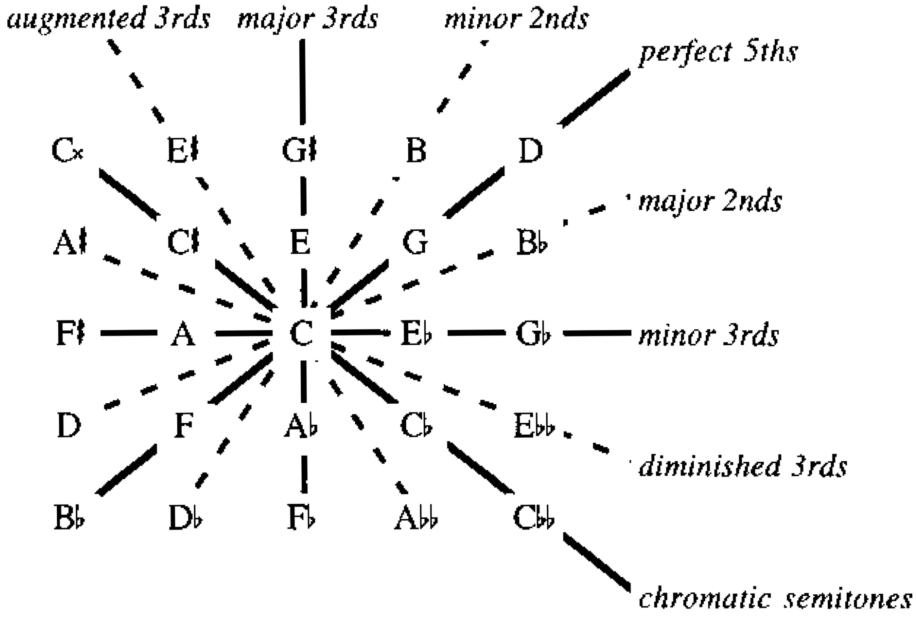
The use of a wheel metaphor here instead of a clock metaphor creates a problem of whether to rotate the image, though unlike in online figure 16.6 it is the primary content that requires rotation. The layout sacrifices easy legibility for stricter adherence to the chosen metaphor. As in figure 16.7, this image focuses on the key signatures of the major and minor keys. It enumerates these on the outer perimeter, using upper and lower cases for major and minor, respectively, but adding the words explicitly as well (in German), which creates visual clutter. Keys with no sharps or flats are in the conventional position at the top. The first two fifths are measured for us, as having six pitches between each pair. This confirms implicitly that these are ascending fifths (and also explains the author's separate circle-of-fourths diagram, not shown). A well-feathered arrow shows the direction in which the fifths progress. Numbers on top of prominent spokes count our way to twelve. Equating the number 1 with C major/a minor makes explicit that those keys are the starting point of this structure. The image omits the seven-flat signatures and therefore does not present a complete picture.

Online Figure 16.9 Just plain Bill, *Circle of Fifths Deluxe 4*, Wikimedia, July 28, 2008, https://commons.wikimedia.org/w/index.php?curid=4463183, Creative Commons License (CC BY-SA 3.0), https://creativecommons.org/licenses/by-sa/3.0/deed.en.



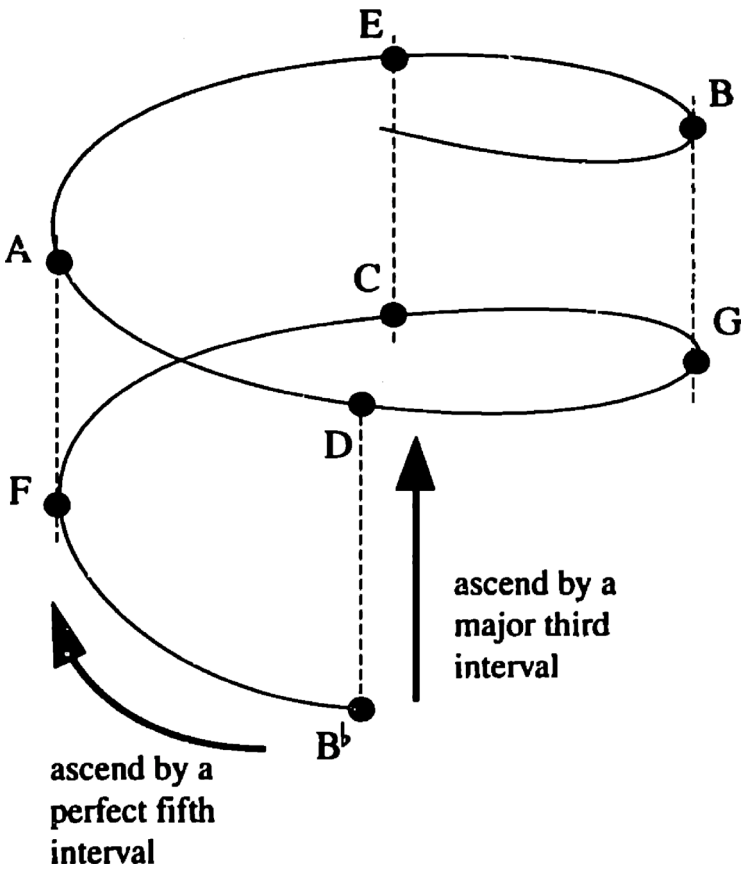
This circle-of-fifths diagram distinguishes major and minor key names by both case and color. (The names for the seven-sharp and seven-flat keys are missing, a problem that occurs in other images we've seen.) Muting the clef sign in the notated signatures puts the emphasis on the arrangement of sharps and flats, though the departure from convention is disconcerting. The seemingly redundant accidental count is useful in the sense that key signatures are often conceived of as a *number* of flats or sharps. The gray band connecting them gives shape to the image overall but is more prominent than necessary. In addition, the image would benefit from more space between the various information circles, as there is a sense of clutter, particularly owing to the enharmonic keys depicted in the lower part of the image.

Online Figure 17.3 Julian L. Hook, "Hearing with Our Eyes: The Geometry of Tonal Space," in *Bridges: Mathematical Connections in Art, Music, and Science*, ed. Reza Sarhangi, 123–34 (Winfield, KS: Southwestern College, 2002), 126.



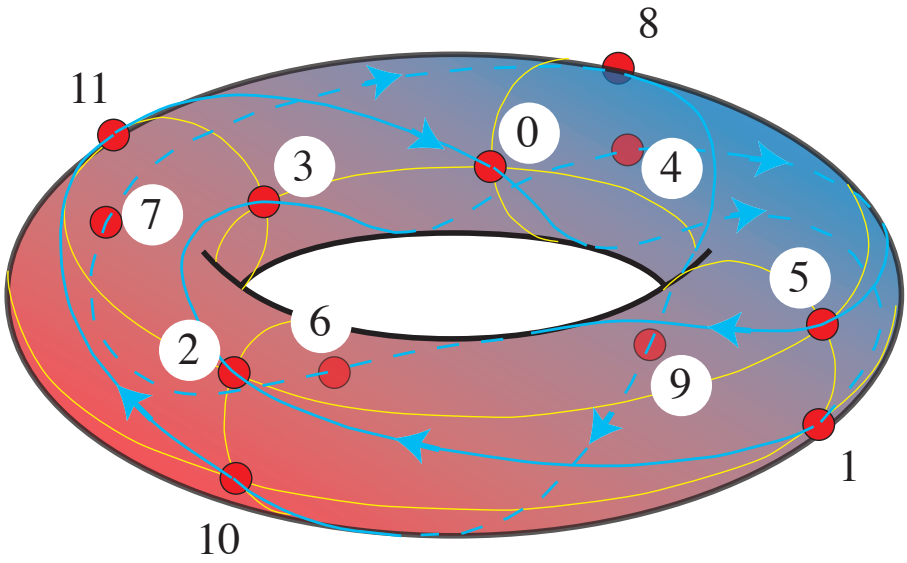
Like figure 17.2, this image gives primary emphasis to the minor and major thirds, though they are drawn on the horizontal and vertical axes. The perfect fifths formed by their combination, one could say their addition, thus reside on the upward diagonal. The image extends the arithmetic by tracing additional interval series. Besides the diagonals that show the perfect fifth as the composite operation M3 + m3, and the chromatic semitone as M3 − m3, the image shows intervals formed by four knight's-move sequences (two steps in one direction and one step perpendicular), minor and major seconds, and the diminished and augmented thirds. The theoretically infinite continuations in all directions are explicit in only half the cases, and the lines that trace the interval sequences compete with, rather than complement, the pitch names. Placing the interval names in a contrasting typeface helpfully moves them to a separate information layer, however.

Online Figure 17.5 Elaine Chew, "Towards a Mathematical Model of Tonality" (PhD diss., Massachusetts Institute of Technology, 2000), 41.



This *Tonnetz* representation makes the wraparound effect of figure 17.4 more explicit. A spiral traces perfect fifths rising from B♭, each a quarter of the way around the circle. After four fifths, we reach D, which lies a major third directly above B♭. This is identical to the structure of figure 17.4, where, beginning from the B-flat at lower center, we can reach D by either going "north" four perfect fifths or east-northeast by one major third. Only the direction of the mapping is different. Unfortunately, this representation is something of an Escher diagram. Traversing the spiral, if we are truly ascending by perfect fifth, by the time we reach D, we're not a major third above the starting point but two octaves and a major third away, and by the time we reach B-flat again, we will have spanned five octaves by the perfect fifth route and just one by major thirds. This representation thus makes more sense if we think of it as a modular space, in which case the torus is a better representation. See online figure 17.6.

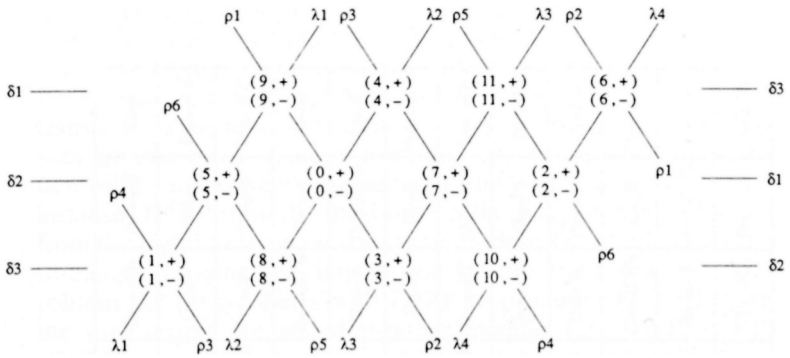
Online Figure 17.6 Guerino Mazzola, Stefan Göller, and Stefan Müller, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhauser, 2002), 621.



This image represents the major-third / minor-third Tonnetz as a torus. The twelve pitch classes are shown as red dots labeled 0 to 11. The four major-third chains (0–4–8, 1–5–9, 2–6–10, and 3–7–11) lie on circles that pass the short way through the center of the torus. The three minor-third chains travel the long away around the torus: 0–3–6–9 on the inside, 1–4–7–10 on the underside, and 2–5–8–11 around the outside (just above the "equator" in this vantage point).

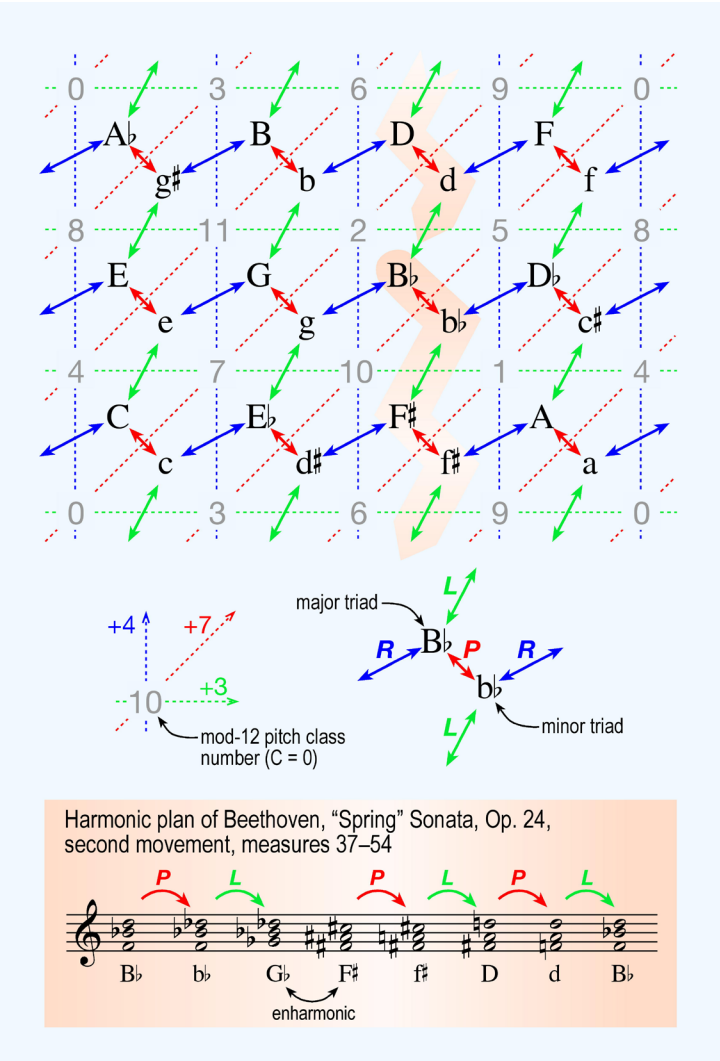
A problem with visualizing a three-dimensional torus in a two-dimensional format is that half the content is hidden from view. Even when the torus is translucent as here, foreground and background can be difficult to distinguish. The path of the blue line, which traces semitones as they loop through the torus, is hard to follow. Just as an understanding of earth's spherical surface structure is easier to fathom if one has a physical globe or an animated globe for which a user can control the rotation, a toroidal representation of the Tonnetz is easier to grasp if it has a physical manifestation (such as a bagel with strategically placed numbers and lines) or if it is represented via animation, ideally allowing the viewer to manipulate the shape's orientation. When confined to the two-dimensional page, however, it is better to keep the representation flat and make the need to wrap around clear (as in two-dimensional projections found in world maps).

Online Figure 17.8 Brian Hyer, "Reimag(in)ing Riemann," *Journal of Music Theory* 39, no. 1 (1995): 119.



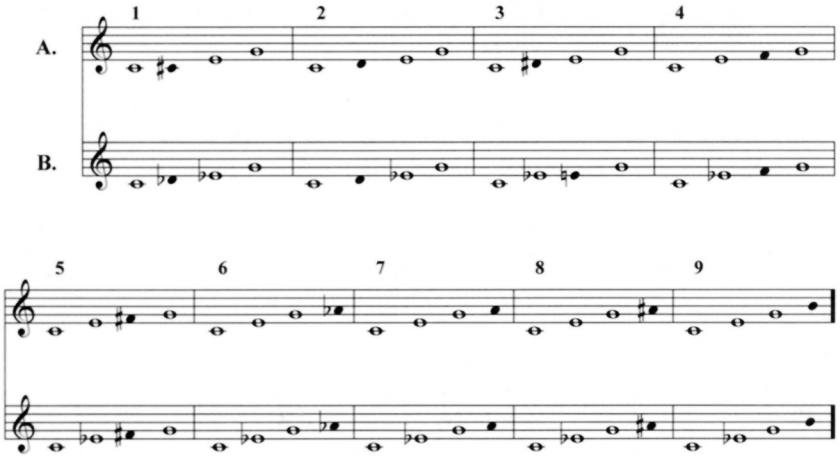
This image presents the same information as figure 17.7 but uses the nomenclature of group theory. Chord root (pitch names) and quality (+ = major) are expressed explicitly. The increased complexity of the symbols and loss of clarity relative to figure 17.7 undercut the gain in formal precision.

Online Figure 17.9 Julian Hook, unpublished (2006).



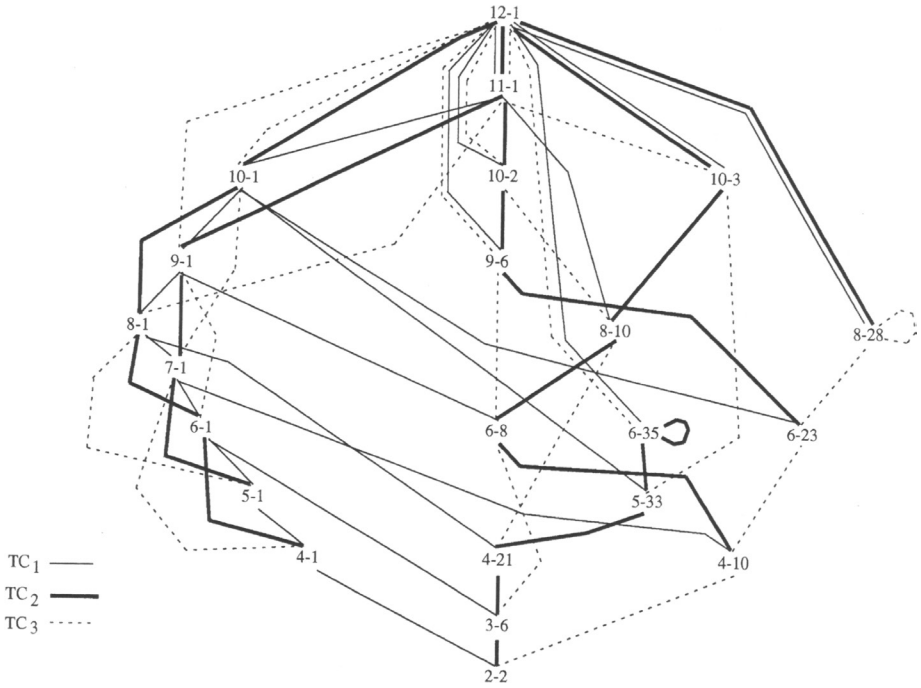
This richly detailed and beautifully designed image represents pitch classes with integers, which it connects by dotted lines in three colors representing the same intervals used in figure 17.3 and figure 17.4 (though with the orientation of fig. 17.3). The image labels triads formed by the triangles as in figure 17.7 and then connects these chord labels with solid, color-coded arrows representing the three neo-Riemannian transformations. The same colors connect the two pitches that remain invariant following the transformation. Information layering in the image is excellent. (A toroidal version of this image appears on the cover of Hook's [2023] *Exploring Musical Spaces*.)

Online Figure 18.4 Bryan R. Simms, *The Atonal Music of Arnold Schoenberg, 1908–1923* (New York: Oxford University Press, 2000), 117.



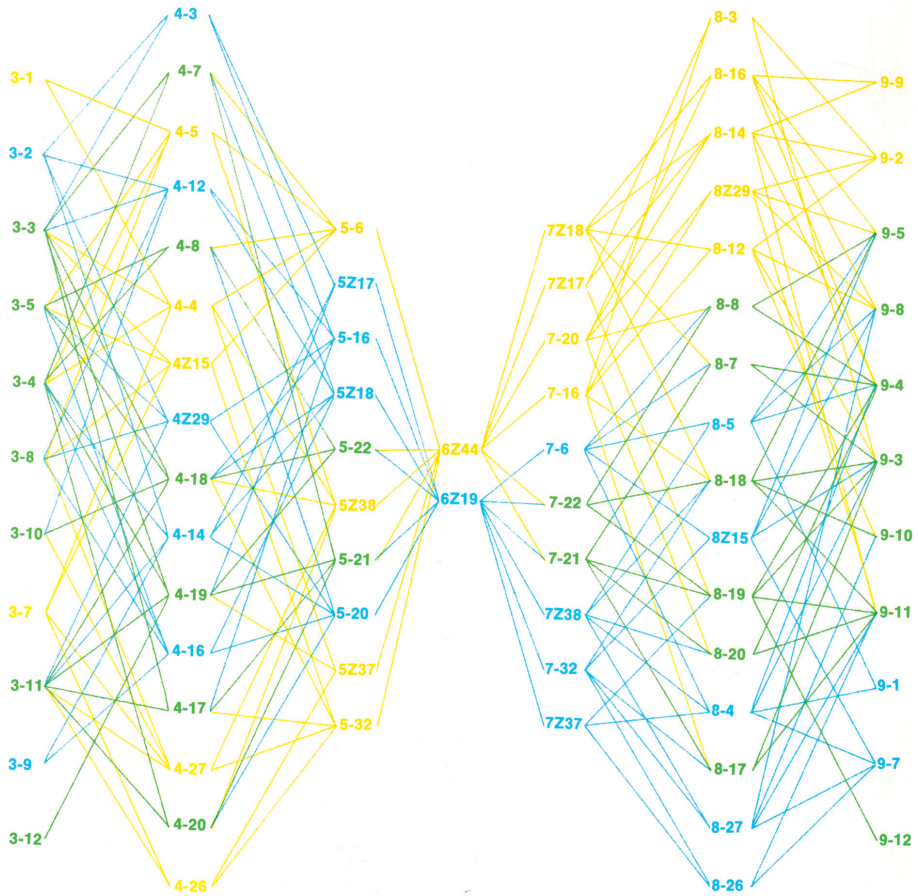
This image shows the sets that result from the addition of a fourth pitch to a major (A) and minor (B) triad. The lack of any annotation renders the image little more useful than the exhaustive tables of chords one finds in many older treatises.

Online Figure 18.5 Robert Morris, *Class Notes for Advanced Atonal Music Theory* (Lebanon, NH: Frog Peak, 2001), ex. 25.2a.



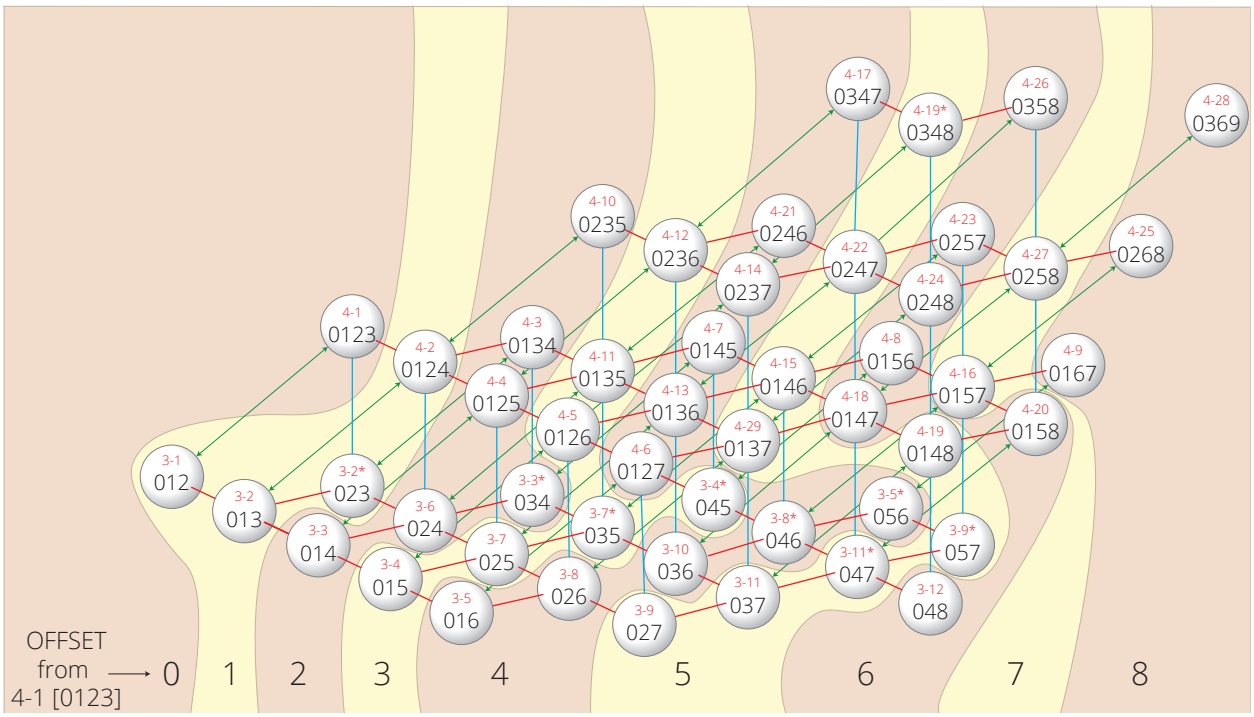
This image proceeds in the opposite direction from figure 18.3. Rather than displaying subsets of a large set, it shows the results of combining smaller sets. Beginning with a whole step (set class 2–2), it maps out which sets are formed when a set is combined with a version of itself that is transposed by one, two, and three semitones. The use of three highly distinct line styles facilitates the tracing of the three paths heading north from each set much more effectively than figure 18.3 does.

Online Figure 18.6 Allen Forte, *The Structure of Atonal Music* (New Haven, CT: Yale University Press, 1973), cover.



Color serves as a label to show membership in the K and Kh complexes around set classes 6Z19 and 6Z44. The K complex around a hexachordal set type includes sets that are subsets or supersets of that hexachord. Sets in yellow and blue are members of the K complexes around 6Z44 and 6Z19, respectively. Green indicates sets that belong to both. These make up the Kh-complex around 6Z19 and 6Z44. Lines leaving a set outward toward its subsets or supersets use the same color as the set name. Sets approached by lines of at least two colors are rendered in green. The structure itself is messily intertwined, but the presence of three colors makes it easier to trace them. Yellow does not stand out well against a white background, so a different color would have made those elements stand out more effectively, though the yellow + blue = green equation is a subtle indicator of what green means.

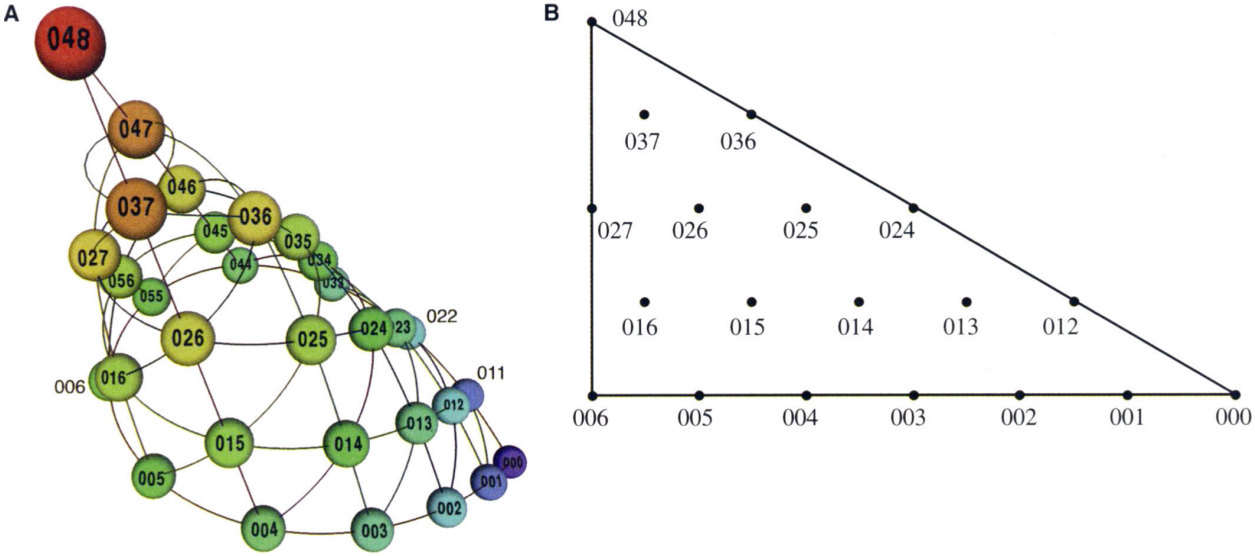
Online Figure 18.8 Redrawing of fig. 18.7.



This redrawing of figure 18.7 shows lines connecting set types that reside within the same plane in one color, while those that jump planes (whether vertically or diagonally) are in a contrasting color. The Forte label is smaller than and different in color from the more informative pitch-class numbers. Spreading the sets still farther apart would make it easier to see the connections.

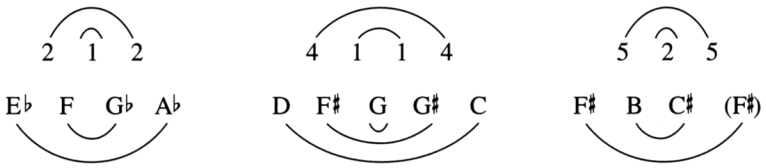
The regions defining offset values from the origin set (0123) are shaded in alternating colors, making their meandering paths easier to trace. This highlights the fact that these regions disconcertingly inscribe a one-dimensional view onto what is essentially a four-dimensional space. See also online figure 18.9.

Online Figure 18.9 Clifton Callender, Ian Quinn, and Dmitri Tymoczko, "Generalized Voice-Leading Spaces," *Science* 320, no. 5874 (2008): 347.



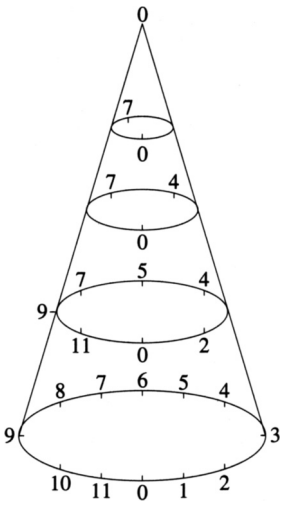
One of the challenges of figure 18.6 is that it attempts to convey four-dimensional information in two dimensions. This image has an easier task: showing voice-leading spaces involving sets of three notes, which might include duplicates. The image on the left treats transpositionally related sets as equivalent, while the image on the right adds inversion as an equivalence relation. Both images begin at the augmented triad at the top. The pattern of the right image is easier to discern: Moving to the left in any row, the third member of the set moves up one semitone. Moving up and slightly to the right, the middle note moves up one semitone. When any of the three edges is reached, the pattern reflects off the edge as if it were a mirror. In the left image, inversions are not considered equivalent, requiring a cone-shaped representation. It is harder to tease out the paths in the center of the cone, which could be helped if the nodes were spread out more. Nevertheless, the space is considerably easier to visualize than the four-dimensional space of figure 18.7.

Online Figure 19.2 Joseph Straus, *Introduction to Post-tonal Theory*, 3rd ed. (Upper Saddle River, NJ: Prentice Hall, 2005), 87.



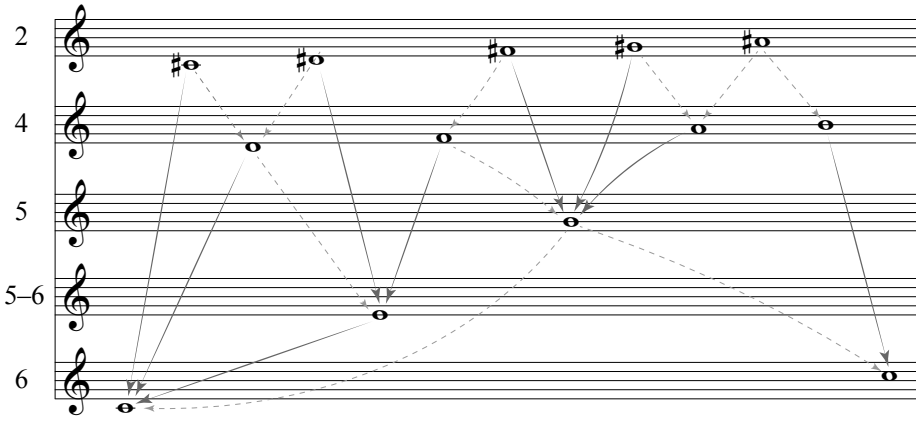
Like figure 19.1, this image arranges members of pitch-class sets in symmetrical order. Here, curved lines below link symmetrically paired pitch classes. Intervals between adjacent pitch classes appear above, with lines above them indicating symmetry. The axes of symmetry are implicitly found at the center of each image, whether a single interval (1 or 2) or pitch class (G), or pairs of intervals (1–1) or pitch classes (F–G♭, B–C♯). With small sets like these, the lines connecting the intervals might be safely omitted, since the symmetry is easily ascertained by the numbers themselves, but the lines connecting corresponding pitches are needed.

Online Figure 20.2 Fred Lerdahl, *Tonal Pitch Space* (New York: Oxford University Press, 2001), 50.



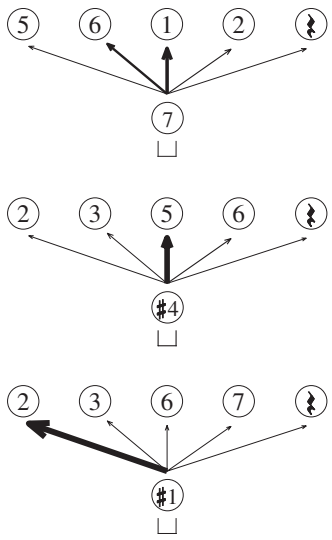
A cone-shaped rendering of the space depicted in figure 20.1. The hierarchy, while it *seems* more "hierarchical," is harder to read than the two-dimensional rendering in figure 20.1. The image has two notational blemishes as well: the whiskers are drawn with a two-dimensional orientation rather than a three-dimensional one (they should be perpendicular to the point where they intersect the circle, not to the 9–3 axis), and the points are not positioned to scale. See the large gaps in the lowest level on either 3 or 9, for instance, and the way degrees 5, 7, and 11 in particular change location when moving from one level to another.

Online Figure 20.5 Fig. 20.4, redrawn.



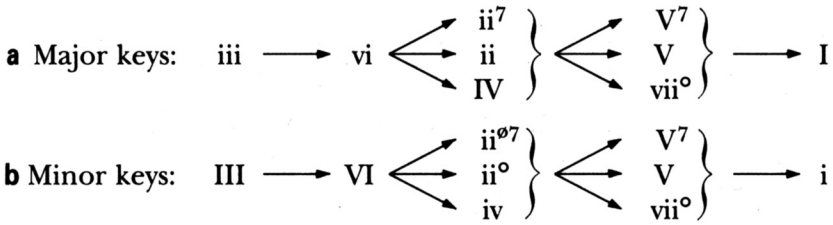
This redrawing of figure 20.4 adds arrowheads to clarify the direction of resolution. By moving the staves closer together, it also makes it easier to trace the lines connecting levels.

Online Figure 20.7 David Huron, *Sweet Anticipation: Music and the Psychology of Expectation* (Cambridge, MA: MIT Press, 2006), 161.



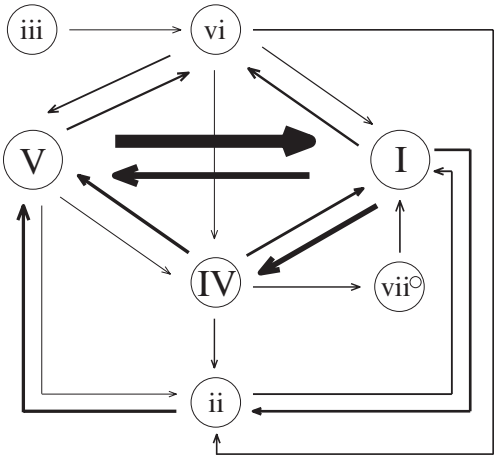
Resolution tendencies for three tendency tones. As in figure 20.6, relative line thickness is proportional to the probability that certain scale degrees (or a rest) will follow each of the tones. The gross proportions are clear from the images, though attaching a number to each arrow would make more fine-grained comparisons possible.

Online Figure 20.9 Ralph Turek, *The Elements of Music: Concepts and Applications*, 2nd ed. (New York: McGraw-Hill, 1996), 1:129.



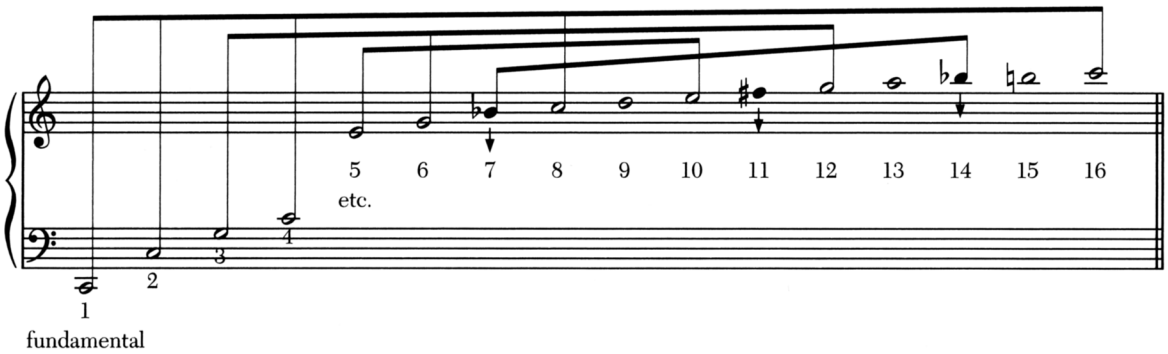
This image accompanies figure 20.8 in the textbook from which they both come. It depicts the same information in a way that is easier to grasp. The addition of sevenths to just two chord functions paints an incomplete picture of the tonal system, however.

Online Figure 20.13 David Huron, *Sweet Anticipation: Music and the Psychology of Expectation* (Cambridge, MA: MIT Press, 2006), 251.



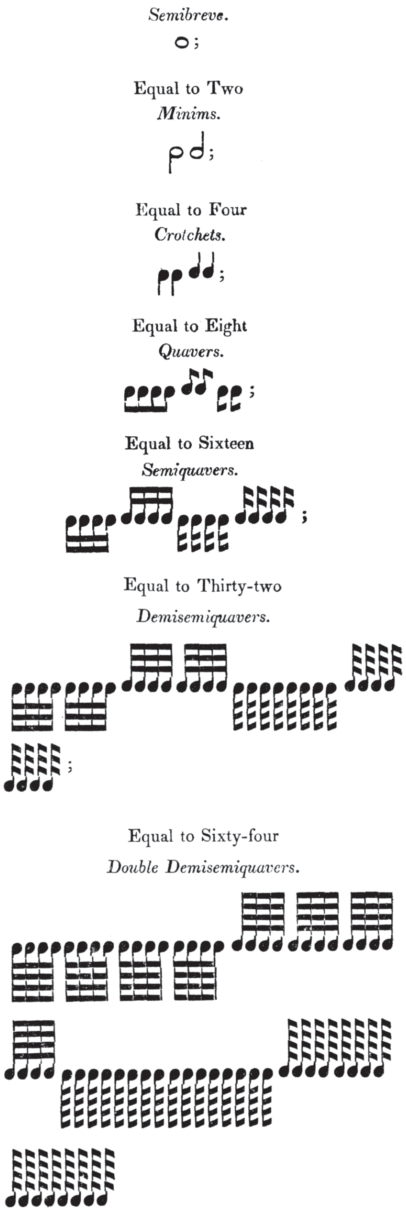
A depiction of the frequency of chord-to-chord interactions in a collection of Baroque music. As with figure 20.12, thicker arrows indicate progressions that occur more frequently in the collection. The image does not convey the same spatial sense of tonal flow implied by online figure 20.9 and figure 20.10, which might be considered a weakness. On the other hand, the use of the same visual structure as figure 20.11 (which does the same analysis on a collection of popular music) better facilitates comparison between the two repertories.

Online Figure 21.2 Robert Gauldin, *Harmonic Practice in Tonal Music*, 2nd ed. (New York: W. W. Norton, 2004), A4.



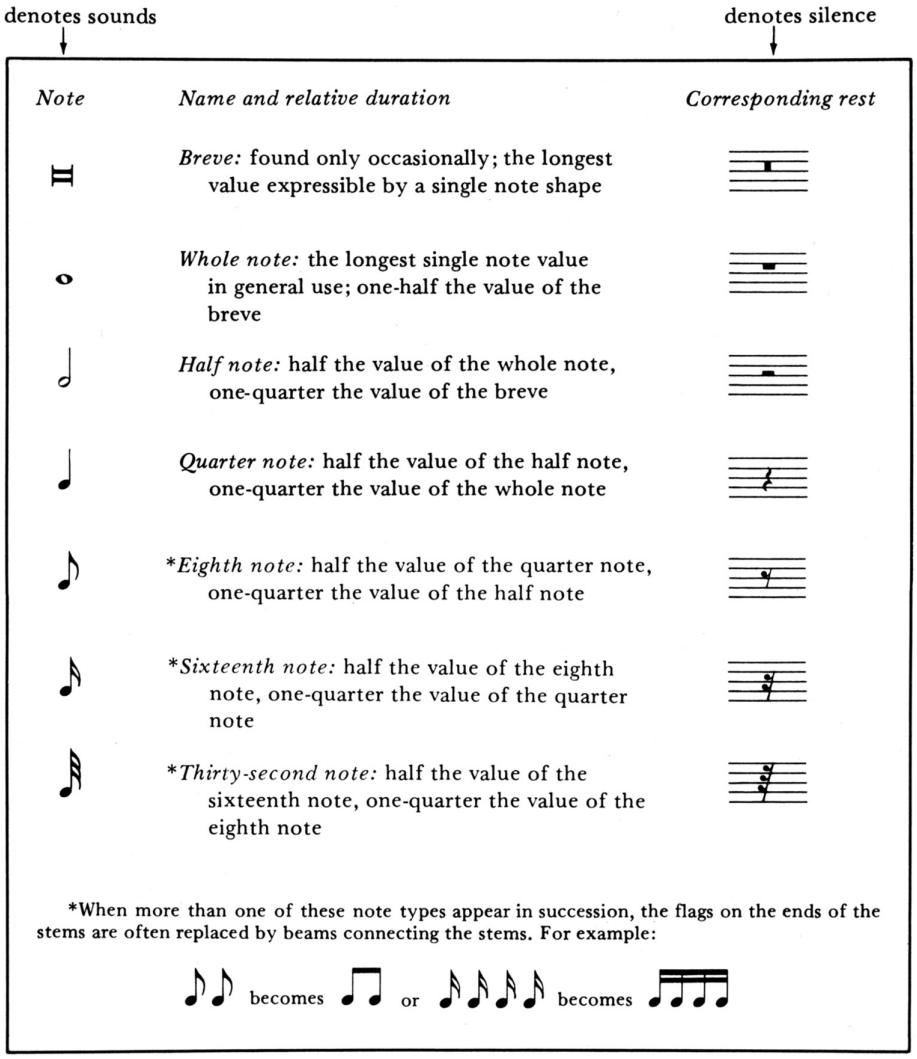
Similar to figure 21.1, this image shows the first sixteen partials and highlights out-of-tune overtones, including their direction, using solid noteheads, and it numbers the partials. (The thirteenth partial is not deemed out of tune here, as it was in figure 21.1.) Numbers indicating which partial a pitch represents are placed inconsistently (see the section on aligning like information), with 3 and 4 obscured by the too-dark staff lines. The image connects octave-related pitch classes with beams. Unfortunately, the beamed groups overlap, and the effort required to see which notes are actually grouped significantly exceeds the value the beams add to the image.

Online Figure 22.2 Thomas A. Busby, *Grammar of Music* (London: J. Walker, 1818), 67–68.



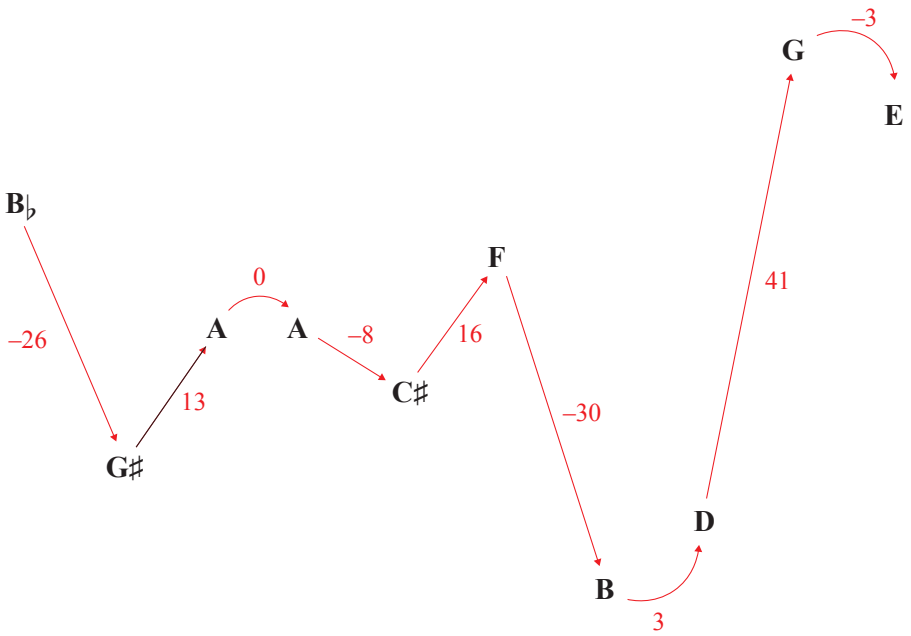
Here the lonely semibreve at the top splits into two, which split into four, and so on, until there are "Sixty-four *Double Demisemiquavers*." Aside from the phrase "equal to," the image does not visually depict a sense of equality as it moves downward. As in figure 22.1, the image displays the various notational options for each duration, showing some of each with flags and some with beams, and some with upward stems and some with downward stems.

Online Figure 22.6 Ralph Turek, *The Elements of Music: Concepts and Applications*, 2nd ed. (New York: McGraw-Hill, 1996), 1:22.



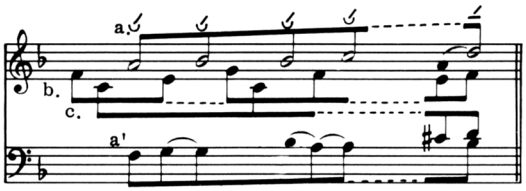
Compare to figures 24.1 through 24.5. This image dispenses with a visual representation of note divisions altogether in favor of a less effective prose-heavy description. The addition of symbols for the corresponding rests is a positive feature.

Online Figure 23.4 Colorized version of the upper half of fig. 23.3.



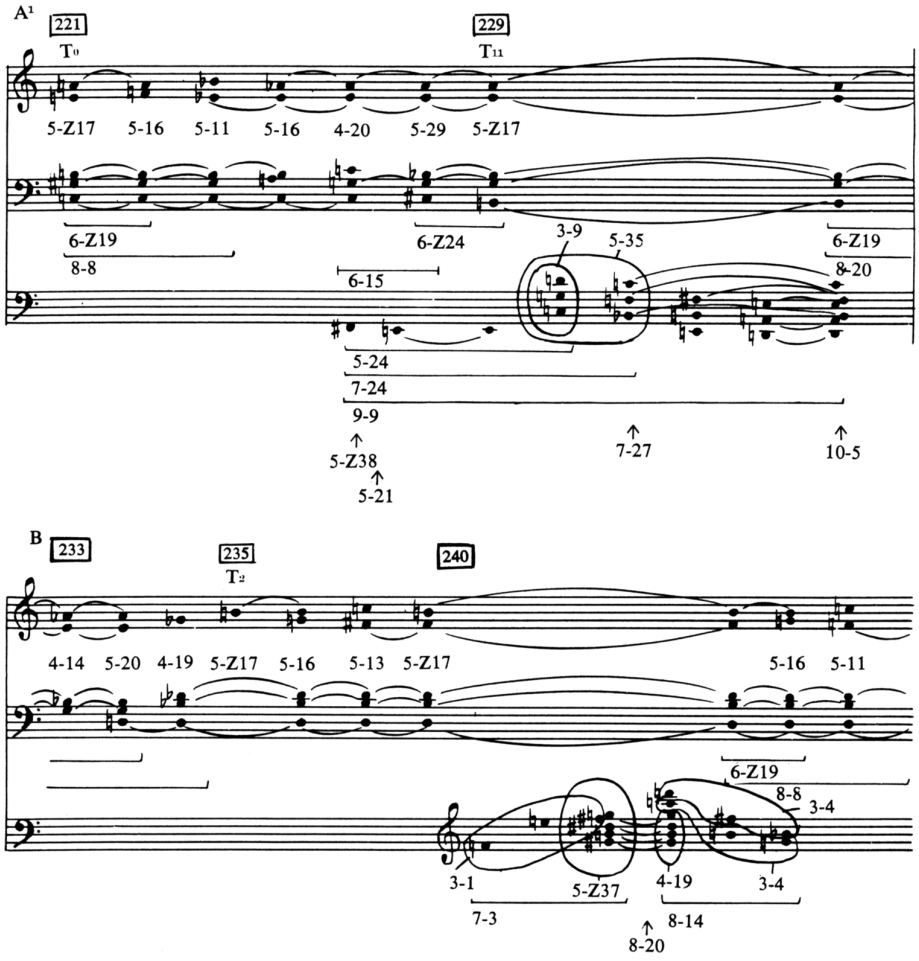
This redrawing of the upper half of figure 23.3 makes two tweaks. First, it removes the circles from around the note names. Their omission comes at the cost of the visual distinction between object (pitch) and transformation (the numerical transposition level), even if the pitch names are made bold. Rendering the intervals (both lines and sizes) in color as here helps restore separation between these elements.

Online Figure 23.5 Grosvenor Cooper and Leonard B. Meyer, *The Rhythmic Structure of Music* (Chicago: University of Chicago Press, 1960), 91.



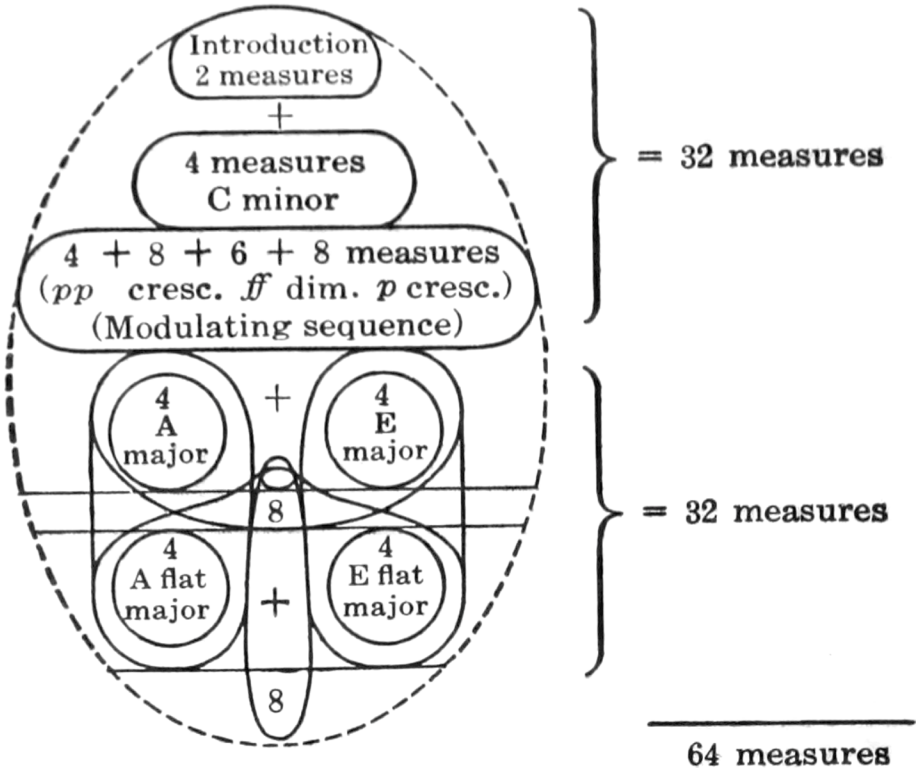
An example of unmeasured musical time, this image depicts the interweaving of different lines, whose individual parts are ordered with respect to one another but not to any external reference. In such images, the addition of temporal information would not enhance the image enough to justify the resulting visual clutter.

Online Figure 23.6 Allen Forte, *The Structure of Atonal Music* (New Haven, CT: Yale University Press, 1973), 167.



This reduction is concerned only with the succession of events; time has no meaning beyond that. Nevertheless, the image concedes value in being able to refer back to the score, so it slips in a few measure numbers to make that possible.

Online Figure 24.5 Hugo Leichtentritt, *Musical Form* (Cambridge, MA: Harvard University Press, 1951), 390.



This image describes the first section of Anton Bruckner's Symphony no. 8, movement 2. Like figure 24.4, it measures music by measures. I discuss the image again in chapter 26.

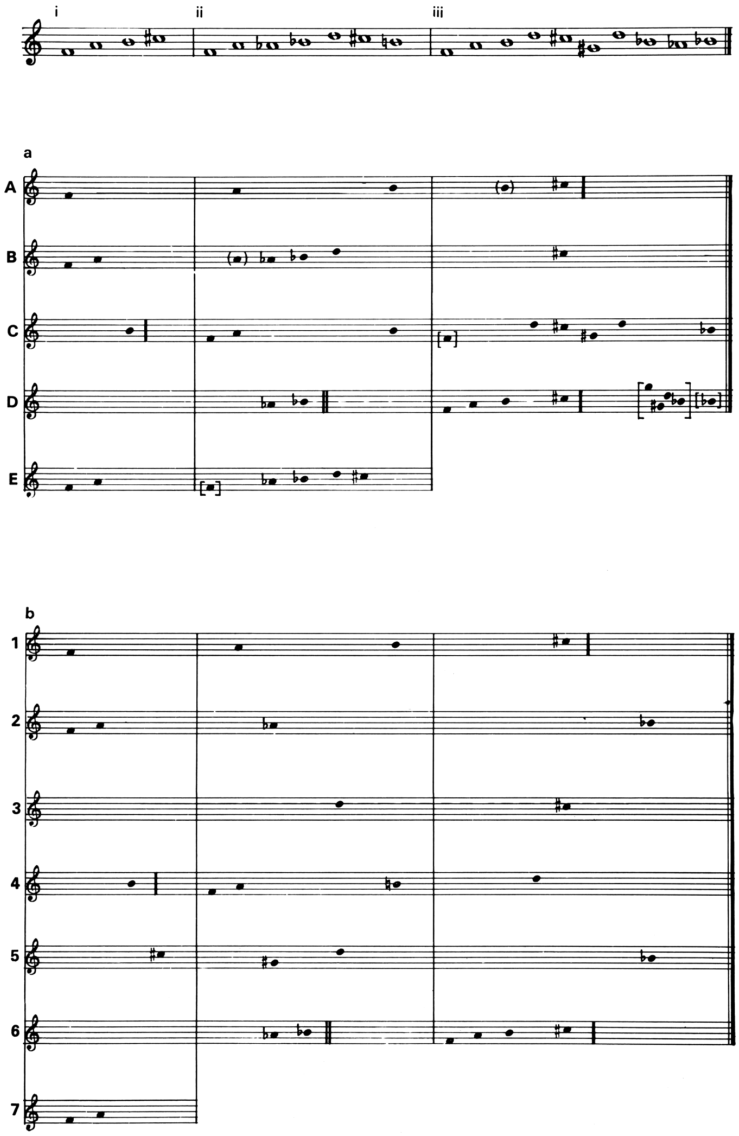
Online Figure 24.7 Redrawing of fig. 24.6.

set	bar	notes
R_0	1–6	
RI_0	7–13	
P_0	13–16	B♭–C is taken by the voice (bs 15–16)
RI_0	17–21	
R_0	22–6	F♯ is taken by the voice (b.24)
RI_0	27–31	
P_0	31–6	
I_0	37–41	D is taken by the voice (b.41)
R_0	42–6	
I_0	46^2–52^1	
R_0	52^2–6	This is interspersed with the residue of RI_0 from the voice: R_0: 52^2, G♯–A; 53^1, C; 53^2, B♭–B; 54, D–F–C♯ RI_0: 52^2, A–C♯–G♯; 53^3, B–B♭–G
RI_0	57–60	
R_0	61–4	F–F♯ is taken by the voice (b.63)
I_0	65–9	
R_0	70–3	C♯ is taken by the voice (bs 71–2)
I_0	74–8	

These sets are grouped to show the periodic return of the opening set in the piano part, R_0. There is a regular alternation of P or R with I or RI sets throughout.

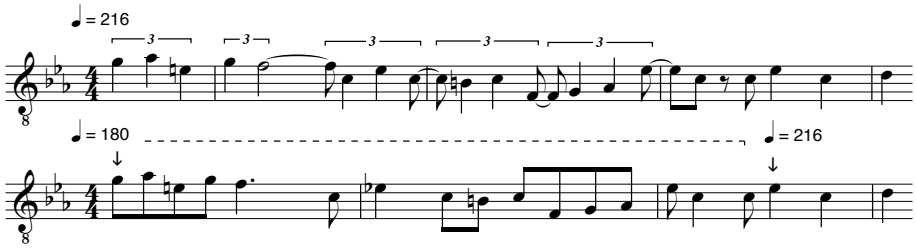
The use of recurrences of R_0 to measure the music was not clear in the original. This redrawing simply adds more white space before each recurrence. The large gap between the labels R_0 and RI_0 in mm. 52^2–60 requires that there be additional help grouping the row forms, which the gray lines supply.

Online Figure 24.8 David Osmond-Smith, *Playing on Words: A Guide to Luciano Berio's "Sinfonia"* (London: Royal Musical Association, 1985), 24.



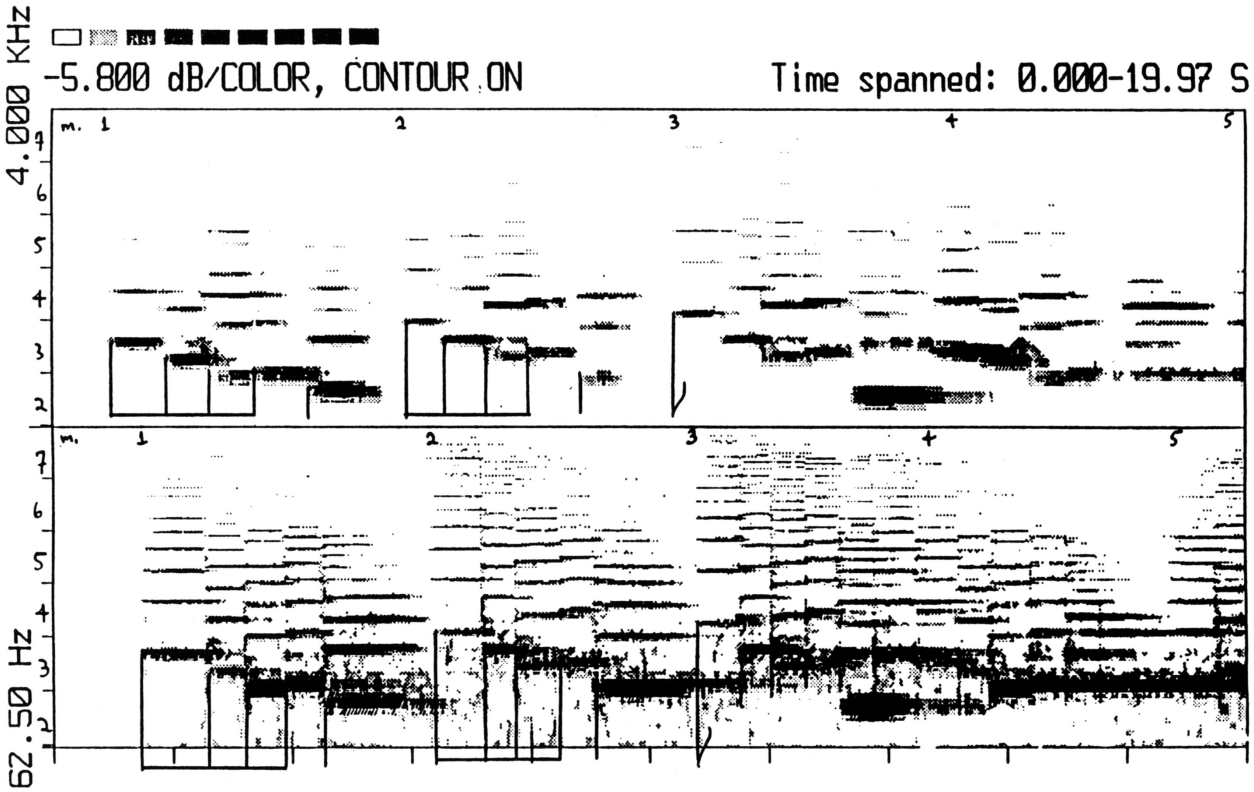
This image ingeniously traces serial organization in the second movement ("O King") of Luciano Berio's *Sinfonia*. The image uses the movement's twenty-one-note series to measure the movement's structure. The series is at the top of the image, divided into three segments, each starting with the dyad F–A. The music cycles through this series several times. As it does, certain notes are heavily accented, through instrumentation and dynamics. These accented notes are shown in the rest of the image directly below the point where they occur within the basic pitch series above. Tracing these allows one to see that the accented pitches follow the same series in quasi augmentation.

Online Figure 25.4 Fernando Benadon, "Time Warps in Early Jazz," *Music Theory Spectrum* 31, no. 1 (2009): 14.



This is another instance of the tempo-reinterpretation technique employed in figure 25.3. Here, a section of a remarkable scat vocal from Louis Armstrong's "Hotter Than That" is notated first in the tempo of the underlying instrumental ensemble and then in a tempo in which the figure aligns more cleanly with the metrical grid. For this short passage, Armstrong's tempo is five-sixths that of the ensemble, covering ten slower beats in the time of the ensemble's twelve faster beats. The notation makes the relationship clear.

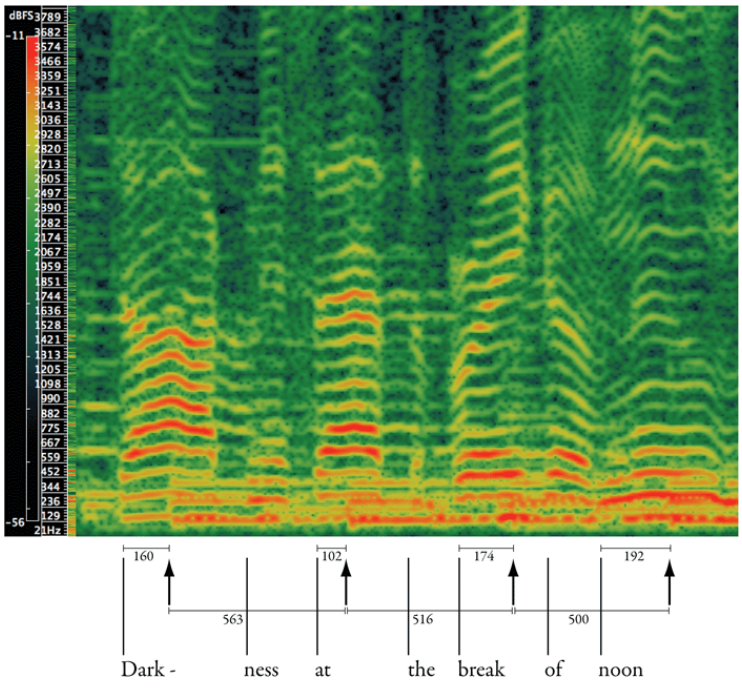
Online Figure 25.5 Robert Cogan, *Music Seen, Music Heard: A Picture Book of Musical Design* (Cambridge, MA: Publication Contact International, 1998), 30.

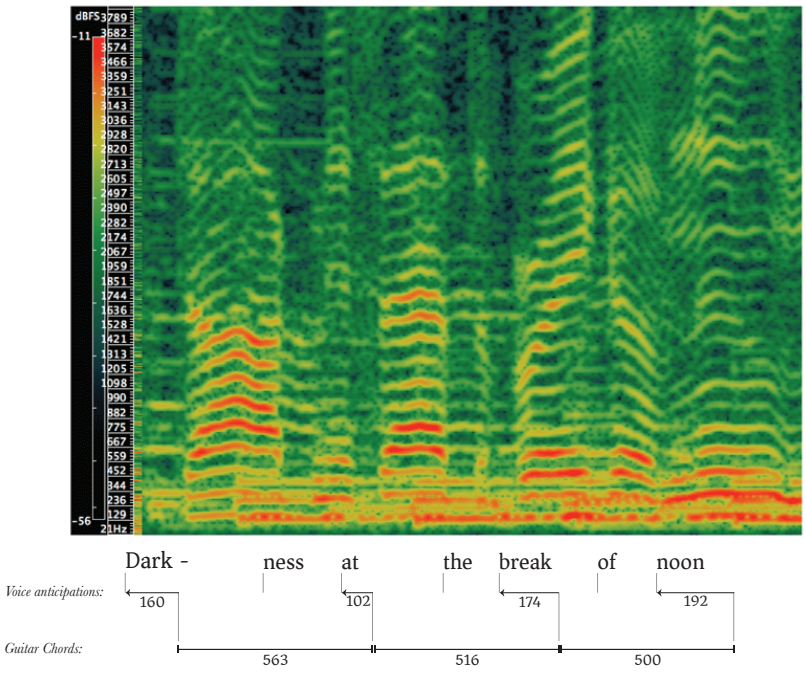


Spectrograms of two performances of the sarabande from J. S. Bach's fifth suite for solo cello, one by Anner Bylsma (playing a Baroque cello) and the other by Pablo Casals (on a modern cello), are measured horizontally in clock time. Overlaid notation helps clarify in musical time where the first eleven notes of the sarabande begin in each.

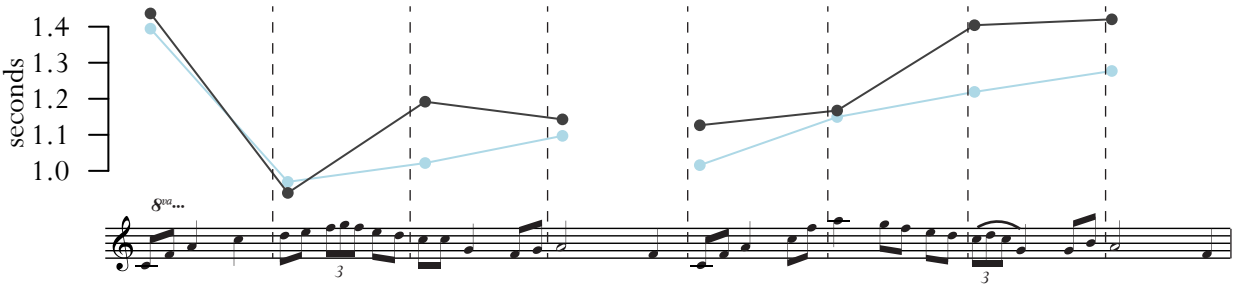
Online Figure 25.6 *Above*, Steven Rings, "A Foreign Sound to Your Ear: Bob Dylan Performs 'It's Alright, Ma (I'm Only Bleeding),' 1964–2009," *Music Theory Online* 19, no. 4 (2013): fig. 10, http://www.mtosmt.org/issues/mto.13.19.4/mto.13.19.4.rings.php; *below*, redrawing.

The upper image depicts expressive timing in an excerpt of a recording of Bob Dylan, combining millisecond timing and a spectrographic representation of the audio. Arrows show where beats expressed by the guitar start, and the image provides times between the beat onsets (ranging from 500 to 563 milliseconds). The image also shows the degree to which Dylan's vocal anticipates each beat (from 102 to 192 milliseconds). The redrawing below disentangles the lines, giving greater emphasis to the lines measuring the anticipations, which is the image's aim.



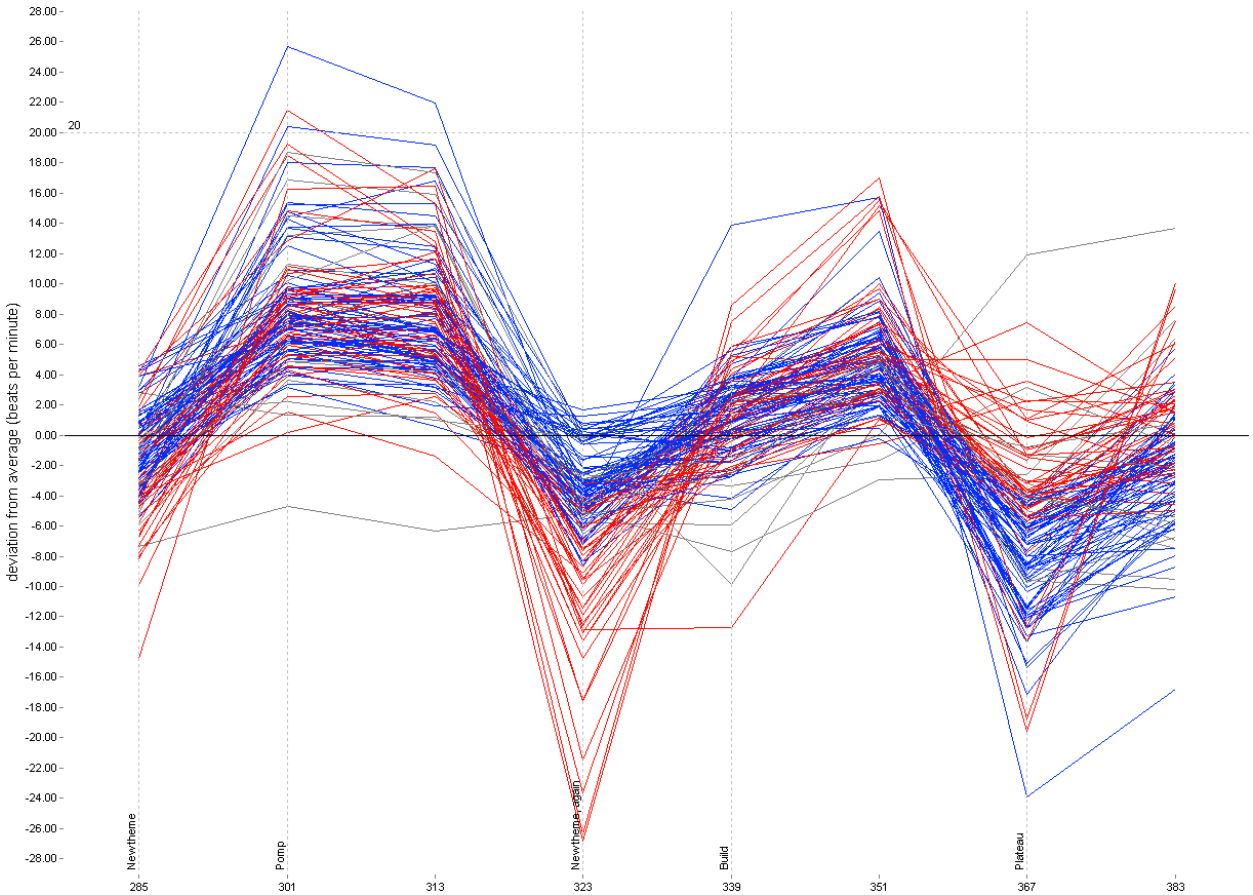


Online Figure 25.10 Mitchell C. Ohriner, "Grouping Hierarchy and Trajectories of Pacing in Performances of Chopin's Mazurkas," *Music Theory Online* 18, no. 1 (2012): ex. 3, https://mtosmt.org/issues/mto.12.18.1/mto.12.18.1.ohriner.html.



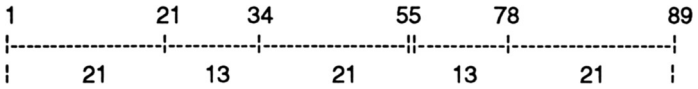
This image shows tempo profiles of a passage by Frédéric Chopin as performed by Frederic Chiu (blue) and Vladimir Ashkenazy (gray). As in figure 25.8, the vertical axis maps duration (here, seconds per measure), so higher equals longer. At least when I try to "perform" the examples in my mind, I would prefer that the vertical axis show tempo, with higher equaling faster.

Online Figure 25.12 Eric Grunin, "An Eroica Project," accessed December 27, 2009, http://www.grunin.com/eroica/index.htm, site discontinued.



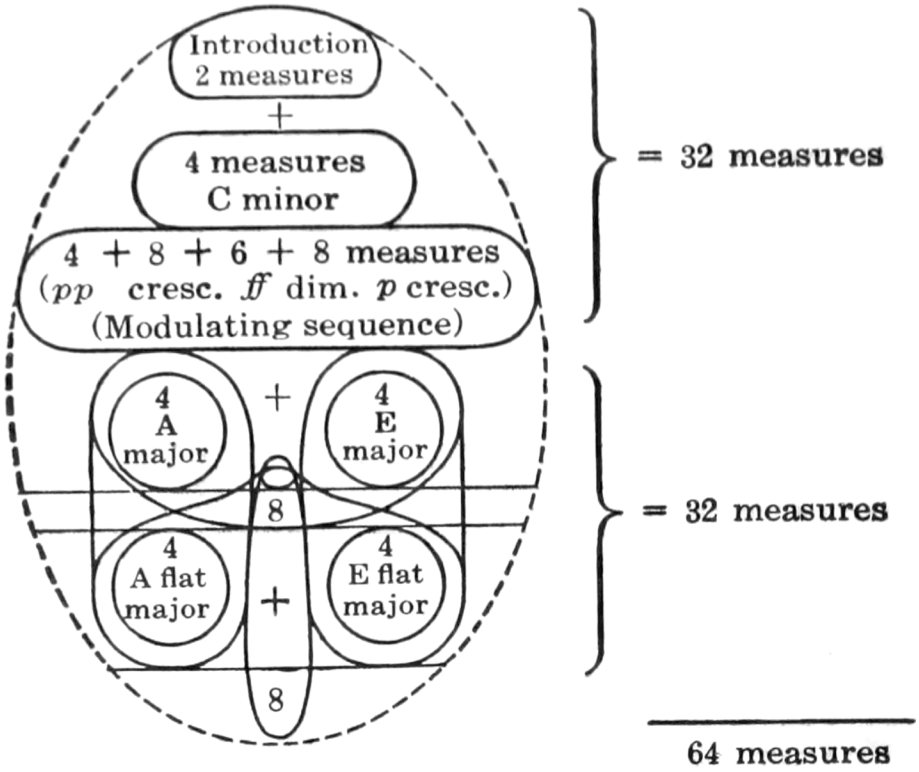
This is a study of tempo in 131 performances of Ludwig van Beethoven's Symphony no. 3, movement 1. This image, which focuses on the second half of the development, shows how the various performances deviate from the average tempo taken for the entire movement over the passage from m. 285 to m. 383. Note how certain key moments are shown with vertical dashed lines, some of which have short descriptors to help those who know the work get their bearings. (Unfortunately, the website from which this image was taken is no longer available and the significance of the color-coding has been lost. Additional images from the site are discussed in chapter 50.

Online Figure 26.2 Charles Madden, *Fractals in Music: Introductory Mathematics for Musical Analysis* (Salt Lake City: High Art, 1999), 69.



This depiction of proportion in the first movement of Béla Bartók's *Music for Strings, Percussion, and Celesta*, seemingly produced on a typewriter using hyphens and virgules, is not very attractive. Additionally, there is no indication that the upper numbers are measure numbers and that the lower ones are distances. Finally, it shows the opening section to be twenty-one measures, but there are only twenty (21–1) measures.

Online Figure 26.5 Hugo Leichtentritt, *Musical Form* (Cambridge, MA: Harvard University Press, 1951), 390.

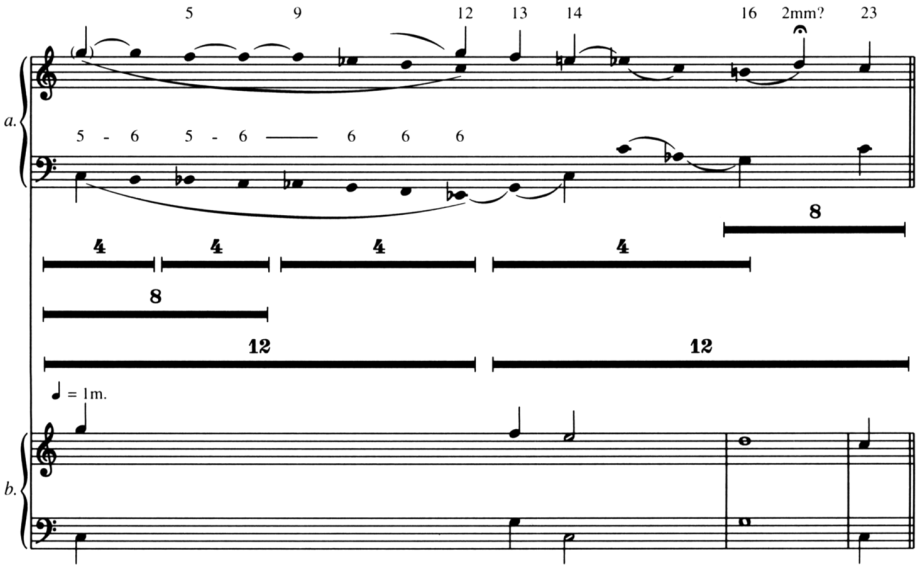


When the meter is unchanging in a piece, using the measure as a yardstick is uncontroversial. This image, which from the perspective of visualization is something of a disaster, depicts structure in the first section of Anton Bruckner's Symphony no. 8, movement 2. In terms of proportion, the only effective part is that the overall 32 + 32 division is clear. Besides the unnecessary circles and curlicues, the proportions vary wildly. If everything were sized relative to the two-measure introduction, here is how much taller each of the sections would need to be:

- 1.9x (4)
- 5.3x (4 + 8 + 6 + 8)
- 2.6x (4 + 4)
- 9.1x (8)
- 3.1x (4 + 4)
- 5.0x (8)

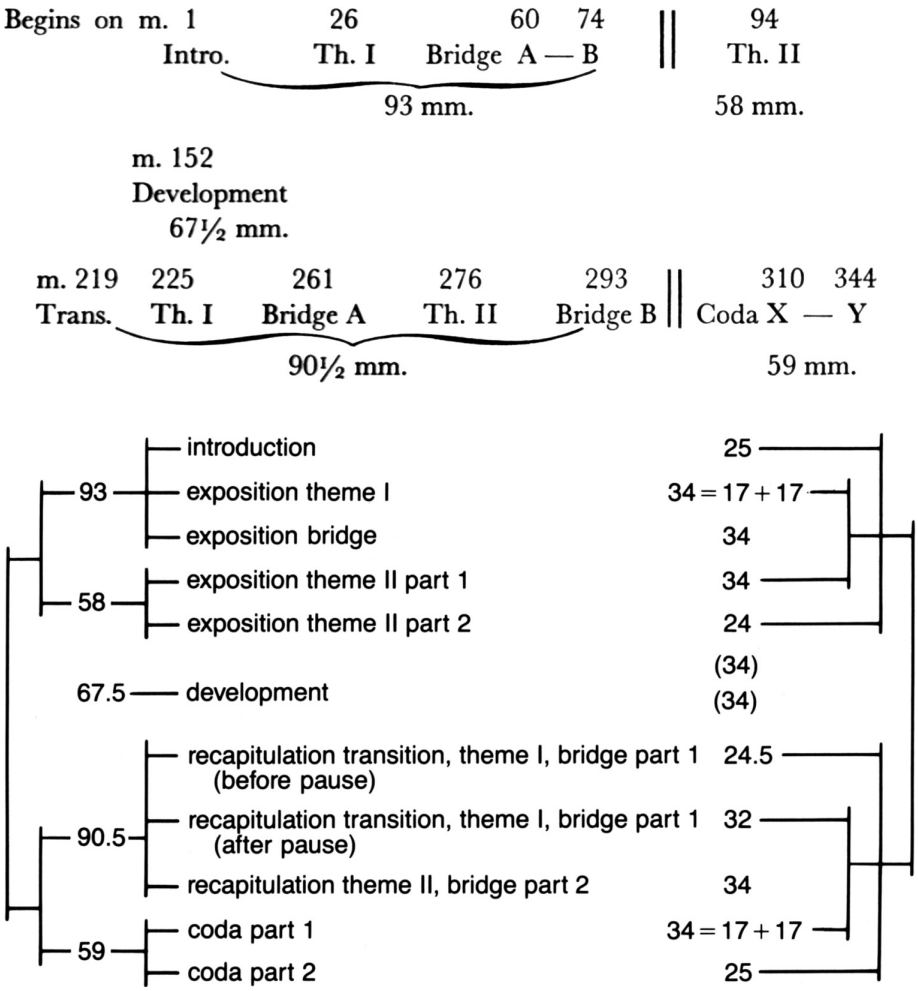
To be sure, the image does not seem to purport to show proportions, but by choosing not to do so, it projects a distorted sense of the music.

Online Figure 26.6 James M. Baker, "Chromaticism in Classical Music," in *Music Theory and the Exploration of the Past*, ed. Christopher Hatch and David W. Bernstein, 233–308 (Chicago: University of Chicago Press, 1993), 293.



In this analysis of the opening of Wolfgang Mozart's *Quartet*, K. 465, movement 1, the appropriation of multimeasure rests to denote sections is readily understood. Their heavier visual weight boosts them to a different visual layer from the rest of the example. Given that the image is clearly concerned with proportion, it would have been better if the lengths of the rests were proportional to the numbers, however. The four-bar segments are all of different lengths, and the final eight is considerably shorter than the four with which it overlaps. Curiously, the durations four and eight, which overlap by an unspecified amount, nevertheless still equal twelve measures.

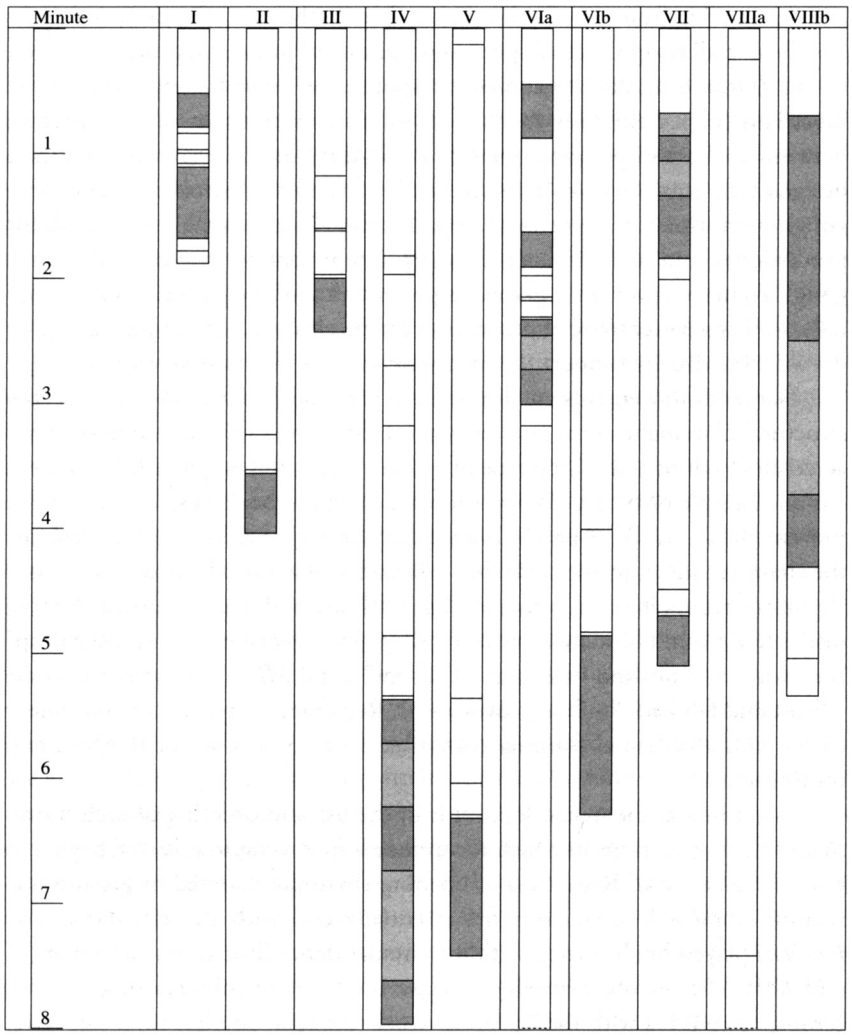
Online Figure 26.7 *Above*, Edward T. Cone, "The Uses of Convention: Stravinsky and His Models," *Musical Quarterly* 48, no. 3 (1962): 293; *below*, Jonathan D. Kramer, *The Time of Music: New Meanings, New Temporalities, New Listening Strategies* (New York: Schirmer Books, 1988), 295.



Regarding the exposition and recapitulation of Igor Stravinsky's Symphony in C, movement 1, the author of the upper image notes that they are "startling in the close parallel of their proportions" (Cone 1962, 293). The numbers do indeed bear this out, and the layout supports the claim, even if imprecisely. The redrawing of this image below puts the proportions from the original image on the left and adds additional ones on the right. The proportions that are of primary interest in the image are not reinforced by spatial proportions, however. In addition, the brackets sometimes group sections and sometimes mark symmetries. It would be better to move the entire apparatus to one side or the other. With some minimal tweaking, the horizontal elements of the brackets could be eliminated altogether.

Online Figure 26.12 Nathan Hesselink, "Rhythm and Folk Drumming (P'ungmul) as the Musical Embodiment of Communal Consciousness in South Korean Village Society," in *Analytical and Cross-Cultural Studies in World Music*, ed. Michael Tenzer and John Roeder (New York: Oxford University Press, 2011), 273 (*below*), 276 (*facing page*).

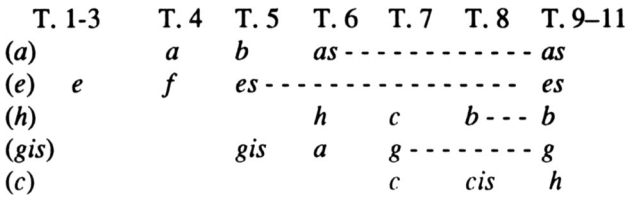
rhythm	*meter*	*duration in beats*	*# times stated*
I. *Mŏrigut* (1 min. 53 sec.)			
ŏrumgut I	free	n/a	2
hwimori	12/8	4	10
iŭmsae I	12/8	8	1
samch'ae	12/8	8	2.5
iŭmsae II	9/8	3	1
nŭrin kaenjigen	6/8	2	5
iŭmsae III	12/8	4	1
hwimori	12/8	4	26
ŏrumgut I	free	n/a	1
insagut I	12/4	12	1
II. *Oemach'i chilgut* (*kilgut*) (4 min. 3 sec.)			
kilgut	12/8	16	5
nŭrin kaenjigen	6/8	2	15
iŭmsae III	12/8	4	1
hwimori	12/8	4	19
III. *Ch'aegut* (2 min. 26 sec.)			
ch'ilch'ae	12/8	16	10
tumach'i	12/8	8	7
iŭmsae II	9/8	3	1
nŭrin kaenjigen	6/8	2	13
iŭmsae III	12/8	4	1
hwimori	12/8	4	17
IV. *Hohŏgut* (8 min.)			
chindadŭraegi	4/4; 12/8	8; 4	14; 15
ŏrumgut I	free	n/a	1
hohŏgut	12/8+8/8 +10/8+ 12/8	24	3
tol hohŏgut	12/8+8/8 +10/8+ 12/8+9/8 +12/8	23	2
chajin hohŏgut	12/8	8	24
chung samch'ae	12/8	8	7
iŭmsae III	12/8	4	1
hwimori	12/8	4	12
tchaksoe	12/8	8	11
hwimori	12/8	4	21
tchaksoe	12/8	8	21
hwimori	12/8	4	15
V. *P'ungnyugut* (7 min. 26 sec.)			
insagut II	12/8	8	1
p'ungnyu	12/8	8	38
pan p'ungnyu	12/8	8	9
pparŭn kaenjigen	12/8	4	5
iŭmsae IV	12/8	4	1
hwimori	12/8	4	48
VI. *Pangulchin'gut* (14 min. 18 sec.)			
ŏrumgut II	12/8	4	9
hwimori	12/8	4	18
ŏrumgut II	12/8	4	12
hwimori	12/8	4	13
iŭmsae I	12/8	8	1
samch'ae	12/8	8	4.5
iŭmsae II	9/8	3	1
nŭrin kaenjigen	6/8	2	7
iŭmsae III	12/8	4	1
hwimori	12/8	4	6
tchaksoe	12/8	8	7
hwimori	12/8	4	14
iŭmsae V	12/8	16	1
pan p'ungnyu	12/8	8	117
pparŭn kaenjigen	12/8	4	24
iŭmsae IV	12/8	4	1
hwimori	12/8	4	65
VII. *Mijigi* (5 min. 7 sec.)			
ŏrumgut I	free	n/a	2
tchaksoe	12/8	8	4
hwimori	12/8	4	7
tchaksoe	12/8	8	7
hwimori	12/8	4	25
iŭmsae V	12/8	16	1
pan p'ungnyu	12/8	8	33
pparŭn kaenjigen	12/8	4	12
iŭmsae IV	12/8	4	1
hwimori	12/8	4	16
VIII. *Yŏngsan* (13 min. 21 sec.)			
ŏrumgut I	free	n/a	1
kajin yŏngsan	12/8	80	10
tadŭraegi yŏngsan	12/8	12	14
hwimori	12/8	4	72
tchaksoe	12/8	8	31
hwimori	12/8	4	31
ŏrumgut I	free	n/a	2
insagut I	12/4	12	2



The table on the facing page provides an impressively detailed analysis of a drumming performance of nearly an hour's length. As in most tables, the image provides no visual sense of proportion. This is addressed in the graphical representation above, which omits much of the information found in the table. Shades of gray link the two images.

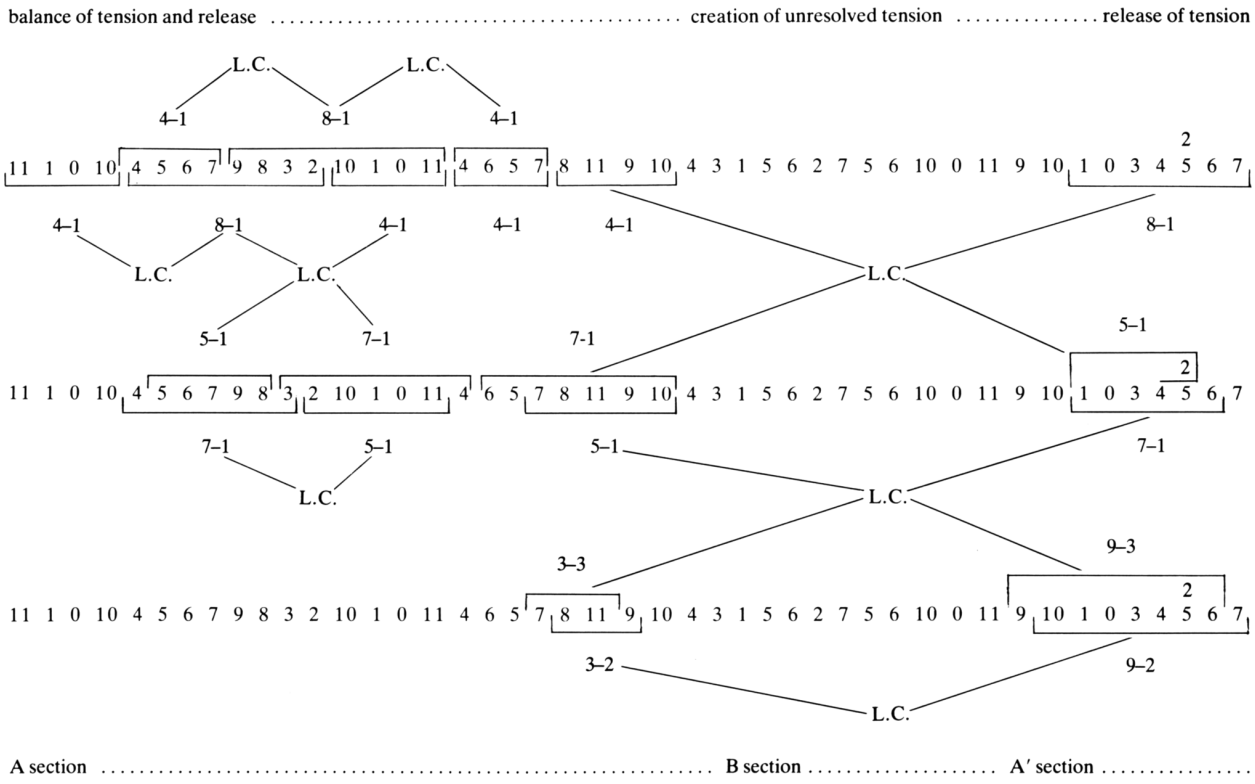
The image above takes a similar approach to figure 26.11, except that time flows down from the top. It was designed to accommodate only eight minutes vertically, but unfortunately sections VI and VIII are longer, so the bars wrap back up to the top again, undermining the impact of the image. Nevertheless, the proportions are much easier to see here than in the numerical table from which the data are drawn. The gridlines that enclose the table are effective—at camouflaging the graphic's excellent information. It would be better to remove them.

Online Figure 27.3 Mark Delaere, *Funktionelle Atonalität: Analytische Strategien für die Frei-Atonale Musik der Wiener Schule* (Wilhelmshaven: F. Noetzel, 1993), 49.



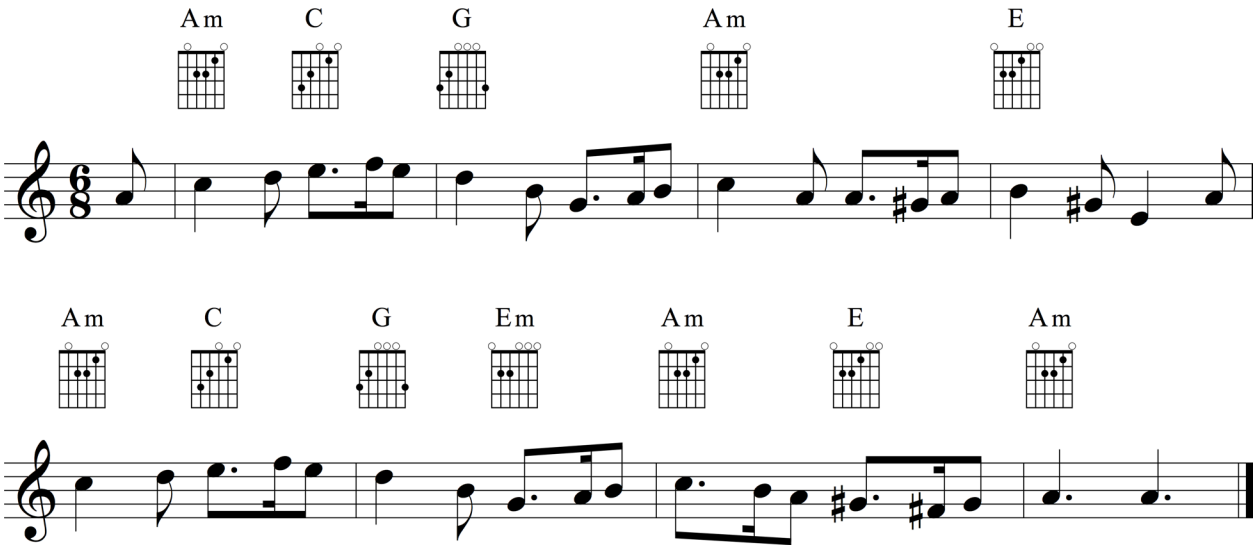
This image uses pitch names (in German) to depict the opening of "Farben," from Arnold Schoenberg's *Five Orchestral Pieces*, op. 16. The passage features a five-voice chord in which each voice realizes a +1 / −2 interval motive, with the motions overlapping, stretto-like. The representation is literally flat, failing to convey the key motive in a visually telling way. It also does not show that the pitches are sounding from the start of the work. This notation has no apparent advantage over conventional notation, except the convenience of being able to simply type out the text.

Online Figure 27.4 Elizabeth West Marvin, "The Structural Role of Complementation in Webern's *Orchestra Pieces* (1913)," *Music Theory Spectrum* 5 (1983): 84.

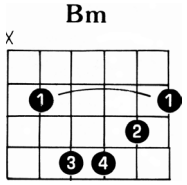


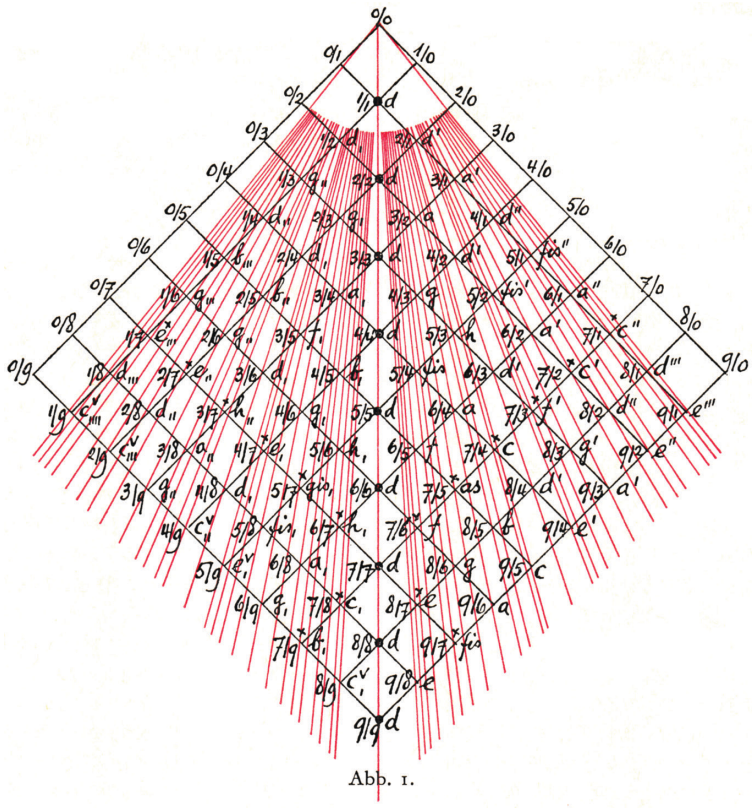
This image shows pitch content of Anton Webern's *Orchestral Pieces*, op. 10, movement 1, reduced to a single line, using pitch-class numbers. This notation allows the focus to remain on the location of complementary sets, which are the focus of the study. Since the pitches are so sparsely spaced in the orchestral score, this compressed representation is useful. On the other hand, it would be informative to see how the complement relations are manifest in the music, and without measure numbers for reference, linking the analysis back to the score is difficult.

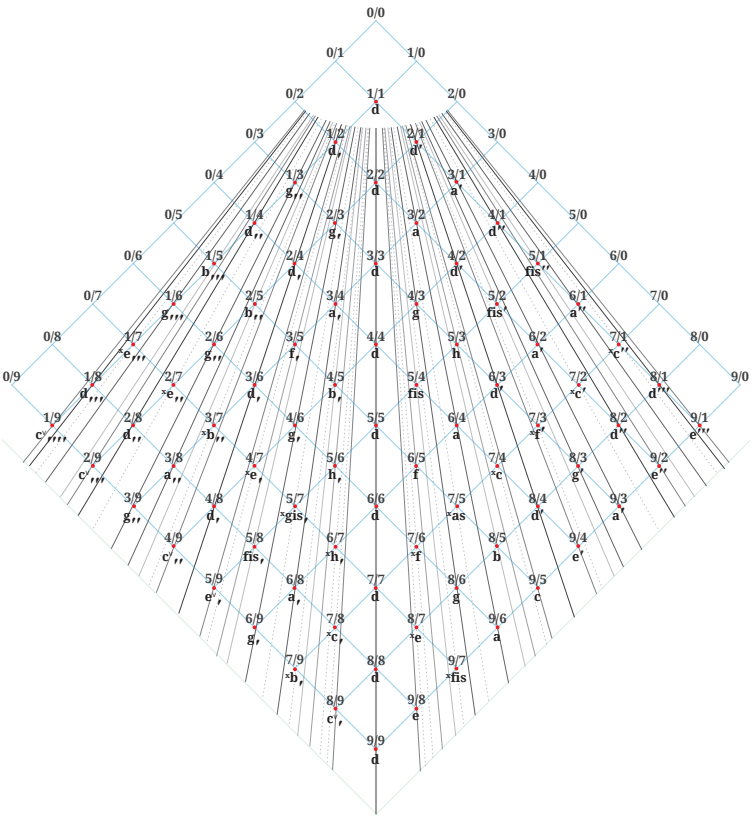
Online Figure 29.4 *Greensleeves.*



Contemporary music intended for performance involving guitar often uses a system akin to Baroque tablature. Chord names are sometimes accompanied by fretboard representations ("guitar tabs") in which simple dots replace finger numbers. The dots are faster to read since they don't invoke the language portion of the brain, though they lack information on which fingers to place where. Instructional guides for guitar still sometimes use circles with numbers on them to signify which finger to use, as in the image to the right. Since there are few ways the fingers can reach a particular configuration, even those with modest experience can figure out which fingers to use to realize a particular pattern, so the increased cognitive load imposed by the presence of finger numbers may not justify their inclusion except for beginners. The chord symbols provide more musical information than the alfabeto system's basic lettering scheme, while the guitar tab tells players where to put their fingers, and nothing more.





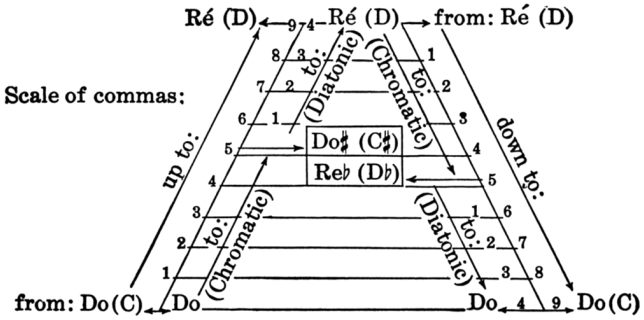


Online Figure 30.2 *Above*, Hans Kayser, *Orphikon: Eine harmonikale Symbolik* (Basel: Schwabe, 1973), 43; *below*, redrawing.

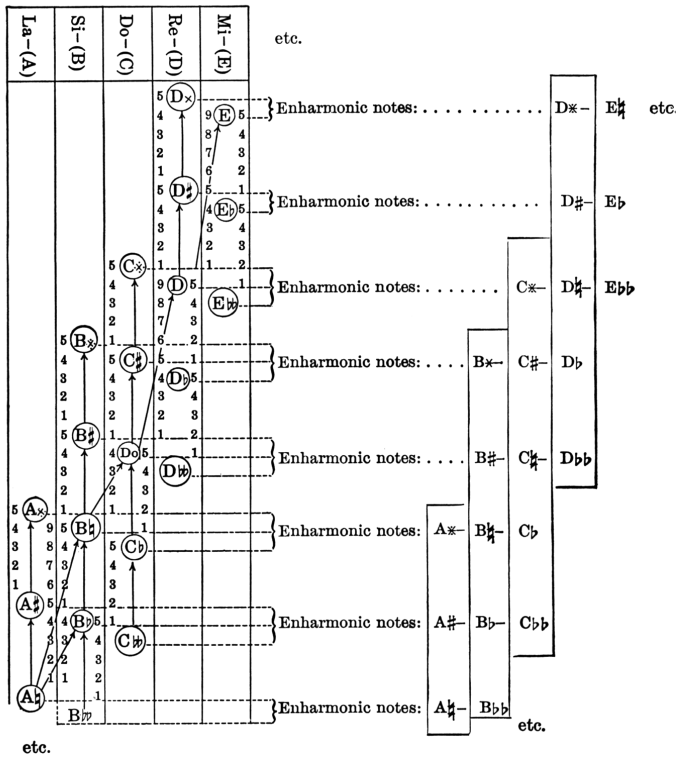
The image above is the original color version, from which figure 30.1 was reprinted in black and white. Rendering the radiating lines in red at least gives the information on the diamond-shaped grid a fighting chance at being seen. The redrawing below makes it yet easier to see the image's elements. The ten-by-ten grid is minimized. For the lines emanating from the origin, relative boldness corresponds with acoustically significant ratios (1:1, then 2:1 and 1:2, then 3:2 and 2:3, etc.). The redrawing represents notes formed from "out of tune" intervals that are therefore musically unusable with dashed lines, and it prefaces their labels with *x*, as in the original. The line treatment allows one to see the most important information, the frequency ratios and resulting pitches. These changes do not correct the fundamental design flaws of the image, however. While a careful traversal of the diagonals of the grid (for example, from 6/1 to 6/2 to 6/3, etc.) allows an understanding of the effects of dividing the frequency in various ways, the lines fanning out from the origin, the primary visual component even in the redrawing, do not add useful information. The redrawing takes advantage of color to further differentiate the information layers: the background ten-by-ten grid appears in cyan, while red dots make the precise location of nodes clearer. The result is considerably more legible.

Online Figure 30.4 Renée Longy-Miquelle, *Principles of Musical Theory* (Boston: E. C. Schirmer Music, 1925), 29, 30.

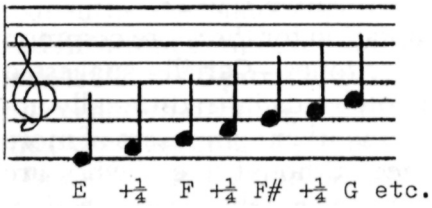
Both of these images work from an (erroneous) assumption that the smallest detectable interval is one-ninth of a whole tone, and they use this assumption to explain the difference between enharmonic notes. Chromatic halftones—that is, those between pitches with the same name (for example, D♭ to D♮ to D♯)—span five-ninths of a step, while diatonic halftones (such as from C to D♭) span four-ninths of a step. The upper image, which invokes a ladder metaphor to show the "scale of commas," is unnecessarily cluttered, while inconsistencies hamper the lower layout. Sometimes the chromatic divisions (one to five) are counted on the left side of a column and sometimes on the right. Sometimes only half steps are counted (whether to four or to five), but sometimes a whole step is counted (to nine).



Comparative Scale of Commas in Whole Tones, Chromatic and Diatonic Half-tones and Enharmonic Notes:

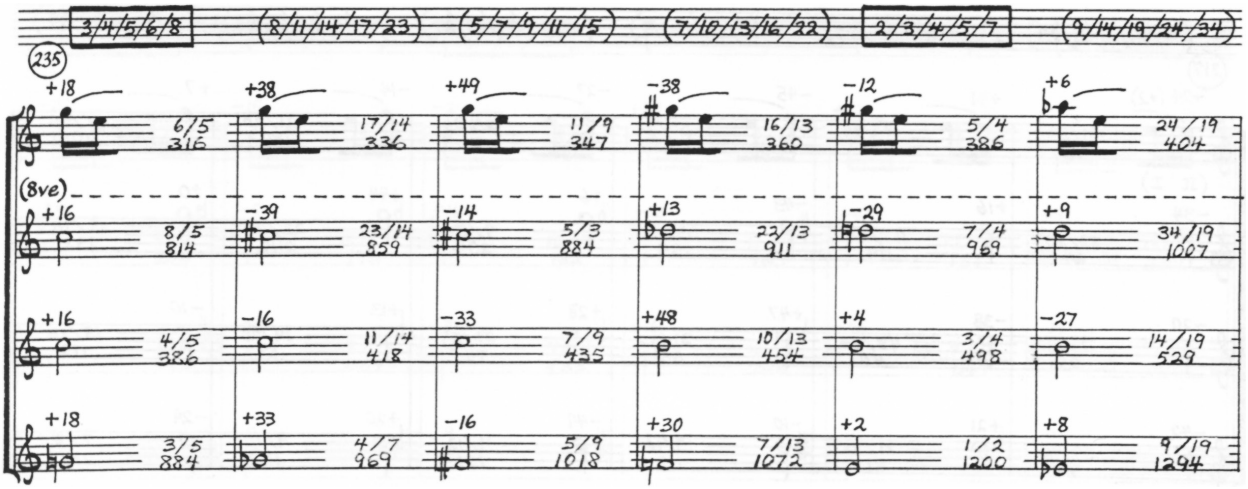


Online Figure 31.3 Eric Hornbostel, *Musikalische Tonsysteme*, cited in Gardner Read, *20th-Century Microtonal Notation* (New York: Greenwood, 1990), 16.



This image proposes a nine-note staff in which each line represents one of the twelve equal-tempered chromatic pitches, and the spaces are the quarter tone between them. The system cannot succeed: it has too many staff lines to process visually in real time.

Online Figure 31.6 James Tenney, *Koan, for String Quartet* (Baltimore, MD: Sonic Arts Editions, 1984), mm. 235–40.



Tenney's *Koan, for String Quartet* is even more intensely microtonal than the system described in figure 31.5. In the passage shown here, the first violin's figure includes an open-string E as a drone. The other four pitches form the frequency ratios shown above the score in each measure. On the right side of each measure, the frequency of the note to be played relative to the frequency of the E is provided as a ratio and in cents (one hundred cents = an equal-tempered semitone). The number above a note is the deviation of that pitch (again in cents) from a tempered version of the pitch. The representation provides as much information as possible to the classically trained string player. Nevertheless, precision in notation is no guarantee of precision in performance, which in this case would require extraordinary preparation and intense rehearsal.

Online Figure 32.2 Hye Min Jeong, *Das Musikalische Material und seine Behandlung im Frühwerk von Krzysztof Penderecki: Eine Studie zum Cluster und zur Klangfarbe* (Frankfurt am Main: P. Lang, 2007), 107.

T. / Instr.	1–13 **	14–21	22–27	28–36	37–73	74–86	87–101	102–105	106–109	110	111–112 **	113–114	115
(1)	O	O					O			O	O	O	O
(2)						O		O				O	O*
(3)				O		O	O	O	O	O		O	
(4)		O	O	O	O	O	O	O	O	O		O	O

(1) Streichinstrumente
(2) Zupf- und Tasteninstrumente
(3) Schlaginstrumente mit Tonhöhe
(4) Schlaginstrumente ohne bestimmte Tonhöhe
* Die Instrumente deuten an dieser Stelle keine genaue Tonhöhe an.
** In diesen beiden Klangfeldern erscheinen nur Toncluster von Streichinstrumenten.

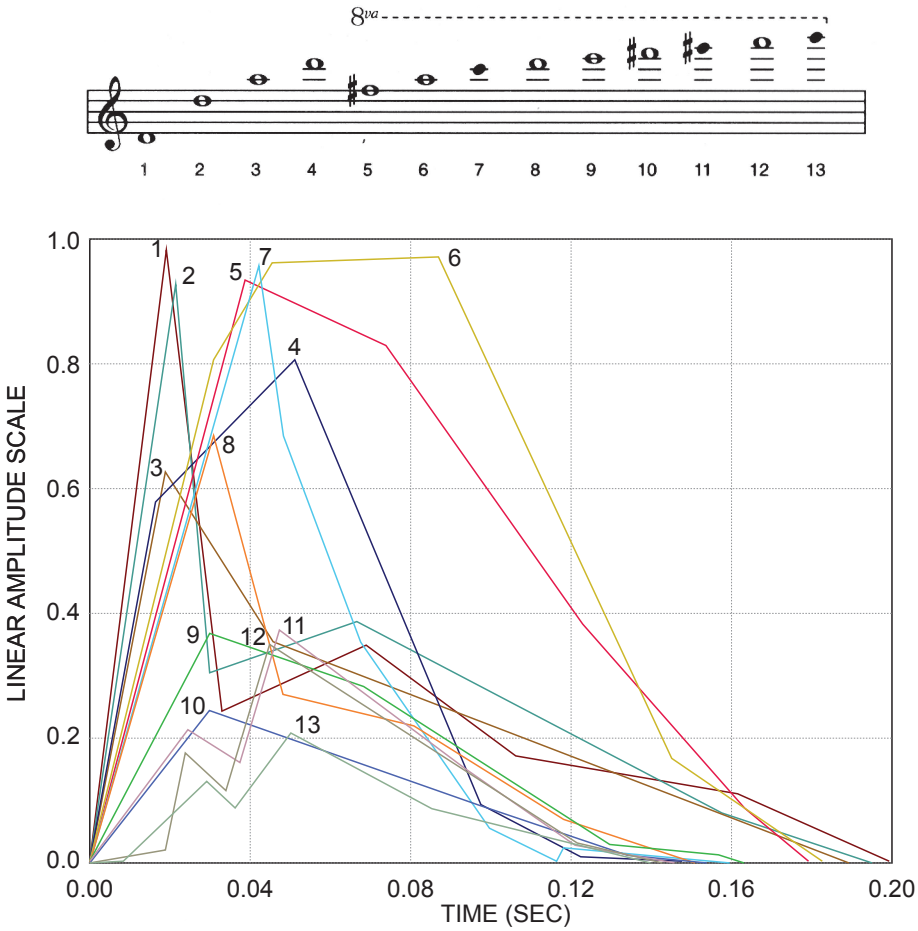
A depiction of timbre via instrumentation, in a work by Krzysztof Penderecki. This kind of timbral analysis relies on viewers' ability to call up the sounds of instruments (or, here, instrument families) in their mind. It is far from precise acoustically, and yet it takes advantage of our categorical way of thinking about sound.

Online Figure 32.4 D. Kim Dunnick, "A Physical Comparison of the Tone Qualities of Four Different Brands of B-flat Trumpets with Regard to the Presence and Relative Strengths of Their Respective Partials" (DM document, Indiana University, 1980), 37–38.

This image shows the amplitudes of each partial (through the fortieth!) for five pitches played on a Bach ML180 trumpet. Amplitude is represented using negative decibels, so smaller numbers represent greater intensity. As is so often the case with data that is intensely numerical, it can be hard to pull meaning from a table of figures like this. Compare it to the approach in figure 32.3 and redrawing in online figure 32.5.

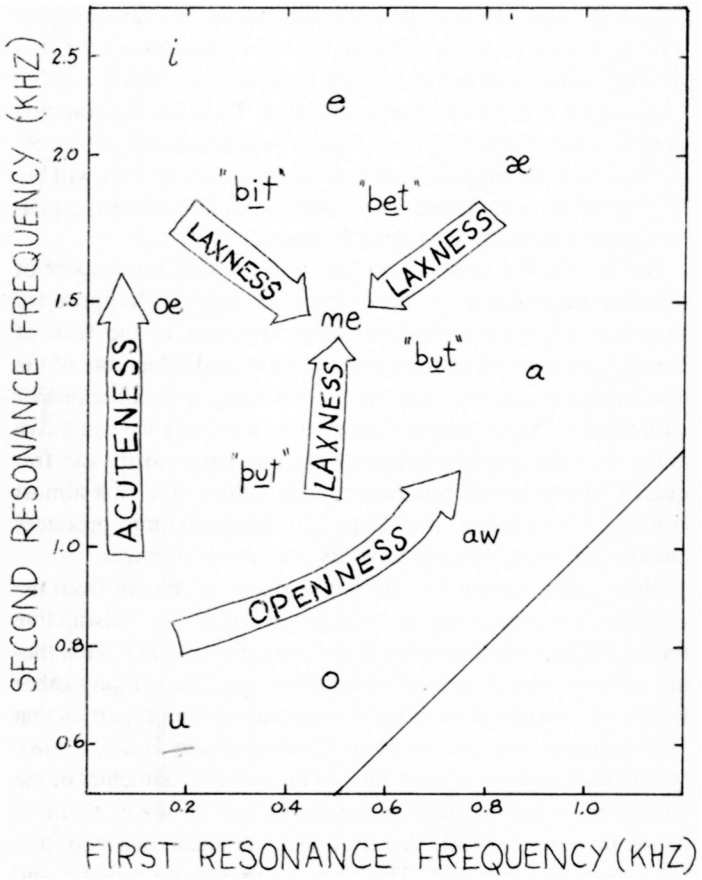
	Pitch				
Partial	165hz	294hz	466hz	660hz	830hz
1	40.4	32.9	15.0	13.8	8.4
2	40.1	21.1	12.4	11.8	21.1
3	31.5	23.5	9.0	12.1	14.4
4	27.9	14.5	15.3	26.9	20.6
5	33.9	20.4	21.1	29.1	29.5
6	28.1	21.4	26.6	28.1	39.1
7	26.5	20.8	29.9	41.0	38.1
8	32.1	25.8	33.1	38.5	40.1
9	27.5	26.0	28.8	43.5	38.8
10	31.0	33.1	33.1	53.0	51.7
11	36.4	28.0	38.6	48.3	49.9
12	39.8	37.1	40.1	59.4	50.0
13	31.6	33.1	39.1	54.9	55.6
14	36.8	37.9	40.0	53.8	62.5
15	50.2	38.6	41.0	62.4	61.2
16	36.4	41.2	44.8	64.0	60.4
17	38.5	46.2	45.7	62.0	63.5
18	45.9	43.1	46.3	64.0	63.5
19	42.0	49.8	47.2	64.0	63.5
20	41.9	47.5	48.6	64.0	63.5
21	48.6	50.0	52.5		
22	45.1	48.8	58.5		
23	47.5	51.1	59.6		
24	55.3	57.2	62.2		
25	50.8	50.9	63.5		
26	48.8	60.7	63.5		
27	57.3	58.3	63.5		
28	55.6	60.6	63.5		
29	54.0	60.1	63.5		
30	58.6	62.2	63.5		
31	59.4	63.1			
32	56.4	63.1			
33	58.9	64.0			
34	63.0	64.0			
35	59.6	64.0			
36	63.0				
37	63.0				
38	63.0				
39	63.0				
40	63.0				

Online Figure 32.5 Redrawing of fig. 32.3.



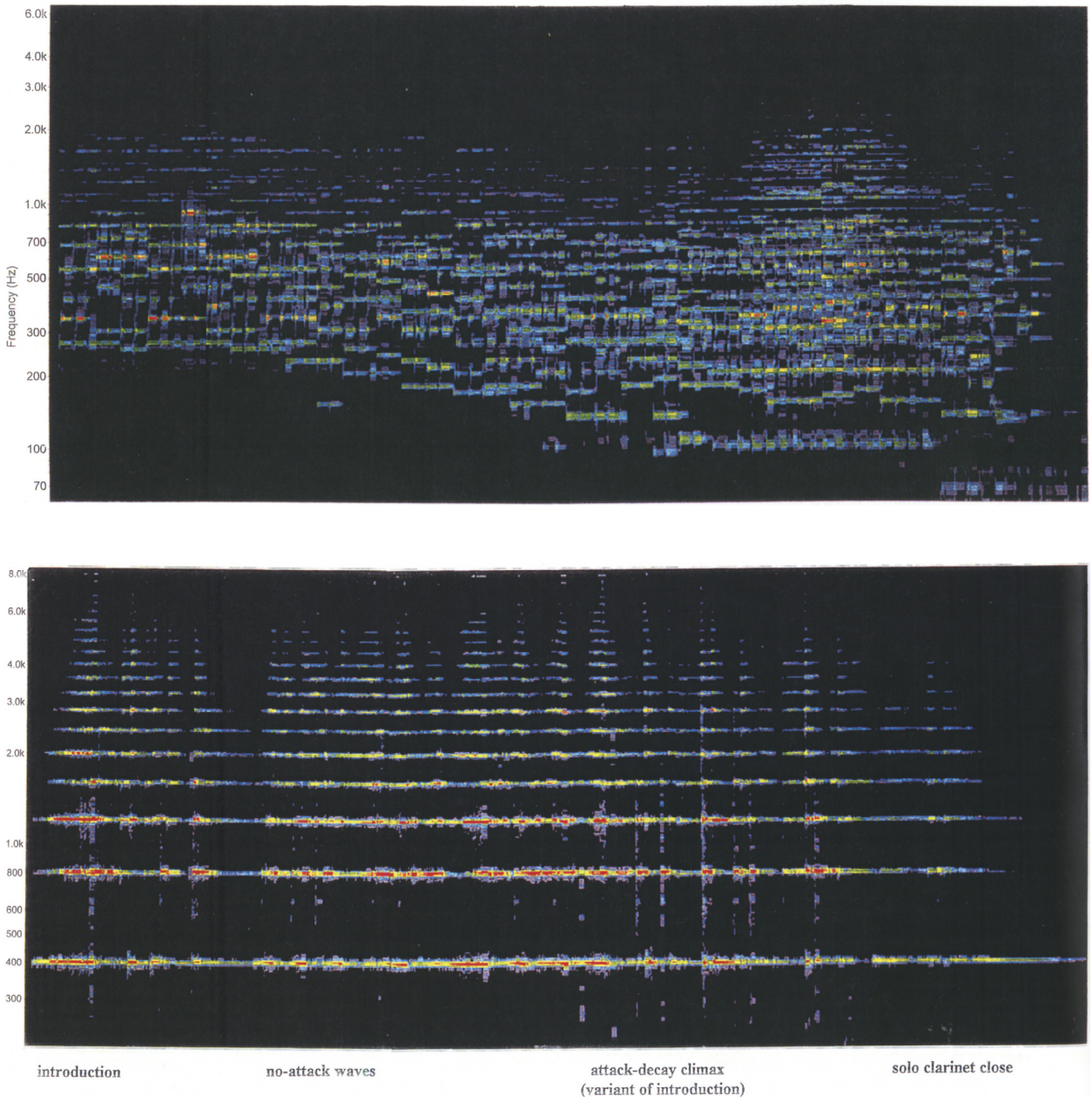
In this redrawing of figure 32.3, the badly entangled lines are rendered in different colors, which makes them easier to trace. (The line paths between 0.12s and 0.16s near the bottom of the image are best guesses. In the original, the lines in this part of the image overlap in a way that makes it impossible to isolate their individual paths.) The use of distinct hues with a high degree of saturation makes it easier to trace each line through the image. This version adds the missing 0.08 on the horizontal axis. It adds a unitless scale to the vertical axis to make relative amplitudes visible. It replaces tick marks in the axes with light dotted lines that extend across the grid. Finally, it relocates the numbers representing each partial to make them adjacent to the peak for that partial. In this way, they serve as data and not just as labels.

Online Figure 32.7 Wayne Slawson, "The Color of Sound: A Theoretical Study in Musical Timbre," *Music Theory Spectrum* 3 (1981): 135.



Similar to figure 32.6, this representation maps vowel sounds onto a grid that measures the sound's first and second resonance frequencies. These are posited to correspond to the properties *openness* and *acuteness*, respectively, with a third property, *laxness*, representing a neutral vowel sound. The figure is essentially the same as figure 32.6, flipped around the upper-left/lower-right axis.

Online Figure 32.10 Robert Cogan, *Music Seen, Music Heard: A Picture Book of Musical Design* (Cambridge, MA: Publication Contact International, 1998), 10 (*above*), 84 (*below*).

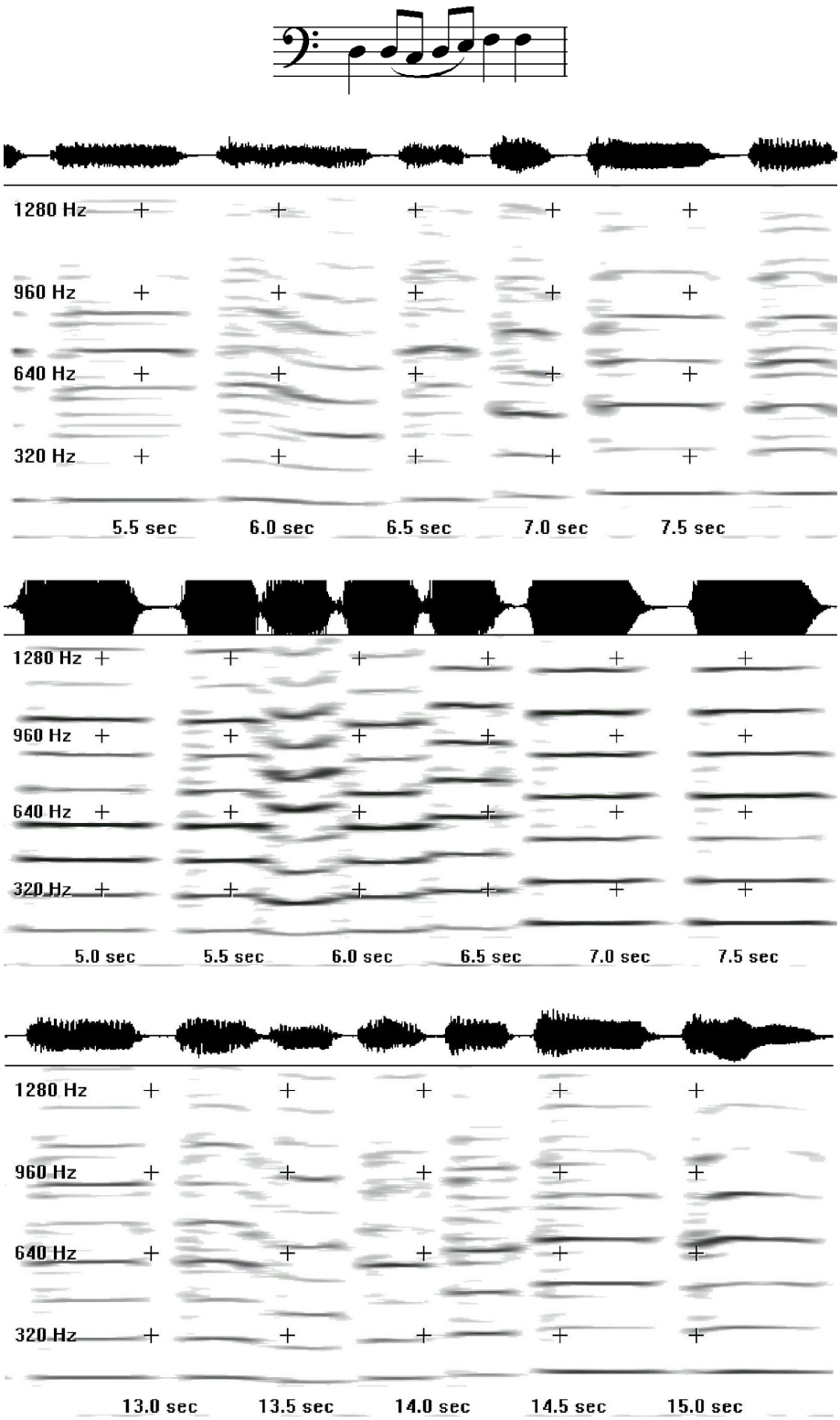


In these spectrograms, time is mapped left to right, frequencies within the acoustic signal low to high, and amplitude using a color scale. The upper image is of a piano performance of J. S. Bach's familiar C major prelude from the *Well-Tempered Clavier*, book 1. The lower image is of a performance of Etude 7 of Elliot Carter's *8 Etudes and a Fantasy* for woodwind quartet.

Like the piano roll, a spectrogram image provides a more synoptic view of the registral space of a piece. In the upper example, the gradual registral expansion over the course of the piece is easier to see than in a score, though it would be amply clear with a piano roll notation. While structural elements of the piece can be recognized in the image, the image does not uniquely illuminate them.

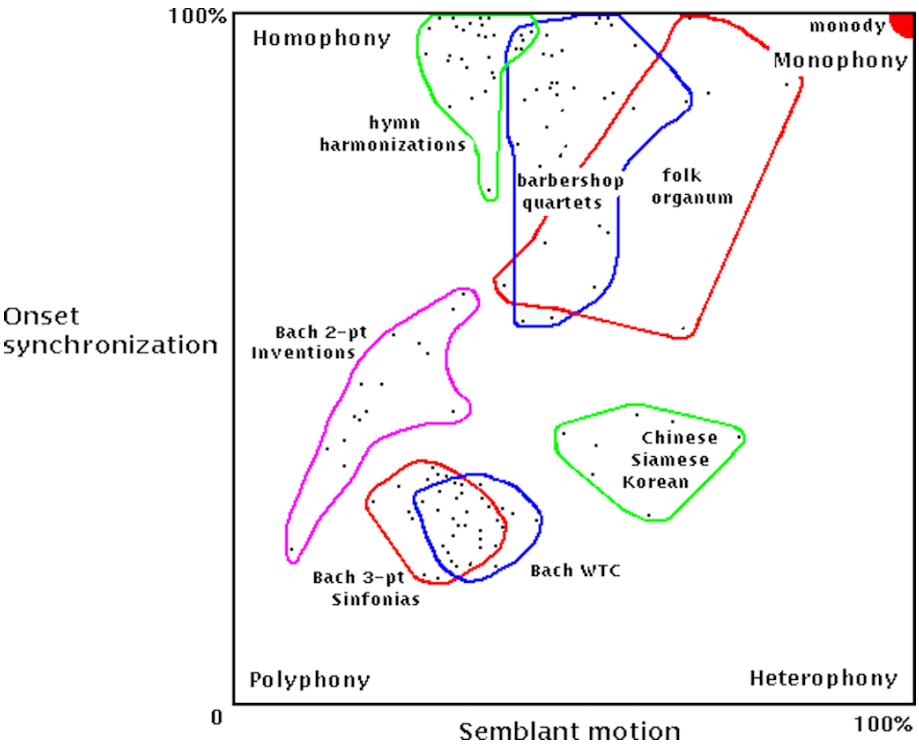
The value of the spectrogram becomes more apparent when timbre plays a more central role, as in the lower image, which contains only the pitch G4 (above middle C). The piece is all about tone color, and the spectrogram captures the experience of listening to the piece in a way the score never could. This image benefits from the addition of text, which annotates differences in activity in different places.

Online Figure 32.11 Jason T. Byrnes, "Pedagogical Applications of the Spectrogram in the Low Brass Studio" (DM document, Indiana University, 2005), 42–43.



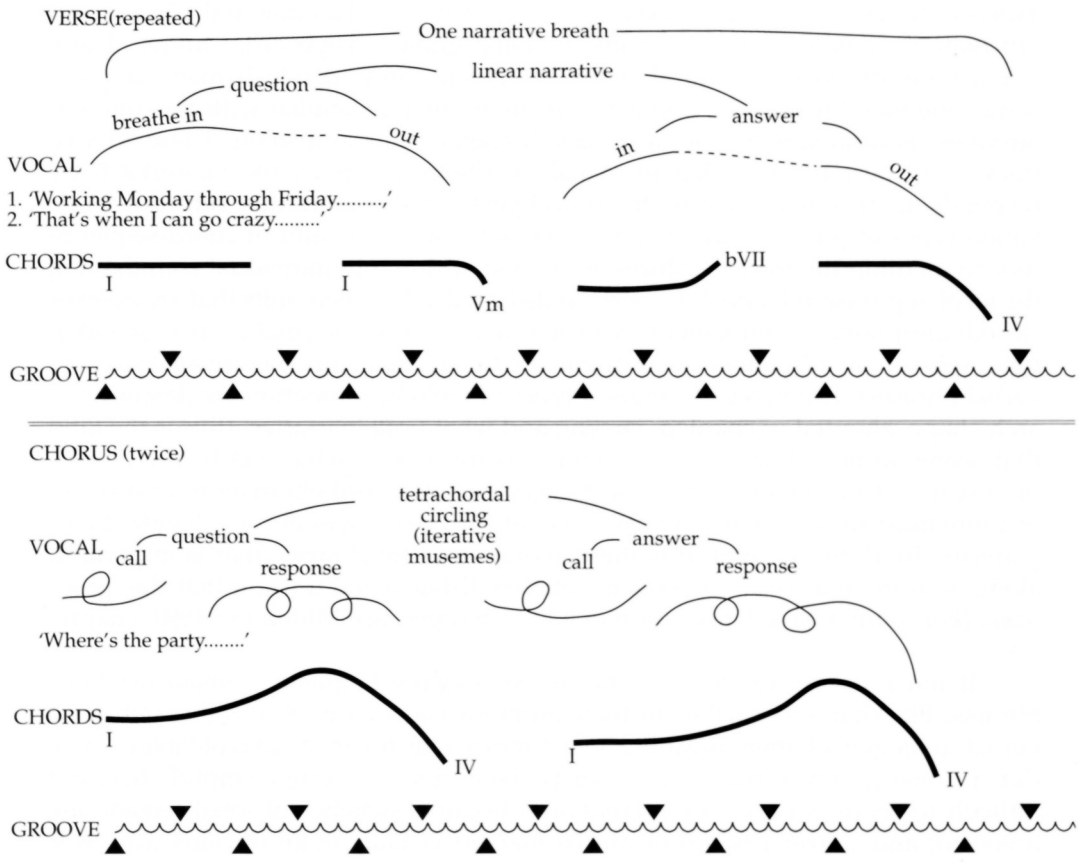
Spectrograms can be employed usefully in a pedagogical setting. These images trace an interaction during a lesson with a beginning trombone student. The student was asked to play the short passage shown at the top. The result was recorded, and the student could see their performance (first spectrogram). The teacher then played the second example, which clearly featured a more robust tone and a more graceful execution of the slurred eighth notes. The student, having heard and seen both performances, then tried to match the teacher's (third spectrogram) and was noticeably more successful.

Online Figure 33.3 David Huron, "Tone and Voice: A Derivation of the Rules of Voice-Leading from Perceptual Principles," *Music Perception* 19, no. 1 (2001): 52.



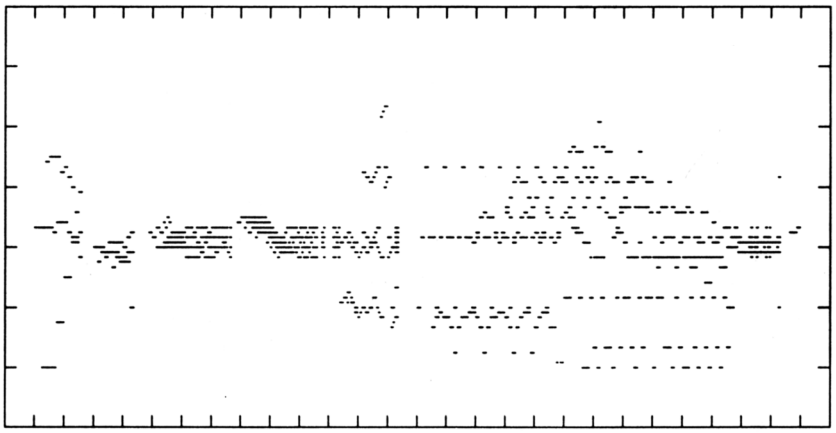
This image maps instances from seven collections of music onto the space represented in figure 33.2. The overlapping enclosures seem to imply that certain pieces belong to more than one category, though it is doubtful that any examples of folk organum are also barbershop quartets, and it is certainly not the case that any pieces belong to both J. S. Bach's *Three-Part Inventions* and his *Well-Tempered Clavier*. It would have been better to color-code the dots as well.

Online Figure 33.5 Richard Middleton, "Popular Music Analysis and Musicology: Bridging the Gap," *Popular Music* 12, no. 2 (1993): 182.



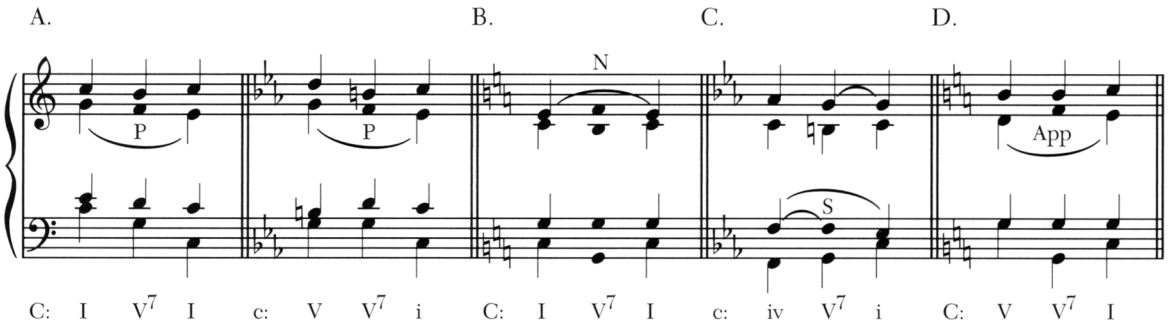
The components in an excerpt from "Where's the Party" by Madonna are given a rough graphical representation. The image is less detailed than the similar figure 33.4 and as a result conveys the texture less successfully, though the image is about quite a bit more than texture.

Online Figure 33.6 Alexander R. Brinkman and Martha R. Mesiti, "Computer-Graphic Tools for Music Analysis," *Computers in Music Research* 3 (1991): 5.



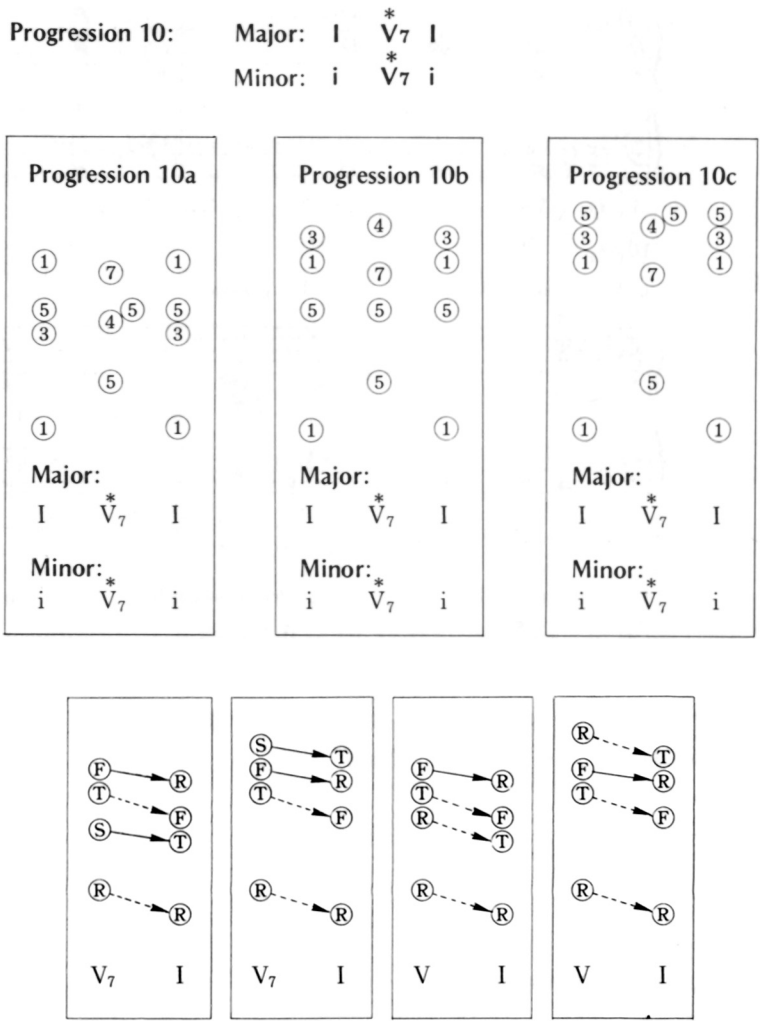
In this piano roll representation of Béla Bartók's *Fourth String Quartet*, movement 1 (mm. 1–26), many textural features are clear, including moments of imitation and changes of textural density from dense to sparse. Because no lines show how notes belonging to individual parts are connected, regions of relative sparseness and denseness stand out, though at the expense of conveying how each instrument contributes. Compare this to figure 33.7.

Online Figure 34.3 Robert Gauldin, *Harmonic Practice in Tonal Music*, 2nd ed. (New York: W. W. Norton, 2004), 148.



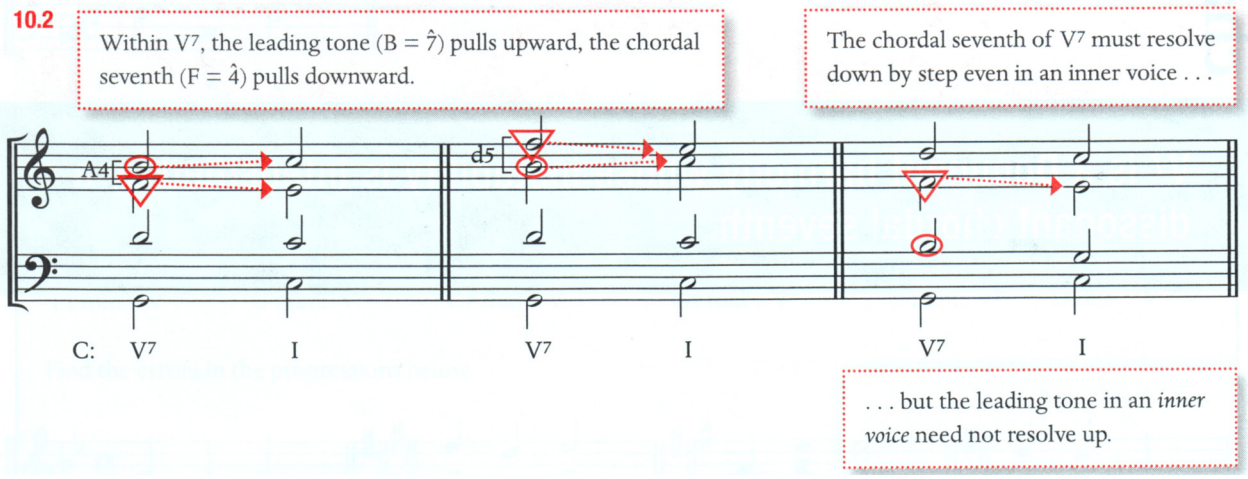
This image puts the V^7 chord into a three-chord context to convey the different embellishing functions the chordal seventh can serve, a nice touch that many textbooks omit.

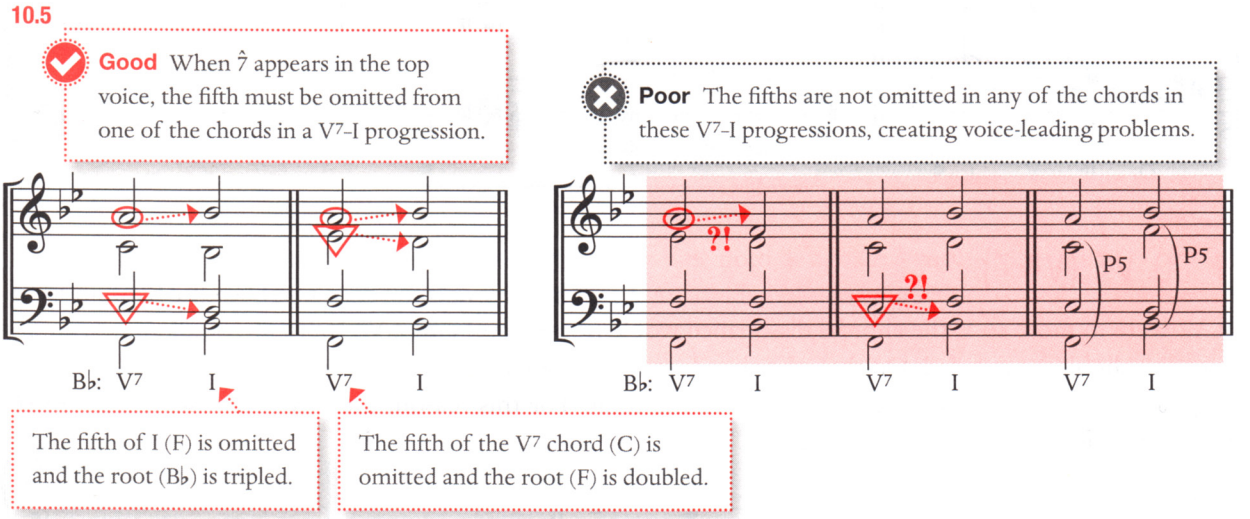
Online Figure 34.7 Allen Winold, *Harmony: Patterns and Principles* (Englewood Cliffs, NJ: Prentice-Hall, 1986), 1:132 (*above*), 1:145 (*below*).

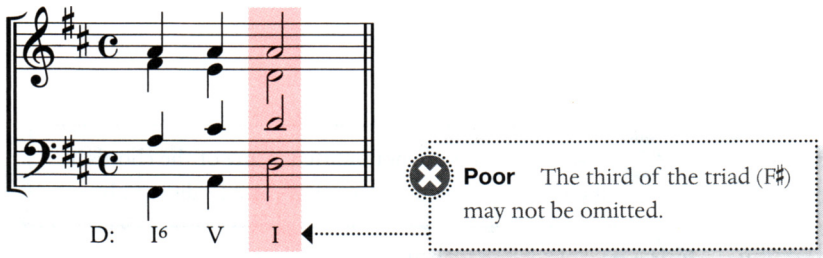


This novel representation of voice leading schema has not inspired copycats. The upper image shows the three possible voicings of a I–V^7–I progression in which the V^7 is incomplete (*). The lower image shows resolutions of V^7 and V–I in which the upper voices, including the leading tone, move downward to the tonic. Rendering these progressions in terms of scale degrees (in the first case) or chord members (in the second) allows them to be applied in any key. The level of detail is so great, unfortunately, that they mask the more fundamental principles that underly them and they end up resembling graphical versions of figure 34.1. (It is worth noting, however, that when I was developing the ear-training software ETDrill in the 1980s and 1990s, the schemata from this text were quite successful in automatically generating error-free voice leading.)

Online Figure 34.8 L. Poundie Burstein and Joseph N. Straus, *Concise Introduction to Tonal Harmony* (New York: W. W. Norton, 2016), 112 (*above*), 113 (*middle*), 114 (*below*).





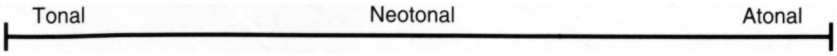


This series of three images clearly explains the resolution of V^7. The first outlines the general principle. The second illustrates both the appropriate use of incomplete chords and the voice-leading problems that can arise when the principles are not followed. The third image presents a final inappropriate resolution.

Many features of the images are laudable. First, they include all relevant principles. This reinforces the information in the prose and puts the information directly where it will be most useful to the student. Rendering tendency tones and other commentary in a spot color puts them into a different information layer from the notation. Shaded regions highlight problem areas, and colored boxes make clear what is acceptable and what is not.

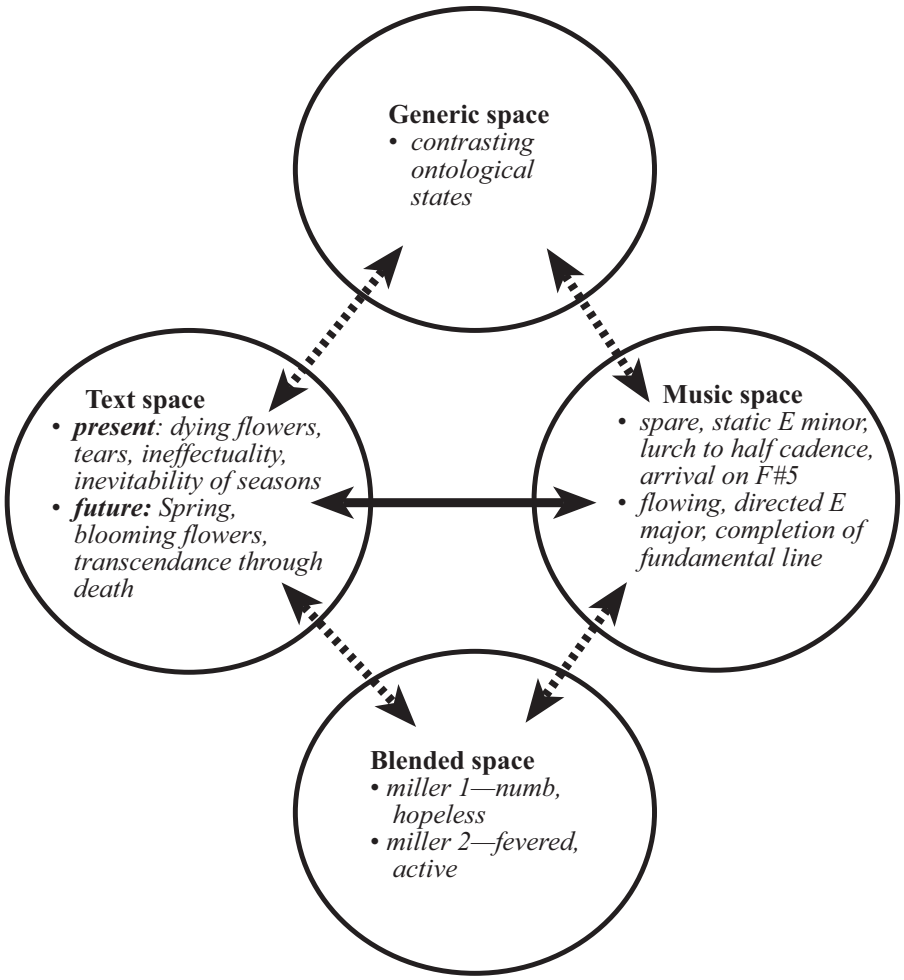
The circles and inverted triangles that mark the leading tone and chordal seventh are perhaps too heavy. Also, the shadows beneath the text boxes are not necessary. Overall, however, the presentation is excellent.

Online Figure 35.2 J. Kent Williams, *Theories and Analyses of Twentieth-Century Music* (Fort Worth: Harcourt Brace, 1997), 2.



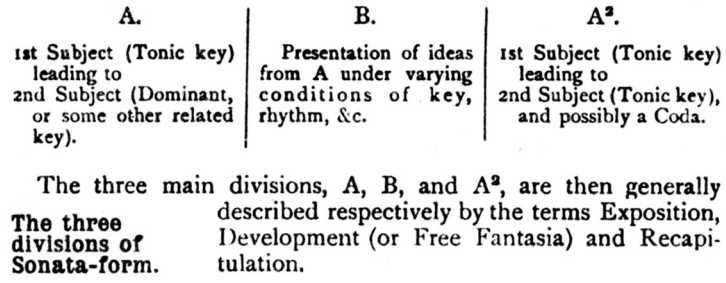
The simplicity of a minimalist schematic image does not reduce the expectation that it should convey a truth. Few would put *neotonal* as an intermediate step in a continuum between *tonal* and *atonal*, either stylistically or historically.

Online Figure 35.6 Lawrence Zbikowski, *Conceptualizing Music: Cognitive Structure, Theory, and Analysis* (Oxford: Oxford University Press, 2002), 262.



This schematic representation of a conceptual integration network (after Fauconnier and Turner 2002) explores how a generic space is realized in a poem by Wilhelm Müller and in music by Franz Schubert, which serve as input spaces to a blended space, the setting of Müller's "Trockne Blumen" in Schubert's song cycle *Die Schöne Müllerin*. The layout is straightforward, though the structure of the diagram overwhelms its content. Inverting the prominence of the circles and arrows to give the text more space to breathe and setting it in a nonitalic font for better legibility would improve the presentation.

Online Figure 36.2 Stewart Macpherson, *Form in Music with Special Reference to the Designs of Instrumental Music*, new and rev. ed. (London: J. Williams, 1930), 120.



A.	B.	A^2.
1st Subject (Tonic key) leading to 2nd Subject (Dominant, or some other related key).	Presentation of ideas from A under varying conditions of key, rhythm, &c.	1st Subject (Tonic key) leading to 2nd Subject (Tonic key), and possibly a Coda.

The three divisions of Sonata-form.

The three main divisions, A, B, and A^2, are then generally described respectively by the terms Exposition, Development (or Free Fantasia) and Recapitulation.

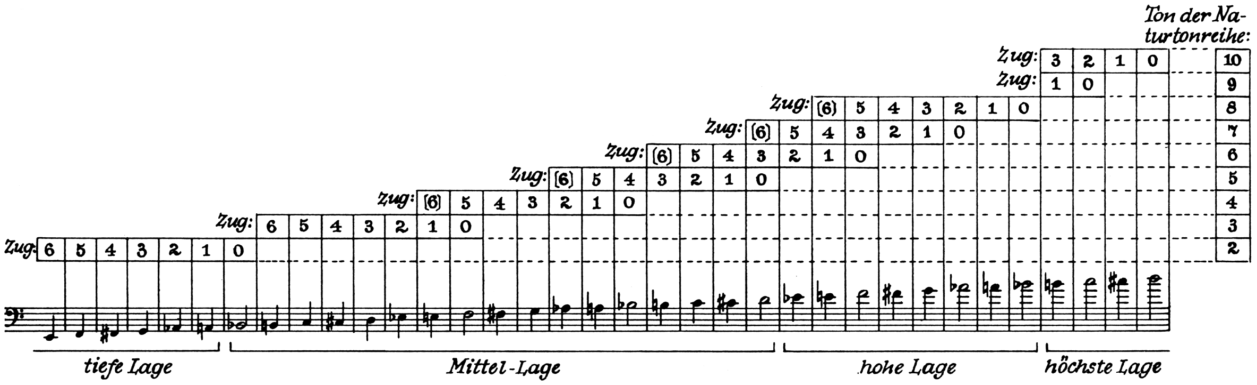
Compared to figure 36.1, this more fleshed-out model of sonata form, which fully embraces the three-part view, not only provides more information but conveys the form's essential features: the tonal contrast within the first section, its resolution in the last section, and the nature of the development section. The combination of horizontal alignment of the big picture and vertical alignment within sections works well. It's just the way newspapers and magazines work, at least in print.

Online Figure 37.4 Robert Morris, *Composition with Pitch-Classes: A Theory of Compositional Design* (New Haven, CT: Yale University Press, 1987), 315 (*above*), 318 (*below*).

This is the most information-rich of the set tables discussed in this chapter. In addition to the name and prime form, the table lists the index number of a set's M-related pair (that is, the set class formed by multiplying each member by 7, mod 12) and explicitly specifies in a dedicated column the index number of a Z-related set if there is one. Next is the interval-class vector, which, unique in this table, includes the instances of interval-class 0, formed by the distance between a pitch class and itself. (This number is redundant with a set's size and has not been adopted in other tables.) Next is a new feature, an invariance vector, which indicates the number of mappings of the set onto itself (in columns 1–4) or its complement (columns 5–8) under Tn, TnI, TnM, and TnMI, respectively. Last is the CINT of a set's prime form, which is simply the distance in semitones between adjacent members, wrapping at the end back to the first member. The table minimizes unnecessary punctuation (except for the curious use of parentheses around the Forte label). The amount of white space between columns makes horizontal scanning tricky, however, and that, plus the amount of information presented, has precluded listing complementary sets adjacent to one another as in the other tables shown. This is unfortunate given the relationship between complementary sets. (Their Forte names are parallel, their interval vectors can be derived from one another mathematically, their M- and Z-related sets are the same, and the first four positions of the invariance vectors are the same.)

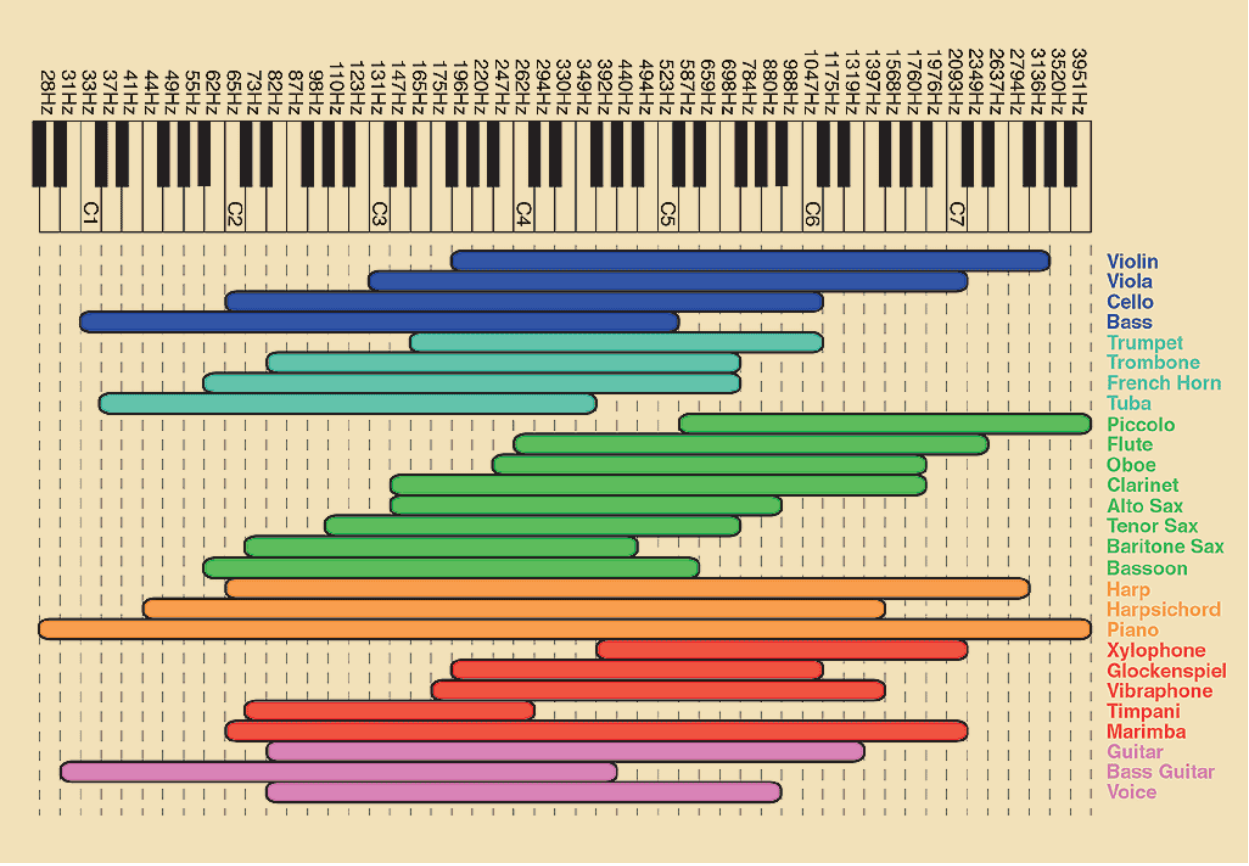
Name (prime form)	M/MI	Z	ICV	Invariance Vector	$CINT_1$
(4-1)[0123]	23		[4321000]	<11005511>	<1119>
(4-2)[0124]	22		[4221100]	<10003411>	<1128>
(4-3)[0134]	26		[4212100]	<11003322>	<1218>
(4-4)[0125]	14		[4211110]	<10001323>	<1137>
(4-5)[0126]	16		[4210111]	<10002432>	<1146>
(4-6)[0127]	6		[4210021]	<11114444>	<1155>
(4-7)[0145]	20		[4201210]	<11003333>	<1317>
(4-8)[0156]	8		[4200121]	<11114444>	<1416>
(4-9)[0167]	9		[4200022]	<22226666>	<1515>
(4-10)[0235]	10		[4122010]	<11113333>	<2127>
(4-11)[0135]	11		[4121110]	<10101313>	<1227>
(4-12)[0236]	27		[4112101]	<10002432>	<2136>
(4-13)[0136]	13		[4112011]	<10012442>	<1236>
(4-14)[0237]	4		[4111120]	<10001323>	<2145>
(4-15)[0146]	29	29	[4111111]	<10000331>	<1326>
(4-16)[0157]	5		[4110121]	<10002432>	<1425>
(4-17)[0347]	17		[4102210]	<11113333>	<3135>
(4-18)[0147]	18		[4102111]	<10012442>	<1335>
(4-19)[0148]	19		[4101310]	<10103535>	<1344>
(4-20)[0158]	7		[4101220]	<11003333>	<1434>
(4-21)[0246]	21		[4030201]	<11116666>	<2226>
(4-22)[0247]	2		[4021120]	<10003411>	<2235>
(4-23)[0257]	1		[4021030]	<11005511>	<2325>
(4-24)[0248]	24		[4020301]	<11116666>	<2244>
(4-25)[0268]	25		[4020202]	<22226666>	<2424>
(4-26)[0358]	3		[4012120]	<11003322>	<3234>
(4-27)[0258]	12		[4012111]	<10002432>	<2334>
(4-28)[0369]	28		[4004002]	<44448888>	<3333>
(4-29)[0137]	15	15	[4111111]	<10000331>	<1245>
(8-1)[01234567]	23		[8765442]	<11000000>	<11111115>
(8-2)[01234568]	22		[8665542]	<10000000>	<11111124>
(8-3)[01234569]	26		[8656542]	<11000000>	<11111133>
(8-4)[01234578]	14		[8655552]	<10000000>	<11111214>
(8-5)[01234678]	16		[8654553]	<10000000>	<11112114>
(8-6)[01235678]	6		[8654463]	<11110000>	<11121114>
(8-7)[01234589]	20		[8645652]	<11000000>	<11111313>
(8-8)[01234789]	8		[8644563]	<11110000>	<11113113>
(8-9)[01236789]	9		[8644464]	<22220000>	<11131113>
(8-10)[02345679]	10		[8566452]	<11110000>	<21111123>
(8-11)[01234579]	11		[8565552]	<10100000>	<11111223>
(8-12)[01345679]	27		[8556543]	<10000000>	<12111123>
(8-13)[01234679]	13		[8556453]	<10010000>	<11112123>
(8-14)[01245679]	4		[8555562]	<10000000>	<11211123>
(8-15)[01234689]	29	29	[8555553]	<10000000>	<11112213>
(8-16)[01235789]	5		[8554563]	<10000000>	<11122113>
(8-17)[01345689]	17		[8546652]	<11110000>	<12111213>
(8-18)[01235689]	18		[8546553]	<10010000>	<11121213>
(8-19)[01245689]	19		[8545752]	<10100000>	<11211213>
(8-20)[01245789]	7		[8545662]	<11000000>	<11212113>
(8-21)[0123468A]	21		[8474643]	<11110000>	<11112222>
(8-22)[0123568A]	2		[8465562]	<1000000>	<11121222>
(8-23)[0123578A]	1		[8465472]	<11000000>	<11122122>
(8-24)[0124568A]	24		[8464743]	<11110000>	<11211222>
(8-25)[0124678A]	25		[8464644]	<22220000>	<11221122>
(8-26)[0134578A]	3		[8456562]	<11000000>	<12112122>
(8-27)[0124578A]	12		[8456553]	<10000000>	<11212122>
(8-28)[0134679A]	28		[8448444]	<44440000>	<12121212>
(8-29)[01235679]	15	15	[8555553]	<10000000>	<11121123>

Online Figure 38.3 Hermann Erpf, *Lehrbuch der Instrumentation und Instrumentenkunde* (Mainz: Schott, 1959), 131.



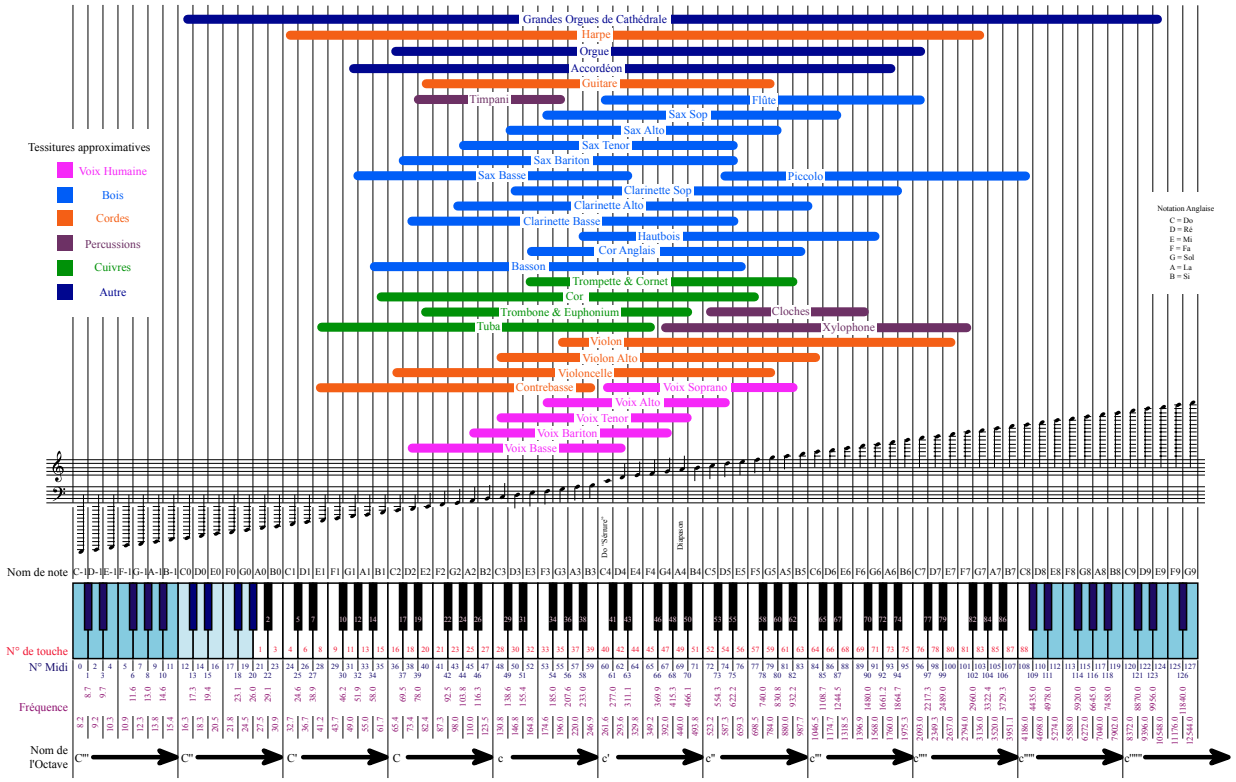
From the same source as figure 38.2, this image provides the various combinations of partial and slide position that can be used to produce each note on the tenor trombone. (In the US, slide positions are normally counted one through seven, not zero through six.) The difficult-to-reach sixth position appears parenthetically, as a warning that it should be used with caution. Although some kind of grid is needed to keep horizontal and vertical alignment clear, something less prominent would suffice.

Online Figure 38.5 Mike Senior and Paul White, "Understanding Instrument & Voice Frequency Ranges," Sound on Sound, August 2001, https://www.soundonsound.com/techniques/using-eq.



This image is more effective than figure 38.4. Instruments are grouped more clearly by family, and the families are rendered in strong, highly contrasting colors. The contrast between information (thick, color) and grid (thin, dashed, gray) is clear. Unfortunately, the gridlines connecting range and keyboard are not differentiated, so one must traverse them carefully to make sure where they lead, particularly for those instruments toward the bottom of the image. It would help to render the lines for at least the Cs in a contrasting color or to include a dividing line at each C within the colored bars. This image's lack of a link between the ranges and pitches on the staff is also a weakness. Finally, the frequency of each pitch is not generally useful information, though there is no harm in including it.

Online Figure 38.6 *Above*, Charles Houghton-Webb, "Tableau des Tessitures," BW Music, accessed June 7, 2017, https://bwmusic.com/range.php; *below*, partial redrawing.



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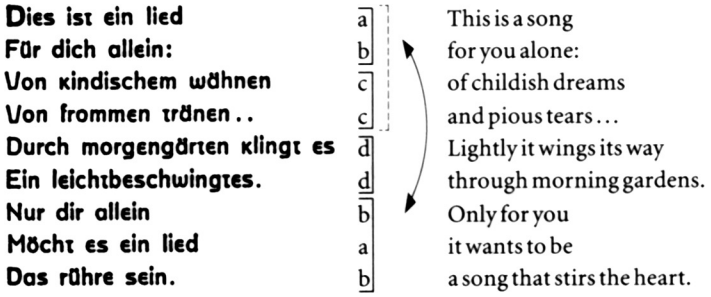
Les touches en noir et blanc indiquent la tessiture d'un piano de concert. Celles en bleu clair se trouvent sur un clavier étendu tel celui du Bosendorfer Model 290 "Imperial" Grand Concert.

The excellent image above presents clearly a rich array of information. It features a ten-and-a-half-octave keyboard, which is wide enough to cover the full possible 128-note range supported by the MIDI standard. Keys not found on any piano are in dark blue, while keys found only rarely (as on the Bösendorfer Imperial piano) are in light blue. For each key, the image gives the American Acoustical Society (AAS) name, the MIDI number, and the frequency, as well as its notation on the grand staff. As one moves toward the ends, the notation becomes less and less useful as the number of ledger lines grows. The alternative octave designations at the bottom of the image are useful, though the arrows are weighted much more heavily than necessary.

However, the instrument ranges shown in the upper half are the main point of the image. As in online figure 38.5, different instrument families appear in different

colors. They are almost arranged in score order, except that timpani are separated from their percussion partners, which appear on the same lines as the low brass; the piccolo shares a line with the bass saxophone rather than being listed above the flute; and the *Grande Orgue de Cathèdrale* reigns at the very top. Also as in figure 38.5, the undifferentiated vertical lines make it hard to trace the ends all the way down to the notes. In fact, in this case the information resides in the white space between the lines. The instrument names appear in the same color as the range bars, which is acceptable, though some of the text is harder to read in these colors than it would be in black. It is not always clear why an instrument name lies in a particular place relative to its range bar. It appears, as in the case of the strings, that the designer tried to keep the instrument names near one another, with the same left-to-right ordering that reflects the ordering of ranges. It would be better to center the text horizontally within each bar. The breaking of the bars into two pieces contributes to a sense of busyness the image does not need. This modest adjustment reduces the number of objects there threefold: each instrument's left bar, name, and right bar are replaced by a single bar with a label: 

Online Figure 39.2 Robert W. Wason, "A Pitch-Class Motive in Webern's George-Lieder, op. 3," in *Webern Studies*, ed. Kathryn Bailey, 111–34 (Cambridge: Cambridge University Press, 1996), 114.



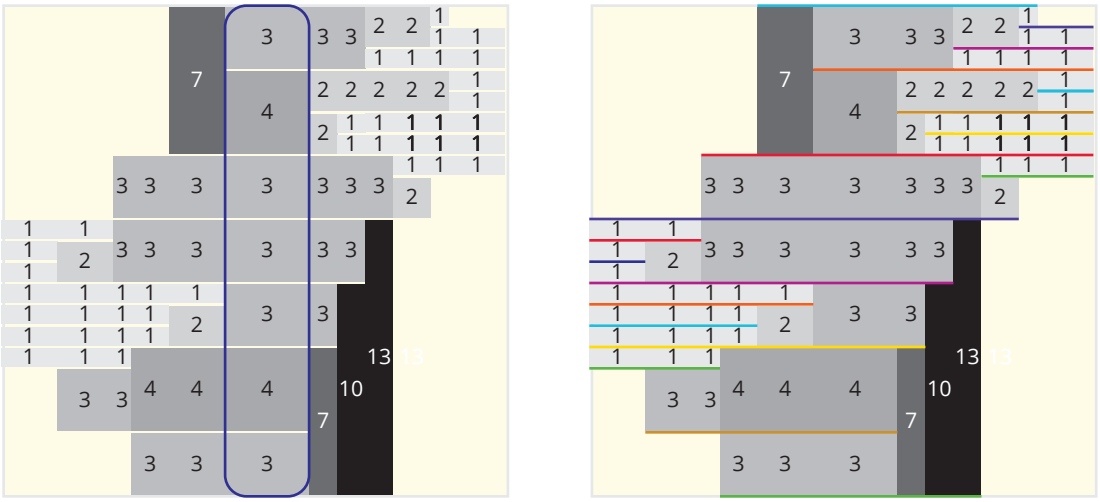
This text reproduces the source poem in its original form and appropriately aligns text and translation side by side. It would be better if the final "a song" was on the line above, to parallel "ein lied" in the original. Putting the rhyme scheme between the original and translation works better than if it were on either the left or the right.

Online Figure 40.3 Michael Klein, "Texture, Register, and Their Formal Roles in the Music of Witold Lutosławski," *Indiana Theory Review* 20, no. 1 (1999): 52.

Timbre	Pitch material
winds	3↑ <7, 9, 0, 2, 4, 6, 8, 9, E, 1, 3, 5, 8, T> 2- 3- 2- 2- 2- 2- 1- 2- 2- 2- 2- 3- 2
brass	4↑ <7, 8, 9, T> 1- 1- 1
pianos	1↑ <E, 3, 0, 4, 1, 5, 2, 6> 4- 9- 4- 33- 4- 9- 4 (9)
winds, brass, pianos	1↑ <E, 3, 0, 4, 7, 9, 0, 2, 4, 6, 7, 8, 9, T, E, 1, 3, 5, 8, T, 1, 5, 2, 6> 4- 9- 4- 3- 2- 3- 2- 2- 2- 1- 1- 1- 1- 1- 2- 2- 2- 3- 2- 3- 4- 9- 4

As in figures 40.1 and 40.2, the representation of the intervals making up the chords in Lutosławski's *Jeux Venitiens*, movement 1, does not make the chords' symmetry pop off the page. The eye needs to scan back and forth from one end to the other to compare corresponding elements. For the last row, the length of the list of numbers requires the fingers to get involved.

Online Figure 40.5 Two rerenderings of figure 40.4 (colorplate 10), Lutosławski's *Jeux Venitiens*, B section, cluster transposition.



These images represent more accurately the route by which the B section's first eight-note cluster reaches its second, as the voices are transposed one by one, in some cases with an intervening pitch. The left image uses the same grayscale mapping as used in the odd-lettered sections in figure 40.4 (colorplate 10): smaller intervals are lighter gray, except that the two largest intervals are both rendered in black. The path along which the T_9 transformation takes place is anything but smooth. The original is superior as a high-level synopsis, but this rendering is accurate and has a fun little surprise: right in the middle, the strings briefly pass through a sonority (see the blue box) that has exactly the same spacing as the sonority coming up in the also very brief section F.

The interval pattern appears so messy in part because it arises from a crisscrossing of parts that is not expressed here. Color-coding the parts as in the right image doesn't help clarify things, unfortunately.

Online Figure 41.4 Bryan R. Simms, *The Atonal Music of Arnold Schoenberg, 1908–1923* (New York: Oxford University Press, 2000), 99.

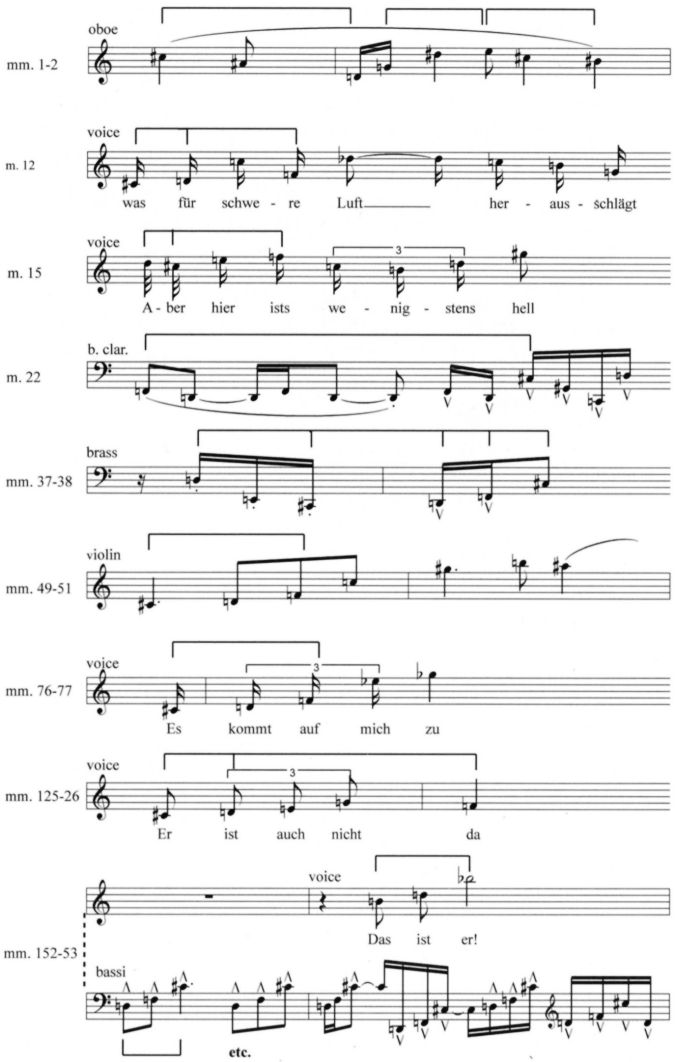
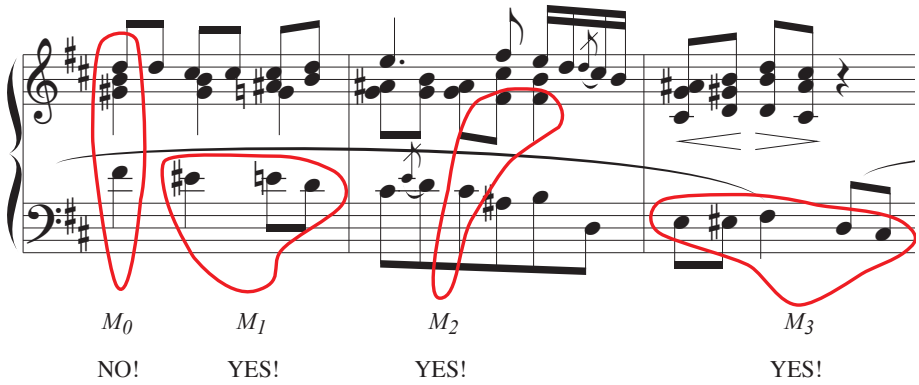
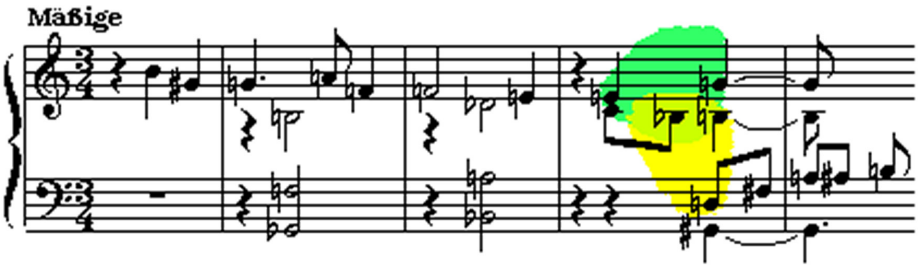


Figure 41.3 showed that segmentation indicated by brackets can be ambiguous. When one does use brackets, however, it's important to do so consistently. This image identifies (014) trichords in melodic fragments in Arnold Schoenberg's *Erwartung*. Brackets with only two legs encompass all the pitches within their bounds, while those with three or more legs reference only the pitches pointed to by those legs and skip those without. The inconsistency leads to confusion, not to mention that the triplet figures are also marked by brackets, which are entirely unconnected to the analysis.

Online Figure 41.9 *Above*, Guerino Mazzola, Stefan Göller, and Stefan Müller, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhauser, 2002), 119; *below*, screenshot of Tim Smith, "Animated Analysis of Schoenberg, *Klavierstück*, op. 11, no. 1" (1997), accessed June 22, 2012, URL lost.

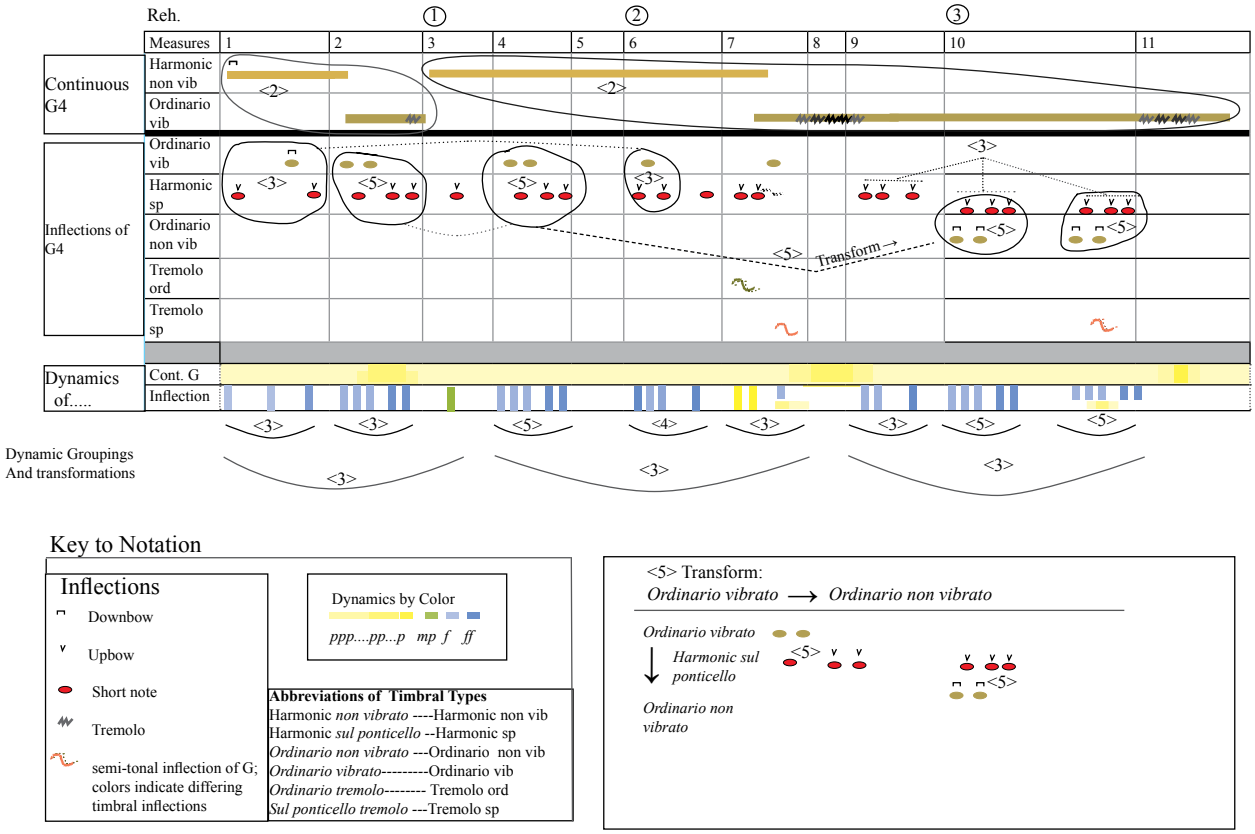




A monochrome version of the upper image appeared in figure 1.2 to illustrate the pop-out effect of curved lines. Here, the addition of a contrasting color greatly enhances the effect.

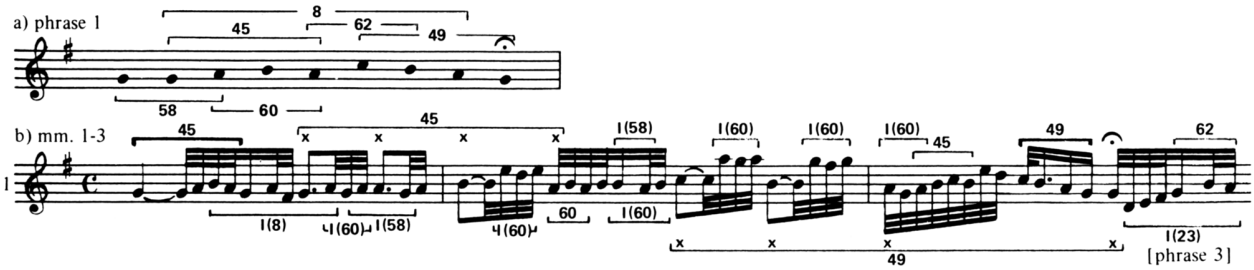
Below is one frame from an animated GIF that traces (014) set types as they unfold in order in the opening measures of Arnold Schoenberg's *Piano Piece*, op. 11, no. 1. Color distinguishes "regular" (yellow) and inverted (green) versions of (014). In general, the colored segment lines in the upper image are easier on the eyes, but the use of filled shapes in the lower image help to distinguish overlapping segment and segment types. The shading is more intense than necessary, however. In general, line drawings should use well-saturated colors while filled shapes should use less-saturated colors.

Online Figure 41.10 Judith Lochhead, "'Difference Inhabits Repetition': Sofia Gubaidulina's String Quartet no. 2," in *Analytical Essays on Music by Women Composers: Concert Music, 1960–2000*, ed. Laurel Parsons and Brenda Ravenscroft, 102–26 (New York: Oxford University Press, 2016), 110.



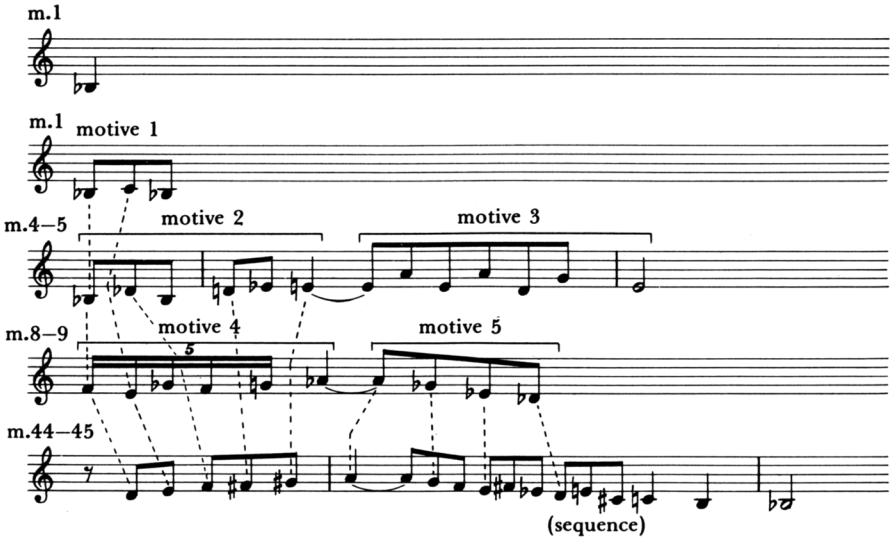
This image uses rounded enclosures to highlight recurring patterns in an analysis laid out with great effectiveness in table form. The analysis is information rich and clearly structured. The annotations break out of the constraints of the grid. That, together with the selective merging of cells, helps the grid recede into its appropriate supporting role.

Online Figure 42.2 Alexander R. Brinkman, "The Melodic Process in Johann Sebastian Bach's *Orgelbüchlein*," *Music Theory Spectrum* 2 (1980): 68.



This image is from a study of the relationship of Bach's chorale preludes to the cantus firmi on which they are based. *Above*, brackets mark segments of a phrase from the cantus firmus, with numeric labels drawn from a motive inventory developed in the larger study. *Below*, instances of these motives that can be found in the corresponding chorale prelude phrase are similarly marked. The labeling system is intuitive, and the brackets are close enough to the music to make it clear which notes are enclosed. Two minor adjustments would improve the image: One is consistency in the placement of motive numbers above or below the bracket, as in 45 and 58 in the upper example, or within the bracket, as in 7, 60, 62, and 49. The former is better. A second involves the labeling of inverted motive forms. The convention I (. . .), derived from mathematical language ("I of 60") visually draws attention away from the motive number, which would retain its central focus with use of a superscript (60^{INV}) or just a prime symbol (60′). Finally, when a motive is composed out (as in segments 45 and 49), a dot (•) to mark pitches corresponding to the cantus firmus would pop out more than the *x* does.

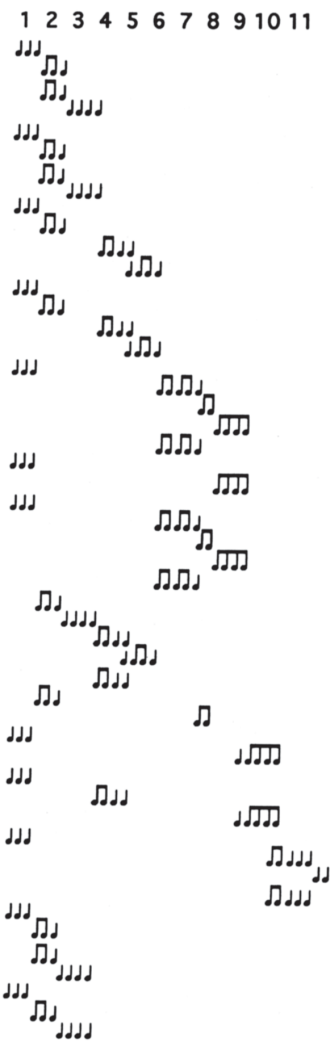
Online Figure 42.5 Mary Wennerstrom, "Form in Twentieth-Century Music," in *Aspects of Twentieth-Century Music*, ed. Gary E. Wittlich, 1–65 (Englewood-Cliffs, NJ: Prentice-Hall, 1975), 25.

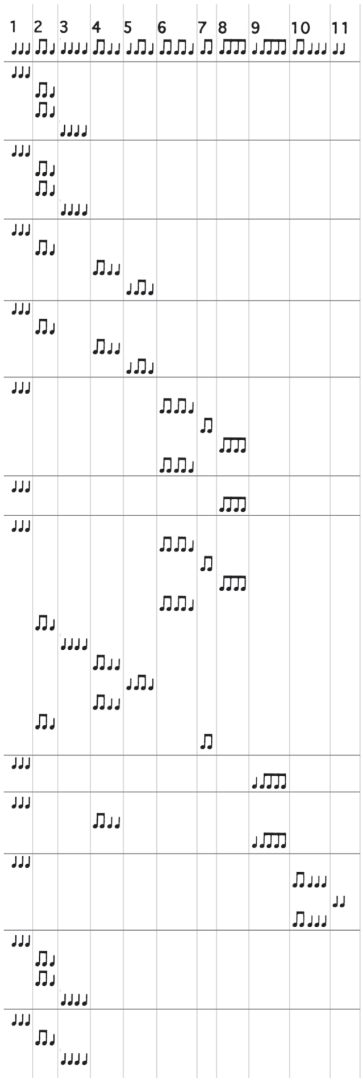


Similar to figure 42.4, this image shows how pitches of a melodic line in measures 44–45 can be derived from earlier material in the movement. (In the last system, the lines leading to the first two notes were likely intended to pass around rather than through the first two notes of the system directly above.) Dashed lines provide visual contrast with the musical notation and make the correspondences easy to follow. On the other hand, because these correspondences are the primary point of the image, marking them more prominently would be justified.

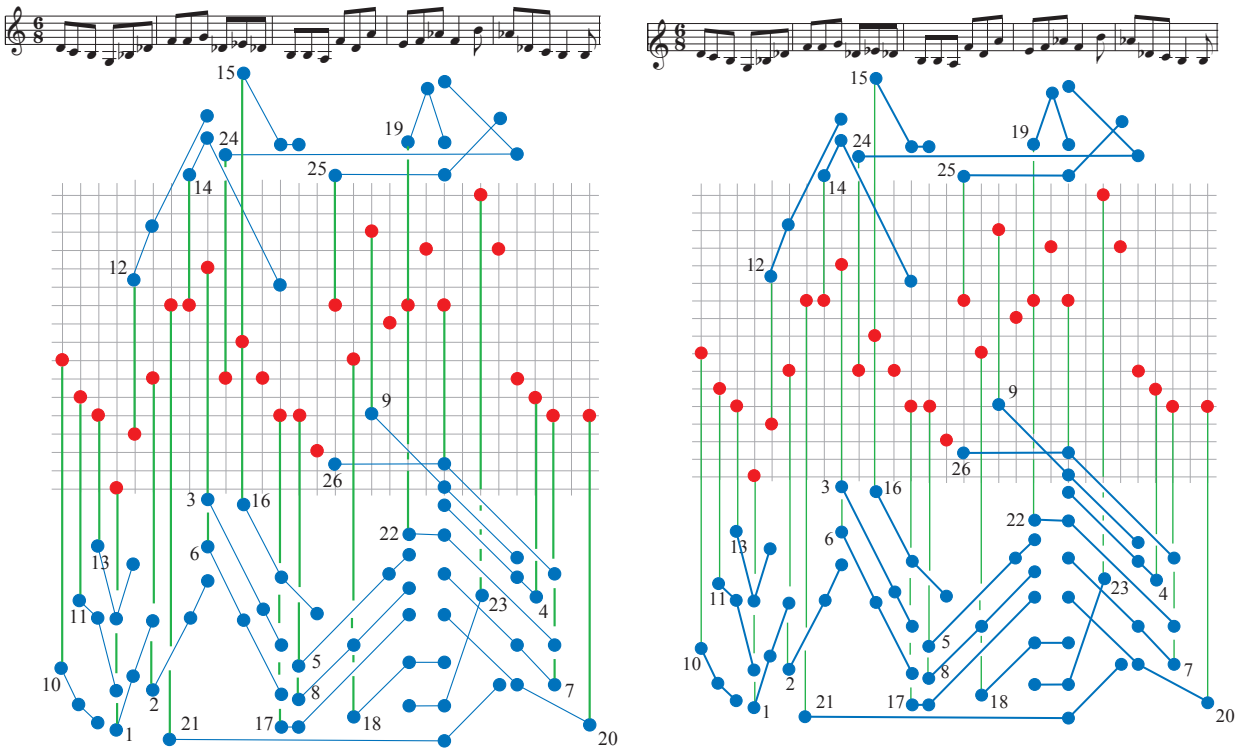
Online Figure 42.7 *Left*, Eero Tarasti, *A Theory of Musical Semiotics* (Bloomington: Indiana University Press, 1994), 219; *right*, redrawing.

The image on the left ingeniously traces motives in the Promenade of Modest Mussorgsky's *Pictures at an Exhibition*, a movement with a great deal of motivic unity. The music reads from top to bottom. Fifty-one rhythmic figures express eleven rhythmic paradigms. One can easily assess the recurrence of patterns by scanning the length of the image, particularly the nearly regular statements of the opening ♩♩♩ motto; the clustering of motives 2–5 in the beginning, middle, and end of the piece; and the contrast of motives 6–8 in a second section and of 9–11 in the fourth. Although the vertical alignment of identical figures provides its own grid, the image's height makes it hard to link figures near the bottom with the motive numbers at the top. The gentle redrawing on the right collates the figures, legend-like, at the top of the image; spaces the columns proportionally to the width of the rhythmic figures; and adds thin gray lines to separate them. To help organize the vertical space, darker gray lines appear above each recurrence of the opening figure.



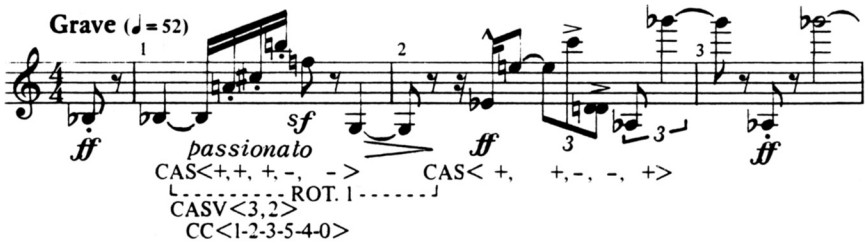


Online Figure 42.8 *Left*, Guerino Mazzola, Stefan Göller, and Stefan Müller, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhauser, 2002), 270; *right*, redrawing.



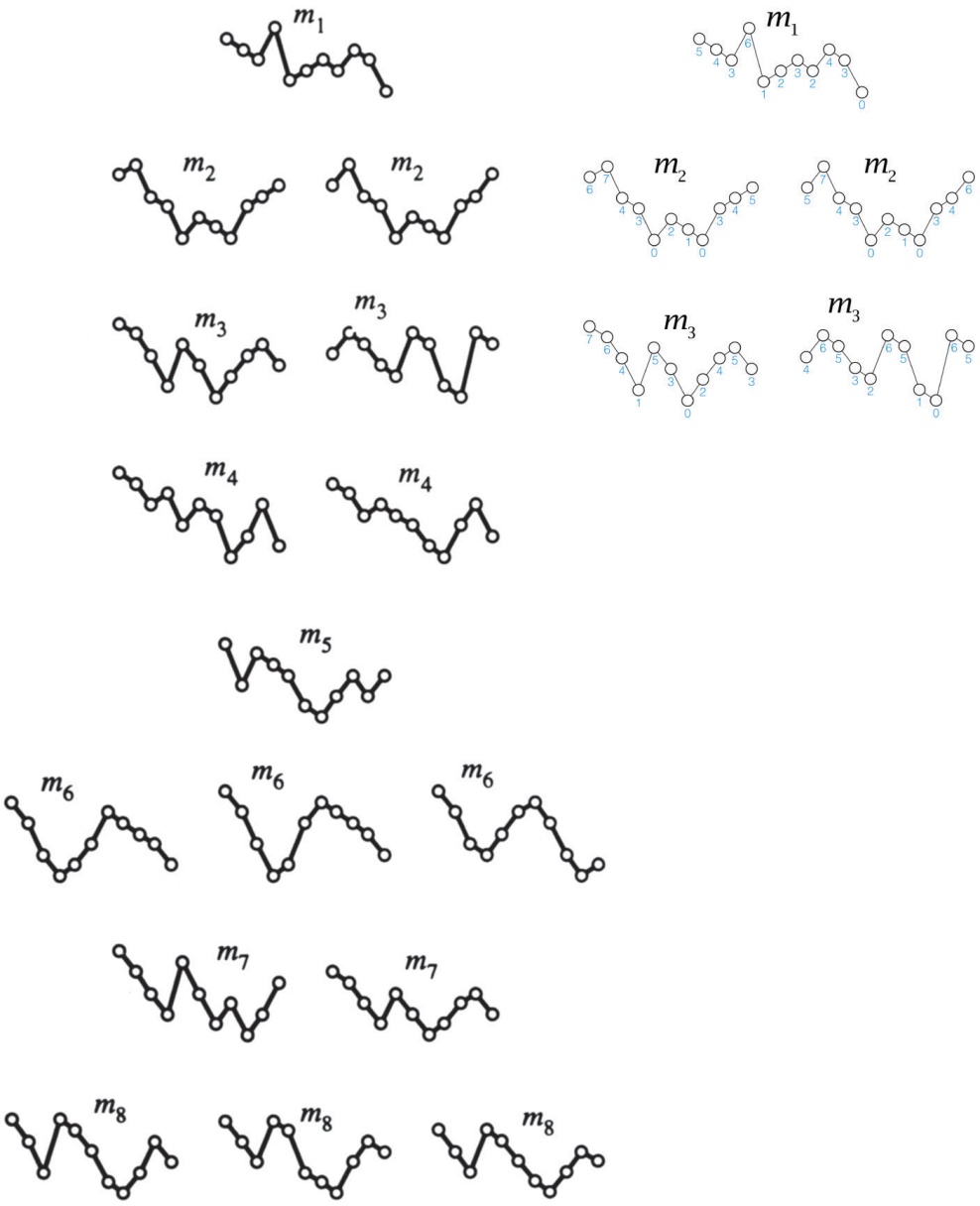
The figure on the left presents a melody designed to realize instances of twenty-six different three-element motive classes. Red dots map the pitches onto a grid that represents semitones vertically and eighth notes horizontally. (It would be preferable for the notes on the staff to align more precisely with the grid.) Most of the notes are then connected to one end of one or two three-note motives. The numeric labels reference a list of motive classes not included here. The motives are plotted on the same conceptual grid but are not tied to a reference point. Their vertical and horizontal positions relative to one another are therefore not meaningful. The image thus arranges the motives compactly, while preserving their individual identities. The design is highly effective. Dots of contrasting colors represent different elements. The gray grid remains distinct from the thicker green vertical lines that link musical surface to motive class and from the thin blue lines that connect the elements of each motive. The blue lines, which express motivic contour, are more important than the green lines, which are simply connectors. The changes in the redrawing on the right are subtle but significant. The blue lines that create the motives are thicker than the green lines to better convey the image's message.

Online Figure 43.2 Michael L. Friedmann, "A Methodology for the Discussion of Contour: Its Application to Schoenberg's Music," *Journal of Music Theory* 29, no. 2 (1985): 225.



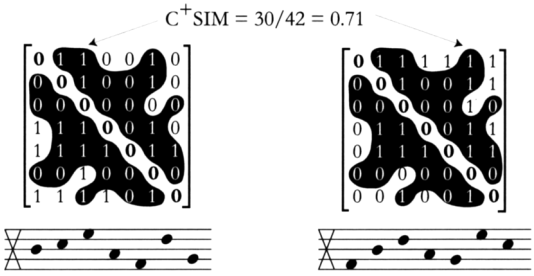
The contour adjacency series (CAS) indicates whether each pitch in a melody is higher (+) or lower (–) than the previous one. It is a mathematical rather than a visual representation. Because only the note-to-note direction is measured, the overall shape of a melody cannot be read and a more visually oriented version is impossible. The contour class is equivalent to the contour segment discussed in connection with figure 43.3.

Online Figure 43.4 *Left*, Ian Quinn, "Fuzzy Extensions to the Theory of Contour," *Music Theory Spectrum* 19, no. 2 (1997): 236; *right*, redrawing of the upper portion.



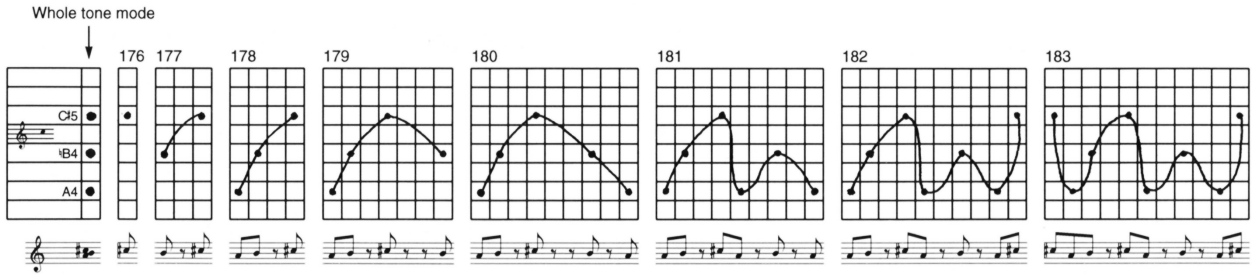
The representation in the image on the left is based on the same principle as the one in figure 43.3, but it uses circles rather than just inflection points to represent contour pitches. This alleviates the problem of the disappearing passing note. The omission of numbers allows the eye to focus on the melodic shapes. However, the partial redrawing on the right shows that adding numbers in a light typeface with a contrasting color makes it possible to see both the large-scale similarities of the motives within a family (m2 and m3) and the details of their differences.

Online Figure 43.5 Ian Quinn, "The Combinatorial Model of Pitch Contour," *Music Perception* 16, no. 4 (1999): 448.



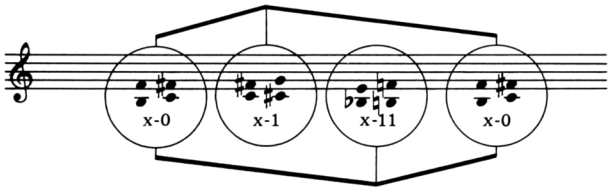
This image provides a visually effective way of representing where equal entries occur in two comparison (COM) matrices as described in figure 43.3. The larger the shaded area, the more similar the contours. The two blobs facing each other across the image are duplicates and one could easily be omitted. The black fill is intense; a lighter gray with a slightly darker outline would accomplish the same thing.

Online Figure 43.9 Erik Christensen, *The Musical Timespace: A Theory of Music Listening* (Aalborg: Aalborg University Press, 1996), 2:33.



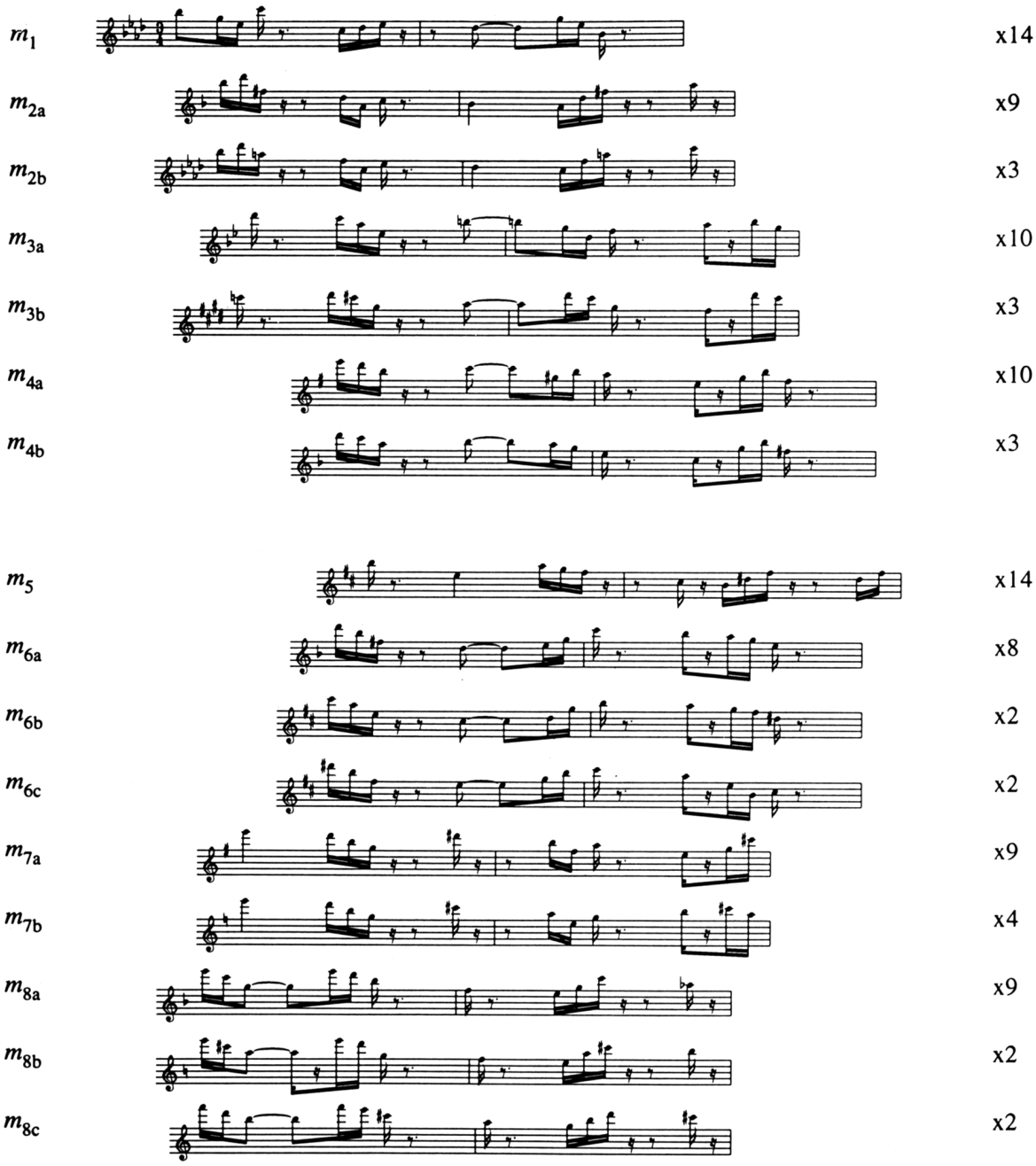
This image uses a gestural representation of contour, in which a small-multiple format illustrates the melodic construction process found in many of Steve Reich's works from the 1980s (this one is from *Music for 18 Musicians*). Event and connector are adequately distinguished from each other, though it would be better if the curved lines were thinner and gray to increase the contrast. The use of curved lines rather than straight lines invites us to hear the music as physical gesture rather than mechanical motion. The grid should be greatly minimized.

Online Figure 43.13 Charles Burkhart, "The Symmetrical Source of Webern's Opus 5, no. 4," in *The Music Forum*, ed. Felix Salzer and Carl Schachter, 5:317–34 (New York: Columbia University Press, 1980), 320, excerpt.



The use of angled beams projects symmetrical 0–1-0 and 0–11-0 contours. A similar approach would benefit figure 43.12.

Online Figure 43.15 Ian Quinn, "Fuzzy Extensions to the Theory of Contour," *Music Theory Spectrum* 19, no. 2 (1997): 234.



Melodies from Steve Reich's *The Desert Music*, which form the basis of the analysis in figure 43.14. Many of the melodic figures are rhythmic rotations of the previous one, and the example (roughly) aligns corresponding rhythms, making these correspondences clear. See chapter 42.

Online Figure 44.3 Redrawing of fig. 44.2.

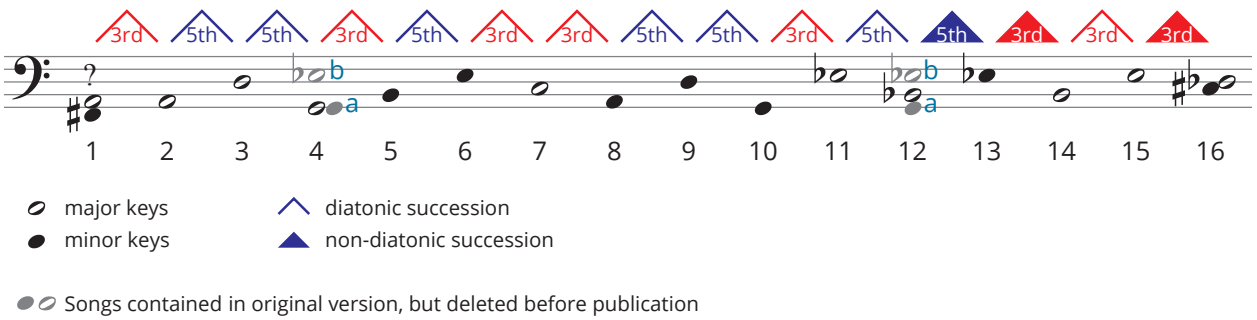
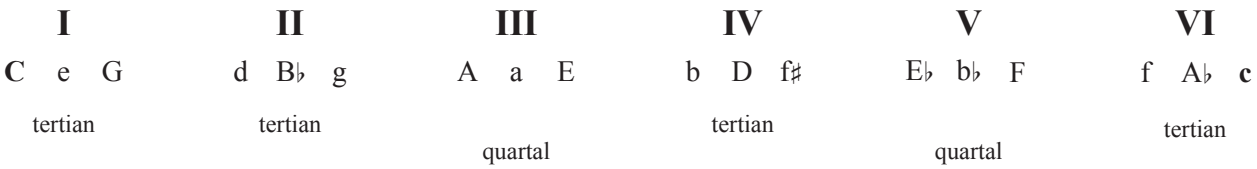


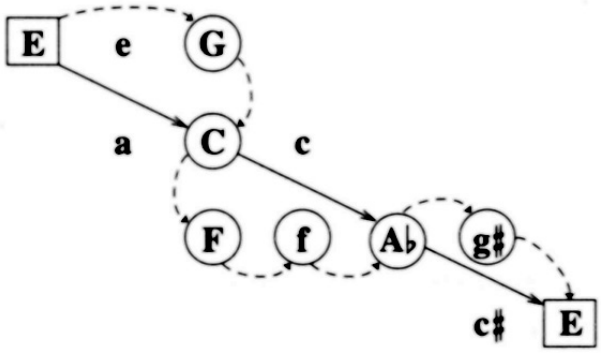
Figure 44.2 showed the keys of the songs in Robert Schumann's *Dichterliebe*. In this redrawing, key centers are rendered on a staff, which for trained musicians makes those relationships more immediate than simply naming the keys does. Intervallic relations between keys, which in the original were described only in the caption, appear directly on the image. Because the image uses only two interval types, the color-coding of these intervals reveals the rough balance between the interval types. Shading of nondiatonic successions shows how these cluster at the end of the cycle. Contrasting noteheads mark major and minor keys, while keys of songs that were not part of the published version appear in gray.

Online Figure 44.5 Redrawing of fig. 44.4.



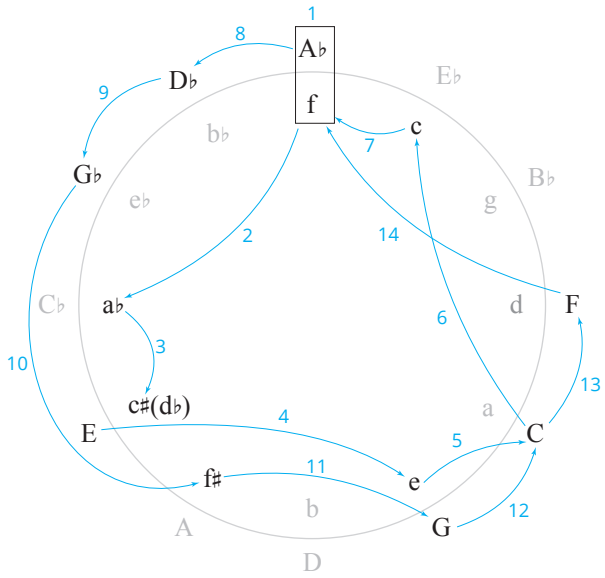
This redrawing of figure 44.4 eliminates all of its lines. Decreasing the white space between the keys *within* sonatas and increasing the white space *between* sonatas allows for removal of the lines between roman numerals and key plans. Rendering the roman numerals that count the sonatas in a larger, bold font increases the effect. The return of a C tonality in the last movement is conveyed simply by making the boundary Cs bold. Finally, using the legend's information at the point of need, centered below each sonata, eliminates the need for the legged brackets and legend. Placing the types of tonal relation at different heights is more than sufficient to show where they occur.

Online Figure 44.7 Fred Lerdahl, *Tonal Pitch Space* (New York: Oxford University Press, 2001), 95.



This image traces harmonic motion in Frédéric Chopin's Prelude in E Major through the Chart of Regions. As in online figure 17.9, the linkage between a schematic harmonic model and a path through it in a work helps legitimize both by making the music appear coherent and the model relevant.

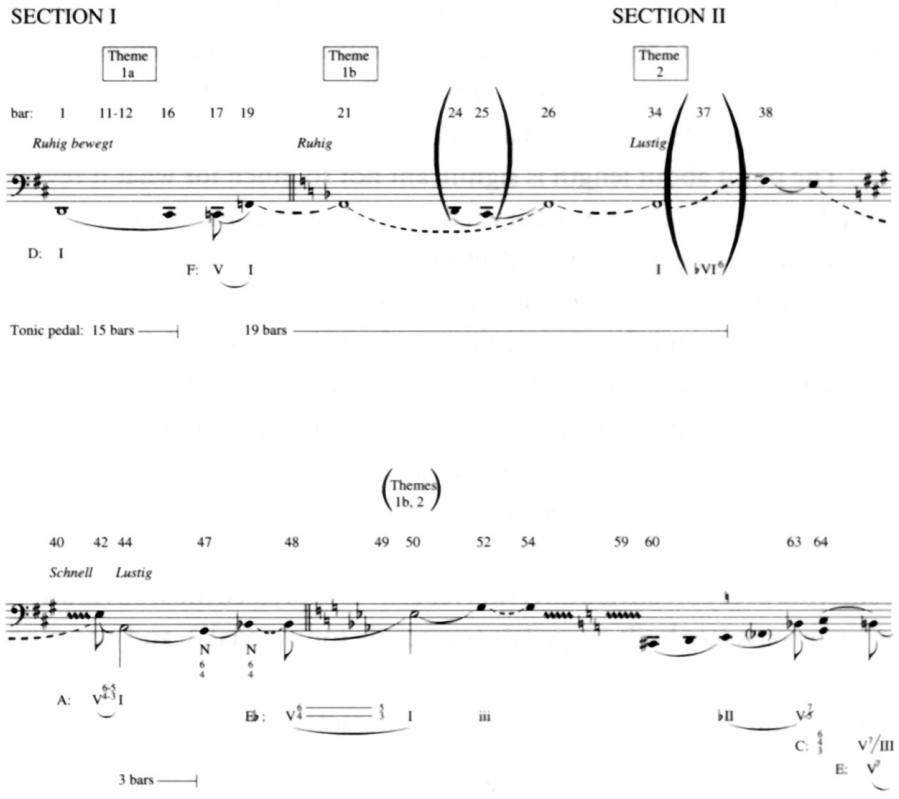
Online Figure 44.9 Redrawing of fig. 44.8.



This gentle redrawing of figure 44.8 lets the excellent design of the original better serve its purpose. The redundant concentric circles are eliminated, and the remaining one, still useful to convey the image's fundamental circularity, recedes to the background. Elimination of the concentric circles has allowed names of relative keys to be closer together than in the original. The redrawing retains keys that are not visited, since they complete the pitch space within which the music is being analyzed, but they join the circle in the background. The arrows tracing the paths of keys have been moved to another information layer through the use of color (cyan is often effective for this) and have been made thinner. Additionally, any time they are contained within or cross the background circle, they curve in the opposite direction of the circle for greater contrast. The numbers are retained because they help viewers follow the sequence of steps and particularly help clarify different departures from the same pitch (such as the C in the lower right). They are set in a sans serif font that matches the color of the arrows. The color change makes it possible to do without the circles of the original.

Not addressed here is that the image does not show where these key centers occur, either within the piece's sonata form structure or by measure number. It therefore fails to convey how the key centers function or how extensive or fleeting they are.

Online Figure 44.10 Derrick Puffett, "Gone with the Summer Wind; or, What Webern Lost," in *Webern Studies*, ed. Kathryn Bailey, 32–73 (Cambridge: Cambridge University Press, 1996), 44.

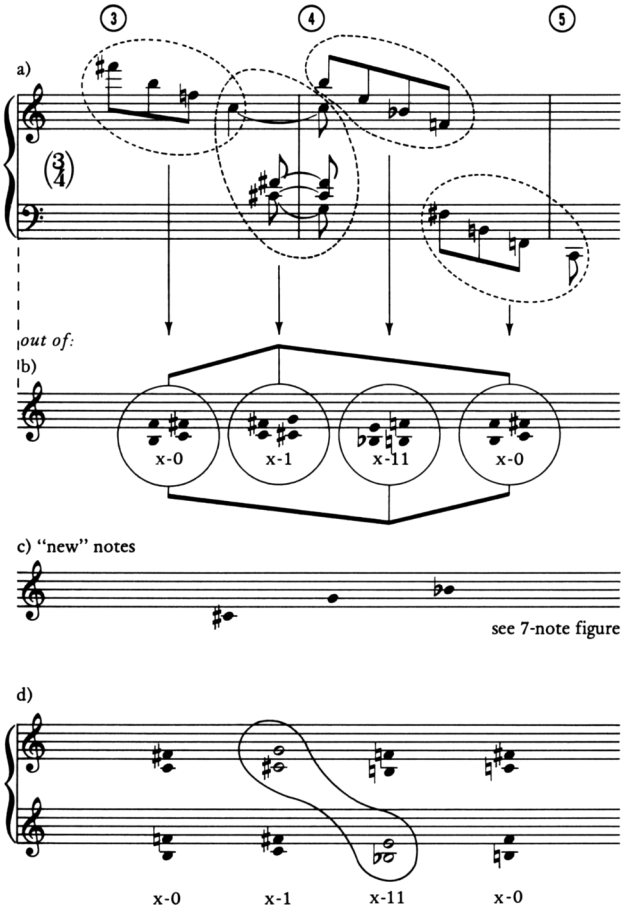


This excerpt of a larger image presents a tonal/harmonic analysis of Anton Webern's early (1904) orchestral work *Im Sommerwind*. The primary emphasis of this image is a bassline reduction (employing a quasi-Schenkerian notation that I will not assess here), accompanied by harmonic analyses of most of the chords. Implied keys are indicated throughout using a conventional representation in which the name of a key precedes roman numerals for chords that the image interprets in that key. When a new key is implicated, it appears one line lower than the previous key shown within that system. Labels for chords that function in both previous and new keys are aligned vertically. The notation is clear and efficient.

A number of other features make the image information rich. Small bar numbers above the staff help locate most of the notes in the score (the layout is not proportional, however, and since the full figure accounts for 253 measures across eight systems, a proportional representation would be unwieldy). Italicized performance markings link the image to the music itself, of particular use to those who know the work and can use the representation as a further reminder of the full musical texture.

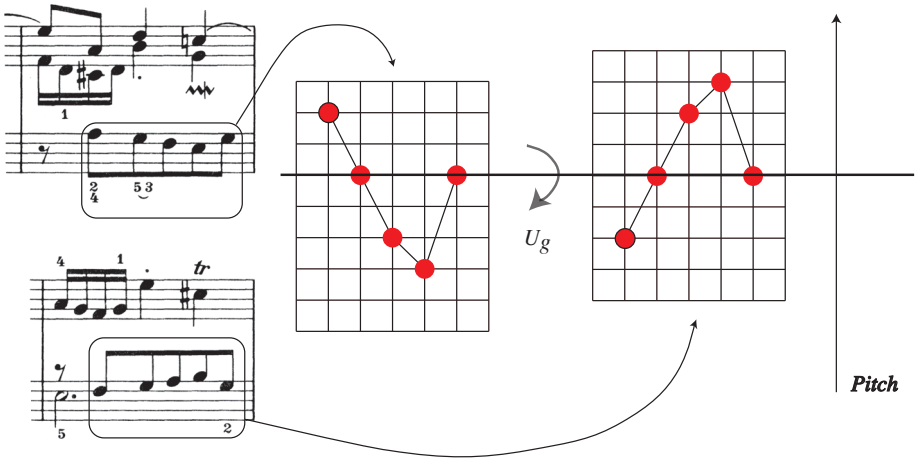
New themes are listed in boxes when they occur and in large parentheses if they recur. The boxes are informationally vacuous, but their unique shape within the image allows for rapid scanning to locate them in the image. Major section divisions are indicated consistently above the staff in all caps. Only the oversized parentheses are visually out of balance, and their size makes them anything but parenthetical.

Online Figure 45.4 Charles Burkhart, "The Symmetrical Source of Webern's Opus 5, No. 4," in *The Music Forum*, ed. Felix Salzer and Carl Schachter (New York: Columbia University Press, 1980), 5:320.



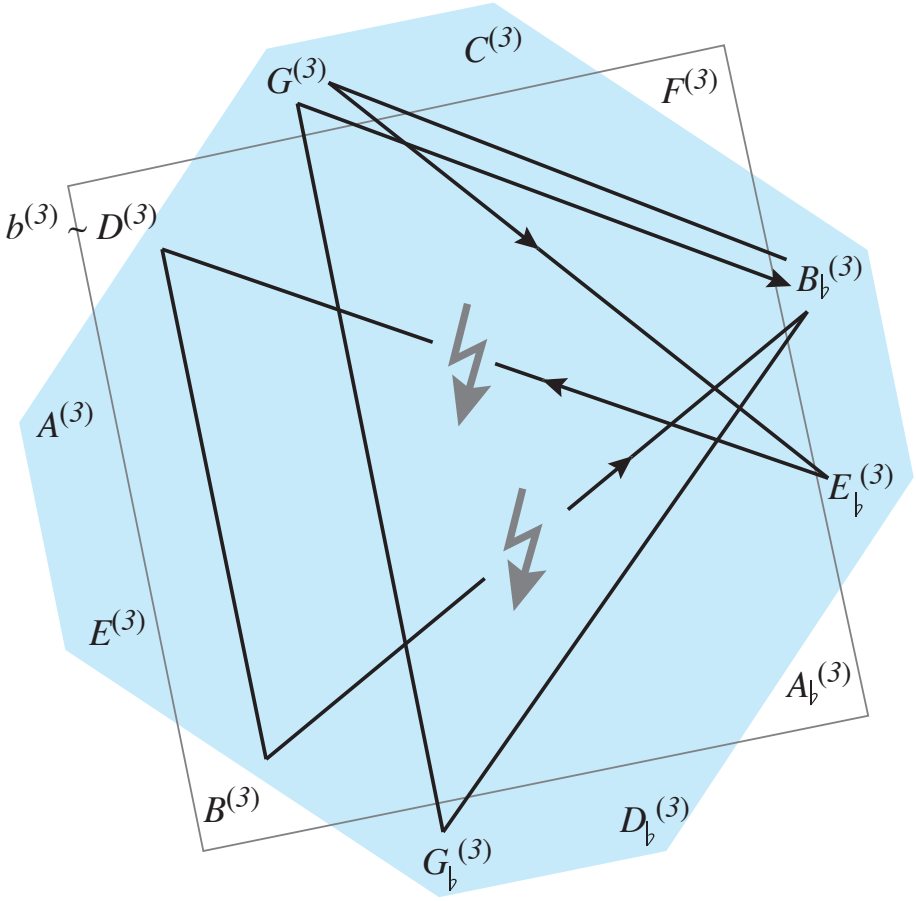
This image posits a symmetrical structure underlying the opening measures of Anton Webern's *Five Movements for String Quartet*, op. 5, no. 4. The pitch-class content of the last chord repeats that of the first. Relative to these, the two intervening chords are respectively a half step higher and lower. The image proposes hearing these as forming symmetrical upper- and lower-neighbor figures with the boundary chords. An angled beam makes the proposed symmetry immediately apparent. The axis of symmetry is clear.

Online Figure 45.5 Guerino Mazzola, Stefan Göller, and Stefan Müller, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhauser, 2002), 141.



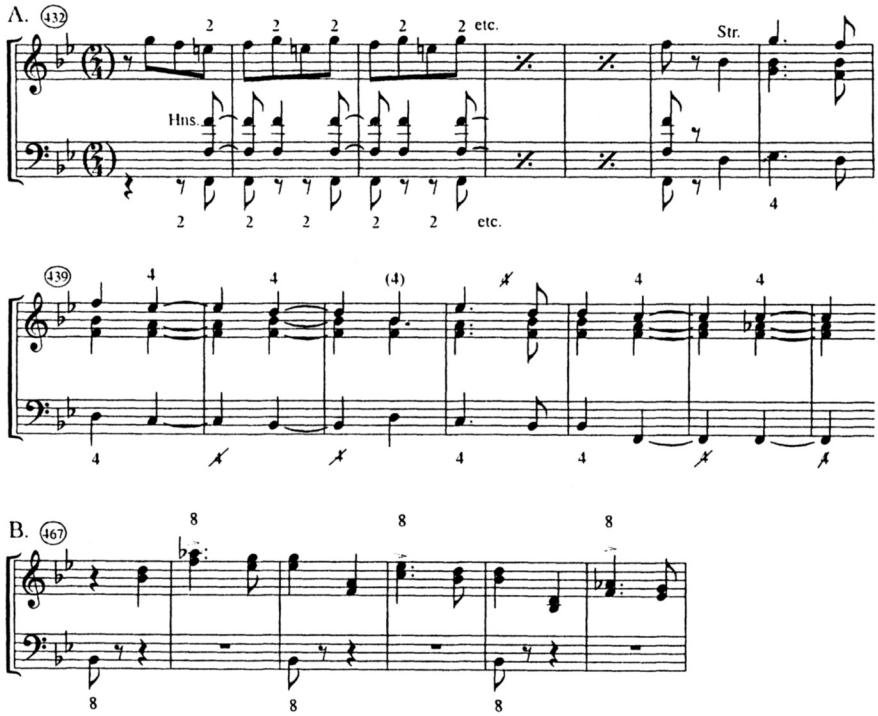
Symmetry can be shown in graphical form as here, where the inversional axis appears in a darker line. The only advantage this has over staff notation is that the whole and half steps are clearer (in the lower musical figure, the fourth note in the circled tenor line should be a B♭).

Online Figure 45.6 Guerino Mazzola, Stefan Göller, and Stefan Müller, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhauser, 2002), 607.



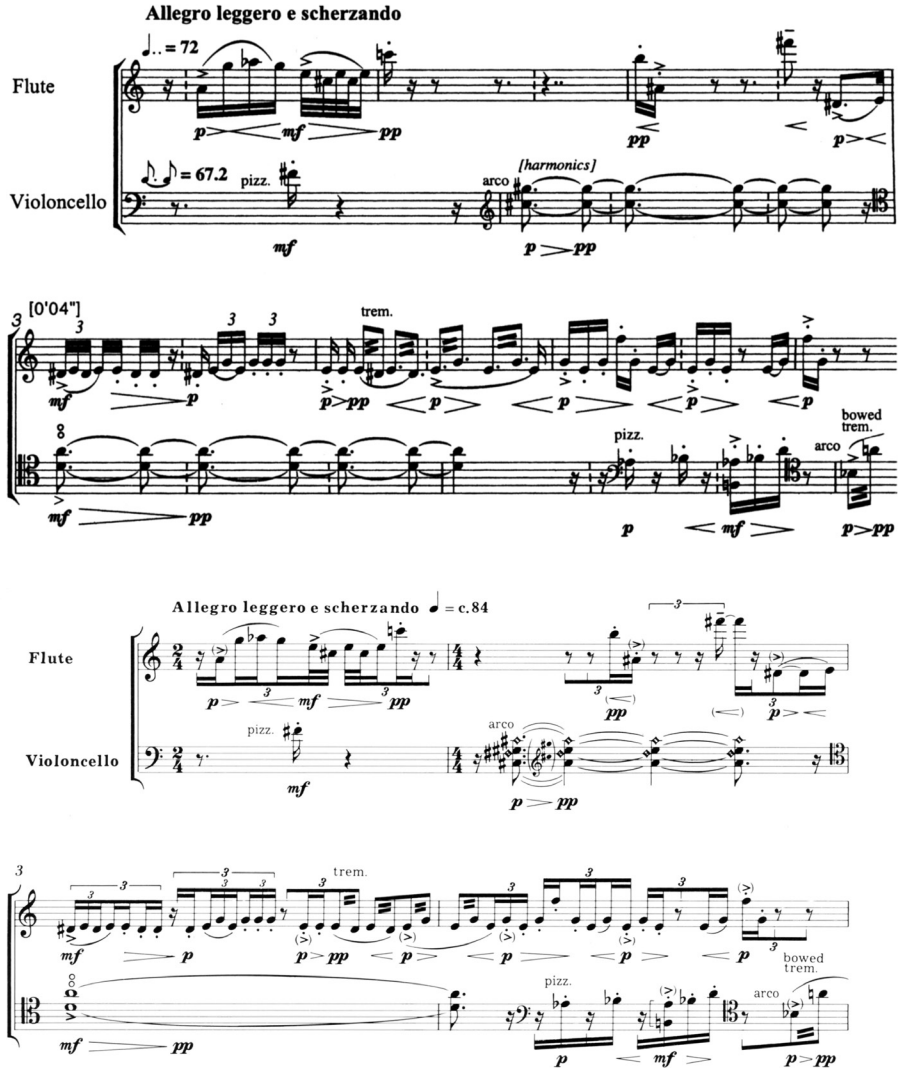
In the modulation plan of Ludwig van Beethoven's Sonata, op. 106, movement 1, except for the opening and closing moves between B♭ and G, the arrangement of keys visited is symmetrical when mapped on a circle of fourths. The symmetry would be clearer if noncompliant tonal paths were rendered more lightly, particularly because the axis of symmetry is not on the horizontal or vertical plane (it runs through the B♭/E♭ and E/A gaps). Here the axis is not implicit and would be better shown explicitly.

Online Figure 46.2 Harald Krebs, *Fantasy Pieces: Metrical Dissonance in the Music of Robert Schumann* (New York: Oxford University Press, 1999), 103.



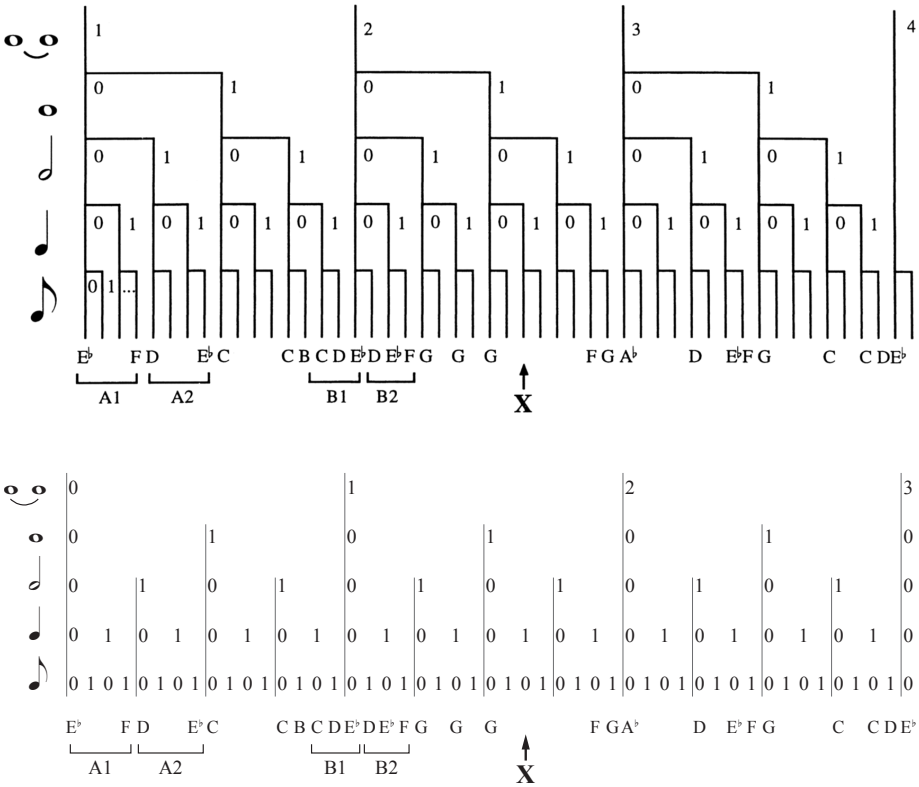
This image takes an approach similar to that of figure 46.1. Different inferred meters appear for each staff. Rather than traditional meter signatures, the image provides only the number of eighth notes per metrical unit. Downbeats that are expected but not articulated in the music have a slash through the number. The durational unit (the eighth note) is understood contextually. Omitting that unit draws more attention to the "measure" lengths and makes it easier to see the gradual lengthening of these measures from two to four and finally to eight. This polymetric interpretation would not be as easily accommodated using the notation in figure 46.1. The approach there invites one to perform the analysis, while this depiction invites one to hear the analysis.

Online Figure 46.4 John Roeder, "Autonomy and Dialogue in Elliott Carter's *Enchanted Preludes*," in *Analytical Studies in World Music*, ed. Michael Tenzer, 377–414 (New York: Oxford University Press, 2006), 395; Elliot Carter, *Enchanted Preludes* (New York: Boosey and Hawkes, 1988), mm. 1–4.



The upper image proposes hearing music, originally notated as in the lower image, in entirely different meters and tempos. The renotation allows a series of pulse streams that occur with metric regularities at odds with the notated meter to fall on new "downbeats," in a way that is not unlike the reinterpretation of tempo in figure 25.3 and online figure 25.4. The music is complex, and this approach successfully uncovers the interactions between two pulse streams moving at different rates. Figure 46.6 is a more involved image involving multiple pulse streams.

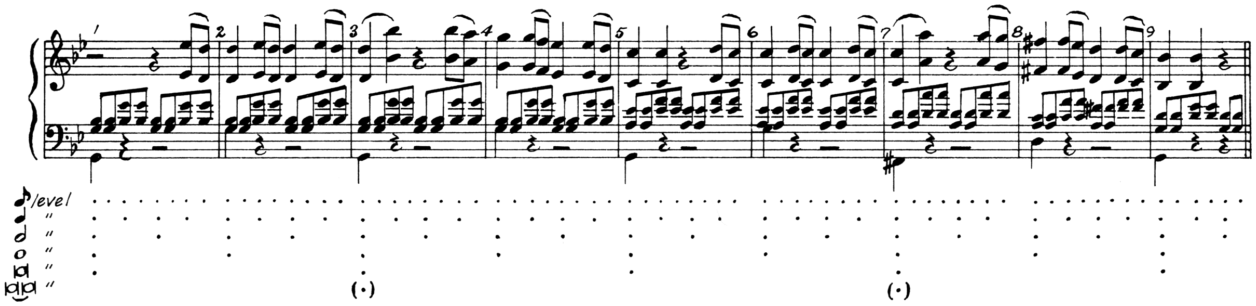
Online Figure 46.7 *Above*, David Temperley, *The Cognition of Basic Musical Structures* (Cambridge, MA: MIT Press, 2001), 332; *below*, redrawing.



The image above uses a tree structure to show a five-level metrical framework for the opening of Ludwig van Beethoven's Sonata no. 8 (*Pathetique*), movement 3. Beats on any level are numbered from 0 to *n*–1, where *n* is the number of beats in one level that occur during a single beat at the immediately higher level. (The top level, that of the breve, is counted from 1, which is inconsistent.) Any location, such as the one marked with an X, can be referenced using an address built by concatenating the beat numbers present at that moment, read top to bottom (in the case of X, 21010). More generally, events with the same address measured from the same metrical level are metrically parallel. The segments labeled A1 and A2 are parallel at the quarter-note level since from that level their addresses are both 00–11.

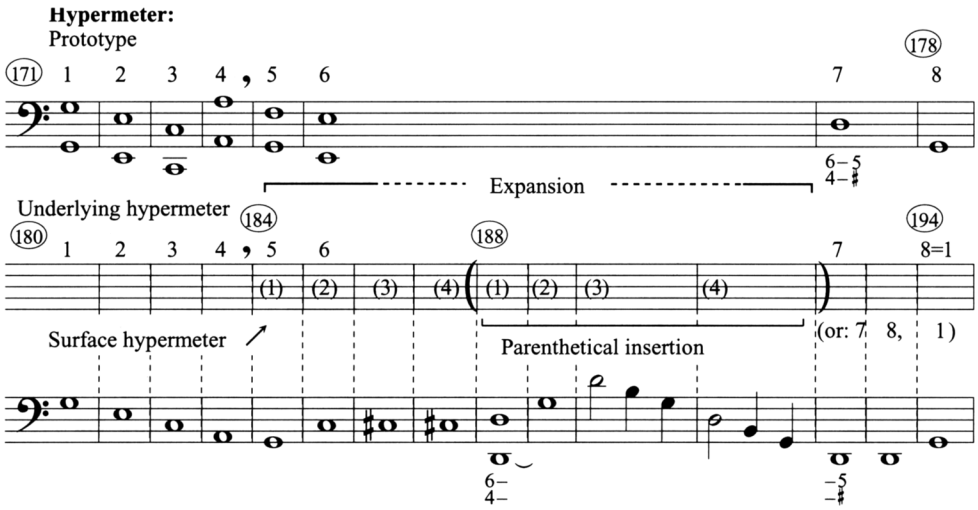
The concept is elegant. Visually, however, the tree structure is somewhat overbearing. It would be better if the beat numbers were vertically aligned with the beats rather than to their right. The redrawing addresses these issues, occupies less vertical space, and numbers the 𝅝 level the same as the others. Light vertical lines are retained to reinforce alignment.

Online Figure 46.8 Fred Lerdahl and Ray Jackendoff, *A Generative Theory of Tonal Music* (Cambridge, MA: MIT Press, 1983), 23.



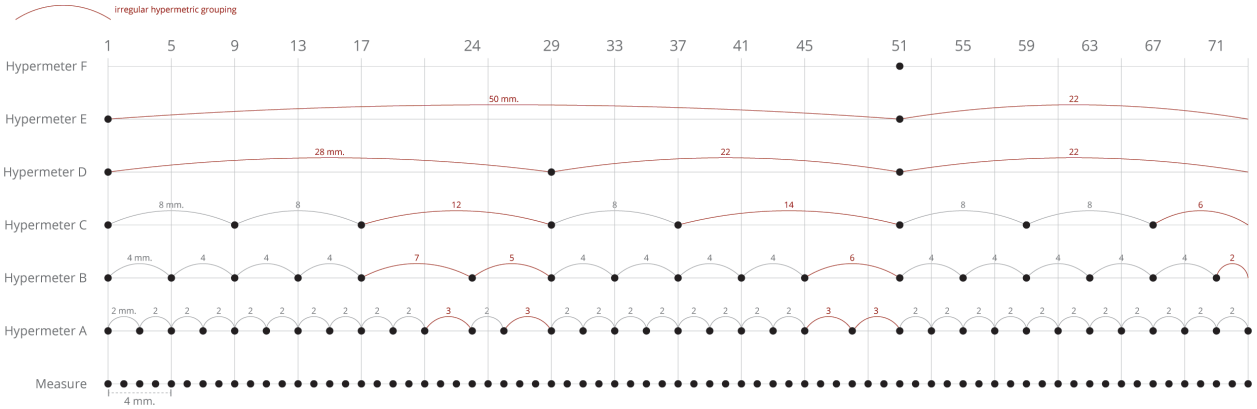
This image shows something similar to online figure 46.7. Dots indicate beats at various metrical levels. The notation is more efficient than in the other depictions of hypermeter discussed in the text, though it would work less well in contexts in which metrical parallelism was a primary concern. I will return to this notation in chapter 52.

Online Figure 46.10 Christopher F. Hasty, *Meter as Rhythm* (New York: Oxford University Press, 1997), 180.



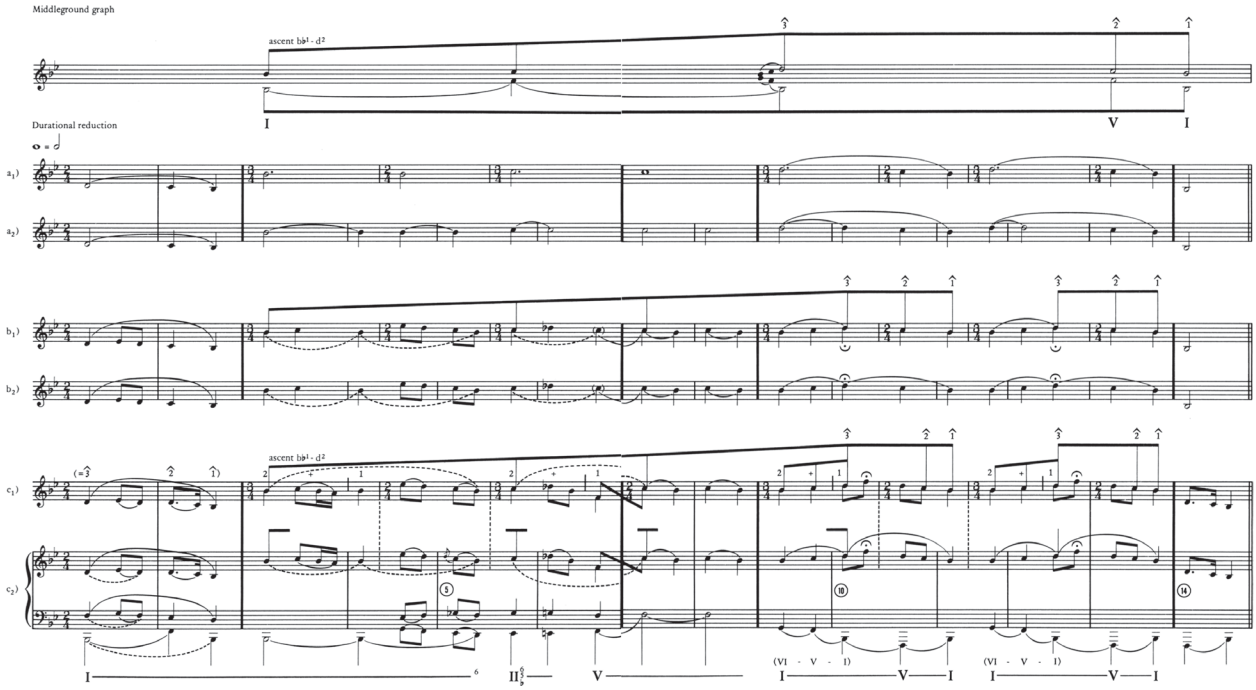
In a manner similar to figure 46.9, this image shows how Mozart takes a prototypical eight-bar hypermeter and expands it, first by replacing bars 5–6 with a new set of bars labeled (1)–(4), which are followed by an insertion again labeled (1)–(4), still expanding the prototype's bars 5–6. The middle staff here, which does not support any pitches, is unnecessary, however. Making the hypermetric analysis an annotation of the bottom staff would also permit elimination of the dashed bar lines.

Online 46.12 Redrawing of fig. 46.11 by Emily Barbosa, 2018, unpublished.

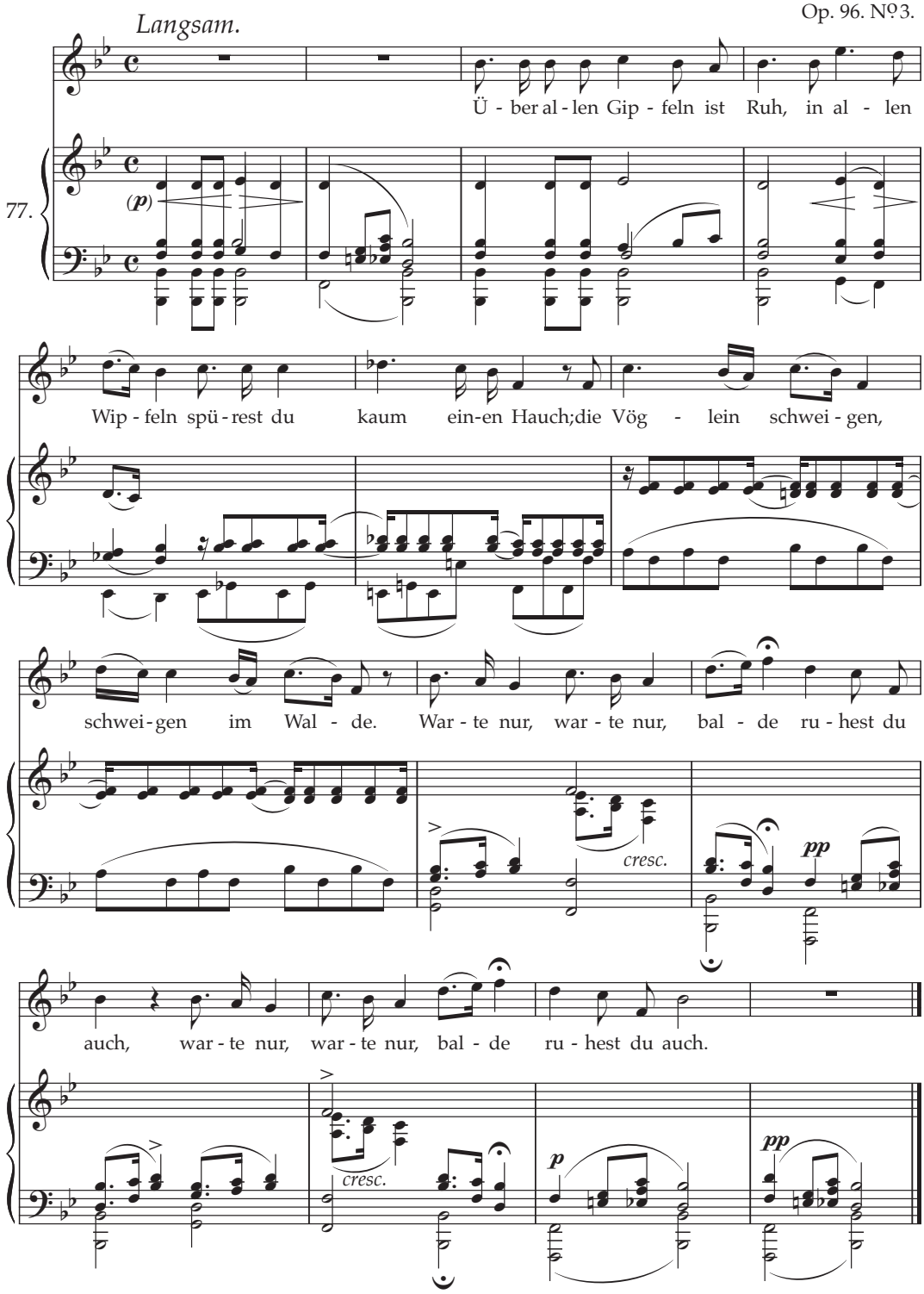


The image offers an attractive redesign of figure 46.11, a representation of the hypermetrical structure of Beethoven's Sonata, op. 13, movement 2. It makes it easier to see the hyperbeats at a given level. It also effectively highlights hypermeasures whose length differs from the default length for that level through the use of a color that pops out visually.

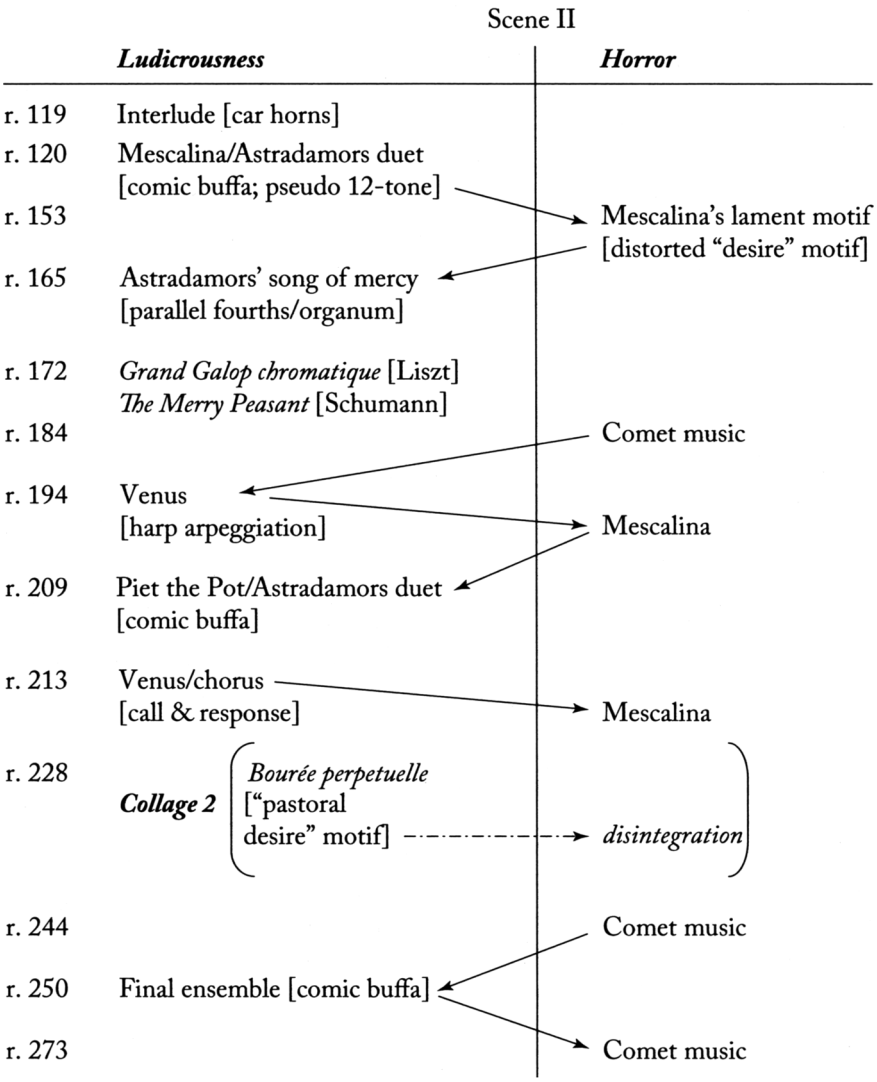
Online Figure 46.13 *Below*, Carl Schachter, "Rhythm and Linear Analysis: Aspects of Meter," in *The Music Forum*, ed. Felix Salzer and Carl Schachter, vol. 6, part I (New York: Columbia University Press, 1987), 20–21; *following page*, Franz Schubert, *Wanderers Nachtlied*, D. 768, mm. 1–7.



Given that hypermeter is conceptually just meter at a higher level and given that Western notation is optimized for the display of meter (but not hypermeter), the approach taken in the image above is novel and clever. In the context of a Schenkerian voice-leading reduction (a topic addressed in chap. 48), first, note values in the original (Franz Schubert's *Wanderers Nachtlied*, D. 768; the score is provided below) are halved (c2 shows the level closest to the music's surface), and then the reduction is rebarred (c1) to reflect an interpretation of the music's hypermetrical structure. Dashed lines are used for bar lines in c1 that do not align with the original in c2.


Langsam.
77.
(p)
Ü - ber al - len Gip - feln ist Ruh, in al - len
Wip - feln spü - rest du kaum ein-en Hauch;die Vög - lein schwei - gen,
schwei - gen im Wal - de. War - te nur, war - te nur, bal - de ru - hest du
cresc.
pp
auch, war - te nur, war - te nur, bal - de ru - hest du auch.
cresc.
p
pp

Online Figure 47.2 Yayoi Uno Everett, "Signification of Parody and the Grotesque in György Ligeti's *Le Grand Macabre*," *Music Theory Spectrum* 31, no. 1 (2009): 49.



The layout of this image is similar to that of figure 47.1. It depicts the alternation of expressive states in a section of György Ligeti's opera, *Le Grand Macabre*. Arrows that make explicit where state changes occur reinforce the impression of *alternating* stages. As in figure 47.1, there is no sense of scale, even less so because, rather than time indices, the image uses only rehearsal numbers, which are not necessarily equally spaced in the score. As is often the case, conveying a sense of proportion through the spacing of elements would be a low-cost way of enhancing information.

Online Figure 47.5 William Benjamin, "Mozart: Piano Concerto no. 17 in G Major, K. 453, Movement 1," in *Analytical Studies in World Music*, ed. Michael Tenzer, 332–76 (New York: Oxford University Press, 2006), 346–47.

Sections and sub-sections: name, character, dynamic(s), and orchestration	Meas. (with timing on four CDs)*	Basic grouping structure (of sub-sections)**	Tonal direction (of sub-sections)	Formal types and functions (of sub-sections)
A. First Orchestral Presentation	**1–74**			
1. Principal theme; placid, *piano* strings and horn with some wind dialogue	1–16	(4+4) + ((2+2) + 4 = 3 by elision)	Establishes tonic key, → full cadence, elided	Sentence, thematic presentation
2. Conclusion to theme becoming transition; active, *forte* tutti; then *piano*, solo winds	16–34 *MP:* 0:28 *RG:* 0:27 *MJP:* 0:32 *MB:* 0:28	(3+3) + (1+1 + 2 =1 by elision) + ((2+2) + (1+1) +4)	Confirms I then leads to V, where a potential half cadence is elided by a standing on V, which passes back to I	Two three-bar waves acting as codettas followed by four-bar phrase transitioning to half cadence; cadential extension, joined to link to new theme
3a. Subordinate theme; initial pathos-tinged lyricism, with mood lightening at cadences; *piano* strings, then winds with string interjections	35–49 *MP:* 1:00 *RG:* 1:03 *MJP:* 1:06 *MB:* 1:01	((2+2) + 4 =3 by elision) + ((2+2) + 4 = 3 by evasion)	Tonally mobile, stepwise descending bass, → elided full cadence; all repeated to second cadence (evaded by bVI)	Sentence: mobile presentation phrase over stepwise-descending bass, followed by continuation-to-cadence phrase; all repeated
3b. Active concluding part to second theme; tutti, *forte*	49–57 *MP:* 1:25 *RG:* 1:29 *MJP:* 1:32 *MB:* 1:26	(2+2) + ((1+1) + 3 = 2 inflated to 3 so that m. 57 overlaps with next sub-section)	Elaboration of bVI → full cadence in tonic key	Sentence-like preparation for and statement of principal cadence of Section 1
4. Codetta section, beginning much like music at m. 16; strings, then tutti, *piano* then *forte*	57–74 *MP:* 1:40 *RG:* 1:44 *MJP:* 1:47 *MB:* 1:40	(4+4)+ (2+2) + (2+2) + (1+1)	Confirmation of arrival on I	Progressively shorter waves, dissipating energy of principal cadence
B. Solo sonata exposition	**75–171**			
1. Principal theme; *piano*, largely as in Section A, but for solo with wind accomp. (strings in 87-90)	75–94 *MP:* 2:10 *RG:* 2:18 *MJP:* 2:20 *MB:* 2:10	(4+4) + ((2+ 2) + (4+4 = 3 by elision))	Confirms tonic key in solo part, → elided full cadence	Sentence with cadential segment (last four bars) repeated; solo presentation of first theme
2. Transition beginning with codettas to first theme; *piano*, str. + fl., followed by solo elaboration; leading to solo passage work with str. and wind accompaniment	94-109 *MP:* 2:44 *RG:* 2:53 *MJP:* 2:54 *MB:* 2:45	(3+3) + ((2+2+1+1) + 4)	Tonic arrival at end of theme is confirmed; then, six bars of modulation to D+ major. (VI of G+ = II of D+) → half cadence in D+ followed by four bars of standing on dominant	Two 3-bar waves followed by six-bar sequential passage effecting modulation. Four-bar cadential extension at m.106 may be heard as expansion of normative two-bar completion of preceding six.

This is just a quarter of an extended table describing in detail the formal organization in Mozart's Piano Concerto, K. 453, movement 1. Five columns provide information and interpretive narrative: affect, nested structure, and formal function are all represented. The detailed reading invites one to sit with a score and one or more of the four recordings referenced in the second column.

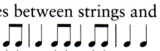
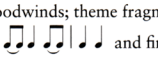
Online Figure 47.6 Joseph Kerman, *Listen*, 3rd brief ed. (New York: Worth, 1996), 169.

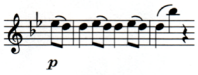
LISTENING CHART 6

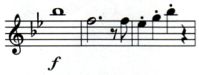
2 15-20 | 1 18-23 | 2B 1 | 1B 1

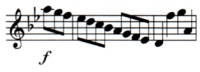
Mozart, Symphony No. 40 in G Minor, first movement

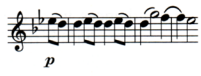
Sonata form, 8 min., 8 sec.

	EXPOSITION		
	0:02	**Theme 1 (main theme)**	Theme 1, *p*, minor key (G minor); repeated cadences *f*
	0:26		Theme 1 repeats and begins the modulation to a new key.
	0:34	**Bridge**	Bridge theme, *f*, confirms the modulation.
			CADENCE Abrupt stop.
	Second Group		
16 19	0:54	**Theme 2**	Theme 2, *p*, in major key; phrases divided between woodwinds and strings
	1:05		Theme 2 again, division of phrases is reversed; new ending
	1:23		Other shorter ideas, *f*, and *p*: echoes of theme 1 motive
	1:48	**Cadence theme**	Cadence theme, *f*, downward scales followed by repeated cadences. Still in the major mode
			CADENCE Abrupt stop.
	2:05	***Exposition repeated***	
	DEVELOPMENT		
17 20	4:12	**Theme 1 developed**	Theme 1, *p*, with its original accompaniment—modulating
	4:26	**Contrapuntal passage**	Sudden *f*: contrapuntal treatment by the full orchestra of theme 1
	4:53	**Fragmentation**	Sudden *p*: beginning of theme 1 echoes between strings and woodwinds; theme fragmented from  to  and finally to 
	5:10		Retransition *f* (full orchestra), *p* (woodwinds), which leads into the recapitulation
	RECAPITULATION		
18 21	5:24	**Theme 1**	Theme 1, *p*, G minor, as before
	5:47		Theme 1, again, but modulates differently than before
	5:55	**Bridge**	Bridge, *f*, considerably longer than before, with more elaborate counterpoint
			CADENCE Abrupt stop.
	Second Group		
19 20	6:38	**Theme 2**	Theme 2, *p*, this time in the minor mode (G minor) All the other second-group themes are in the tonic key (minor mode); otherwise much the same as before
	7:38	**Cadence theme**	Scale part of the cadence theme, *f*
	CODA		
20 23	7:50		New imitative passage, *p*, strings; based on theme 1 motive
	7:59		Repeated cadences, *f* Stop, this time "confirmed" by three solid chords.









This excellent listening guide to Mozart's Symphony no. 40 has a different target audience than online figure 47.5 and is less information rich. A grid-less table, white space, and typography provide the necessary orienting structure. The prose in the third column, which includes real-looking dynamic symbols and rhythmic notation, makes ample cross-reference to earlier music ("Theme 1 repeats"; "Still in the major mode"; "but modulates differently than before"; "otherwise much the same as before"). Another listening guide appears later in this chapter.

Online Figure 47.7 *Above*, George Perle, *Serial Composition and Atonality: An Introduction to the Music of Schoenberg, Berg, and Webern* (Berkeley: University of California Press, 1991), 113; *below*, redrawing using Variations Timeliner.

EXPOSITION

I.	First Group	
	A. Subject I (bars 1-2)	4/4/4
	B. Episode (bars 3-9)	4/4/4
	C. Modified return of Subject I (bars 10-11)	4/4/4
	D. Transition (bars 12-13)	4/4/4
II.	Second Group	
	A. Subject II (bars 14-18)	6/6
	B. Episode (bars 19-20)	6/4
	C. Modified return of Subject II (bar 21 to beginning of bar 23)[2]	/6
	D. Codetta and transition (second half of bar 23 through fifth eighth-note value of bar 27)	3/3/3/3

DEVELOPMENT

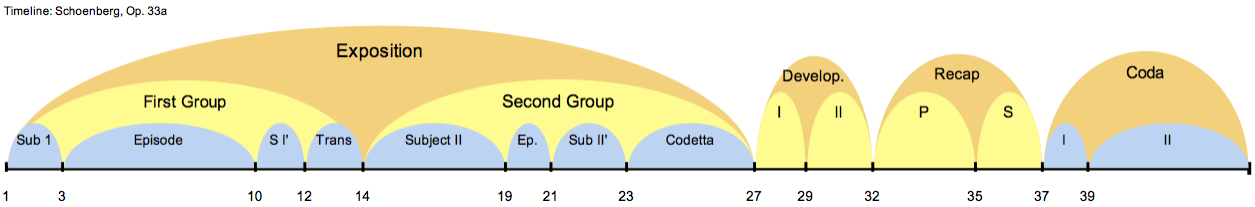
I.	(Conclusion of bar 27 to middle of bar 29)	Various types of segments
II.	(Conclusion of bar 29 to *fermata*, bar 32)	4/4/4

RECAPITULATION

I.	Modified return of Subject I (following *fermata*, bar 32, through bar 34)	4/4/4
II.	(Modified return of Subject II (bars 35-36)	6/6

CODA

I.	(bars 37-38)	4/4/4
II.	(bar 39, including upbeat through bar 40)	4/4/4

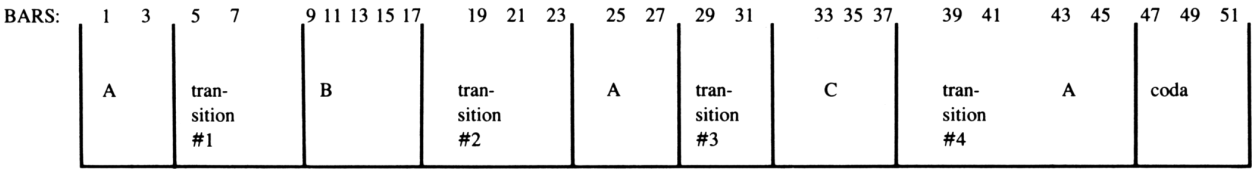


The image above provides a sonata-form interpretation of Arnold Schoenberg's *Klavierstück*, op. 33a. The structure of this picture is affected by the author's desire to show how the twelve-tone row is segmented in different sections. While most sonata-form pictures emphasize the timeline along which the sections are depicted, this one is purely schematic. The major section divisions are centered, all caps, while the elements of these sections appear in outline form. The locations of the sections are provided almost as an afterthought, in parentheses after the

section description. As a result, figuring out which section starts at, say, m. 21 requires considerable effort. The image also does not convey the relative proportion of the sections, which it turns out is a significant feature of this piece.

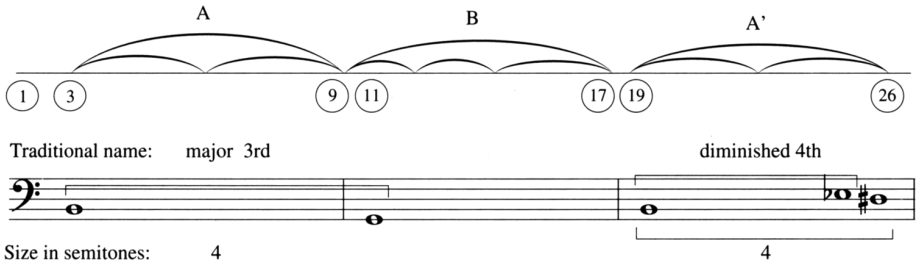
The version in the lower image, produced with Variations Timeliner, shows the unusual proportions a sonata interpretation yields, though it does not provide the row-segmentation information found in the original.

Online Figure 47.10 Richard S. Parks, "Pitch Organization in Debussy: Unordered Sets in 'Brouillards,'" *Music Theory Spectrum* 2 (1980): 124.



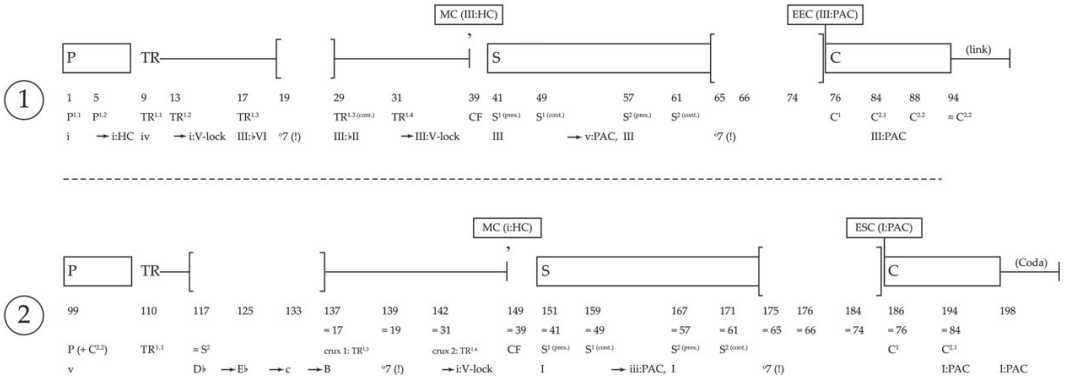
This is a simple image with some quirks. The measure numbers, which are just the sequence of odd numbers, are not equally spaced. Since all but four bars of the piece are in 4/8 time and there are only a half dozen minor tempo changes, there is no reason for them not to be roughly equal. Or better, the image could list only the numbers of measures that are formally significant. The long vertical lines, which serve only to mark off points on the line, drown out the text. They could be shorter and much less prominent. (Presumably, there should be a line between transition 4 and the last A section.) The long horizontal line at the bottom, which carries no information at all, could be eliminated entirely. The word *transition* overpowers the labels for the primary sections. The primary section labels could be larger. Finally, the image is information poor. It explains nothing about how the sections are defined.

Online Figure 47.11 J. Kent Williams, *Theories and Analyses of Twentieth-Century Music* (Fort Worth: Harcourt Brace, 1997), 22.



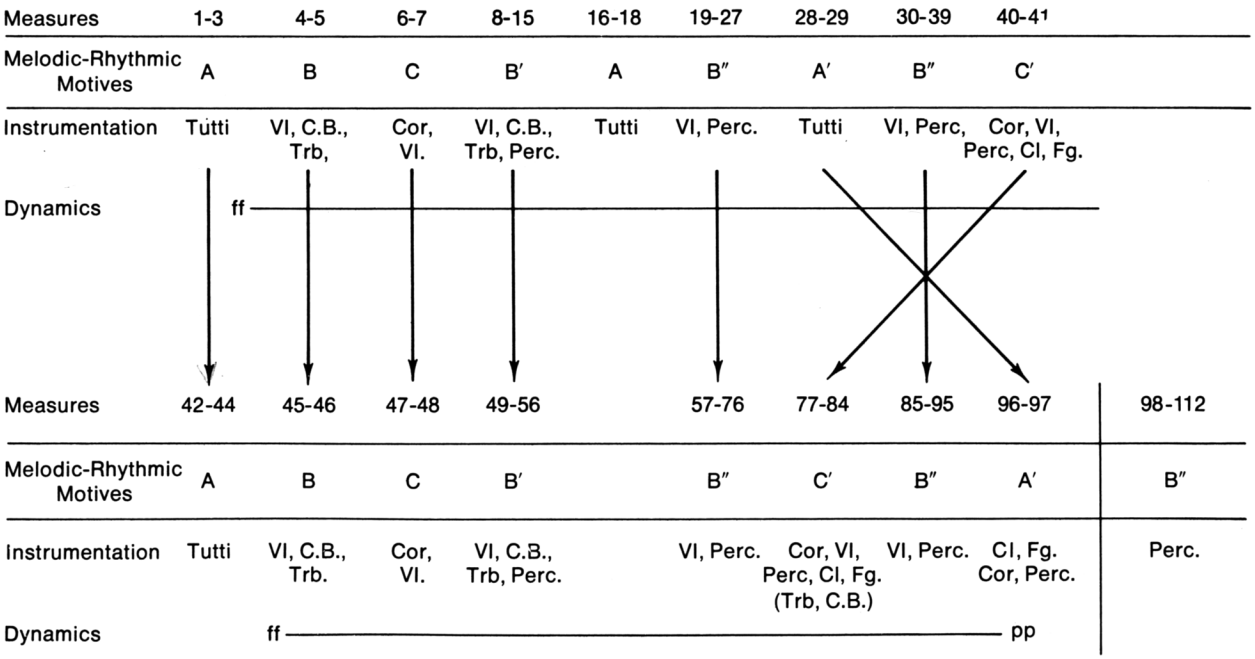
Like online figure 47.10, this image, referring to Aaron Copland's song "The World Feels Dusty," presents relatively minimal information and makes curious choices in the display of measure numbers. The overall A–B–A structure is clear, as is the internal phrasing. Labeling the first and last measures of each section is unusual, but it here raises the question of what happen in measures 10 and 18. And why not also provide measure numbers for the internal phrase divisions?

Online Figure 47.18 Andrew Davis, "Chopin and the Romantic Sonata: The First Movement of op. 58," *Music Theory Spectrum* 36, no. 2 (2014): 288.



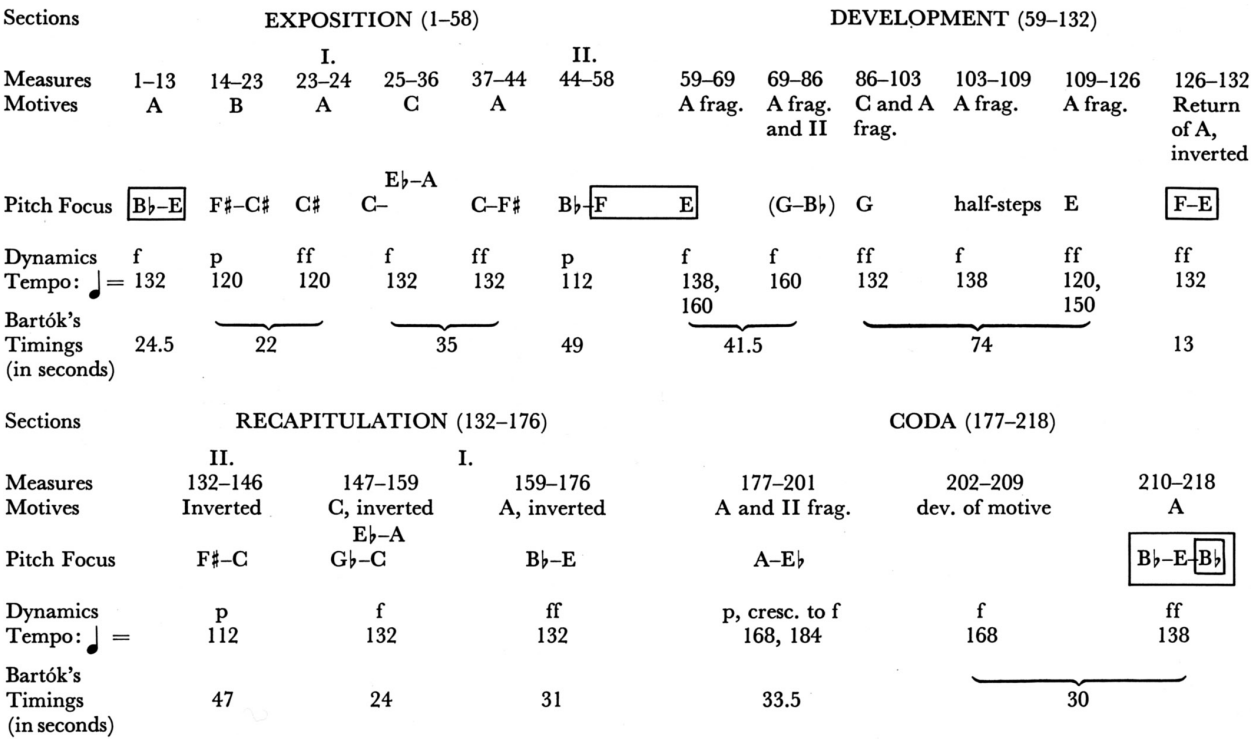
This image demonstrates that a grid is not necessary. The detailed diagram of Frédéric Chopin's *B Minor Sonata*, op. 58, movement 1, is organized on the macro level by large boxes for the major thematic area, lines for transitions and codas, and open brackets for places of tonal instability. In the second half, numbers of corresponding measures from the first half are listed ("= 17"), facilitating quick cross-reference. As in figure 47.17, however, horizontal spacing is proportional to the typographical symbols rather than to the music being represented. Equivalent distances in measures vary dramatically when measured on the page.

Online Figure 47.19 Mary Wennerstrom, "Form in Twentieth-Century Music," in *Aspects of Twentieth-Century Music*, ed. Gary E. Wittlich, 1–65 (Englewood-Cliffs, NJ: Prentice-Hall, 1975), 13.



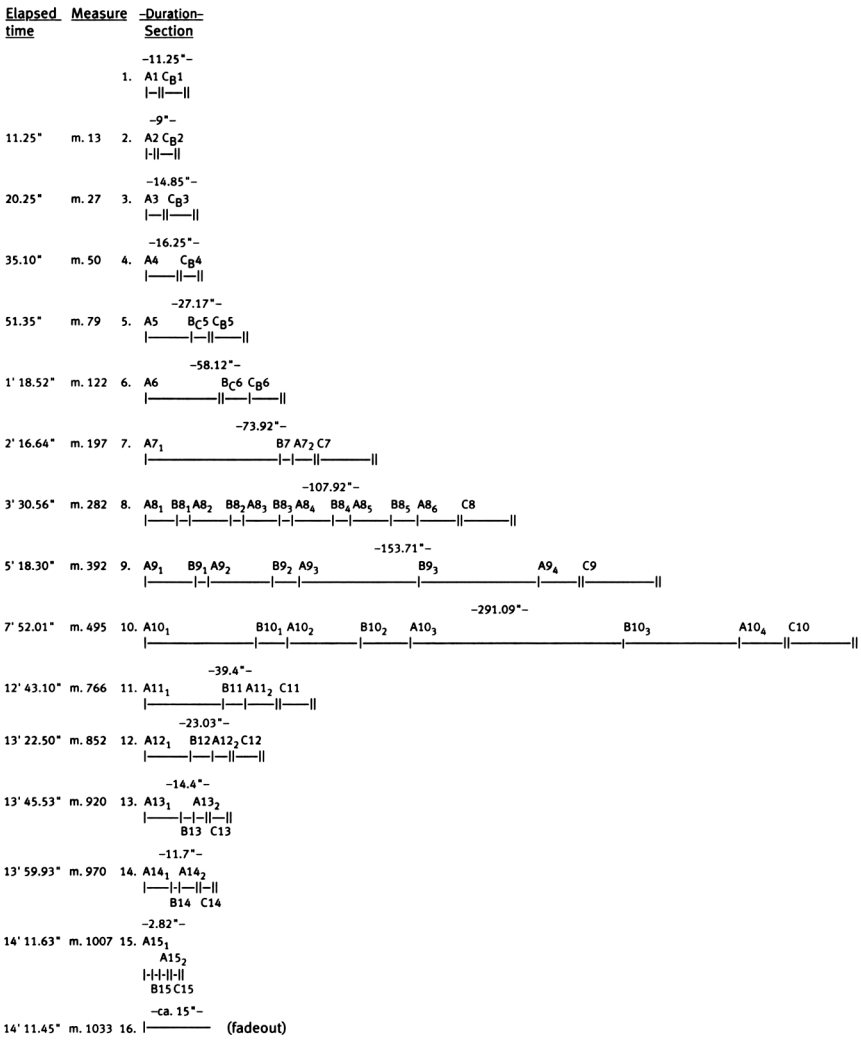
Like figure 47.17 and online figure 47.18, this image, representing part of Igor Stravinsky's *L'Histoire du Soldat*, presents a sequence of sections without trying to represent their relative proportions. The downward arrows provide the most direct information regarding sections that correspond to one another, making the reversal of A′ and C′ toward the end of each half clear. Their darkness overwhelms the rest of the information, however. The arrows need only to contrast, not dominate; thin and gray would be just as effective and would make it easier to scan for similarities between the two streams. The lack of a corresponding section for A (at m. 16 in the first half) and B″ (m. 98 in the second) could be made explicit. The horizontal lines between information categories are benign but expendable. The amount of information provided invites extended study, links well to the score, and tells a clear story of this *Histoire* of *L'Histoire*.

Online Figure 47.20 Mary Wennerstrom, "Form in Twentieth-Century Music," in *Aspects of Twentieth-Century Music*, ed. Gary E. Wittlich, 1–65 (Englewood-Cliffs, NJ: Prentice-Hall, 1975), 20.



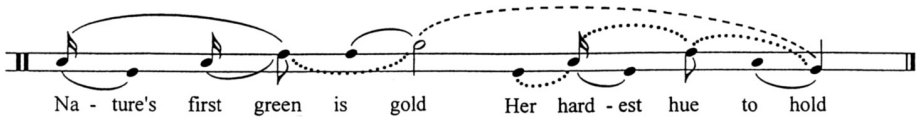
This image, similar in layout to online figure 47.19. is also rich with information. The layout showing the form of Béla Bartók's *Fifth String Quartet*, movement 1, rewards careful study. In particular, it invites comparison of exposition and recapitulation and of development and coda. This is among the rare images that is not overengineered, in fact rather the opposite. Given that it conveys at least eight kinds of information, the image could use stronger visual clues to help organize it. The typography is uniform, and the elements seem to be evenly distributed, which visually flattens what is a richly layered information hierarchy. Rendering headers in a different typeface would set them apart from the rest of the information. Using actual dynamic symbols rather than the standard font would help them stand out. Spacing lines consistently would make it easier to scan them efficiently. Being consistent about centering or (better) left-aligning information in the same column would enforce the vertical alignment of items in columns (section 1 of the exposition should appear unambiguously to begin in m. 1 and not m. 23, for example). Using a proportional representation when possible is generally preferable and certainly possible here. Finally, drawing attention to the reversal of sections 1 and 2 when they return in the recapitulation would draw attention to a central structural feature of the movement.

Online Figure 47.22 Frank Cox, "Rhythmic Morphology and Temporal Experience: *Doubles*, for Piano and Taped Synthesizers (1990–1993)," in *Musical Morphology: New Music and Aesthetics in the 21st Century*, ed. Claus Steffen Mahnkopf, Frank Cox, and Wolfram Schurig, 86–122 (Hofheim: Wolke, 2004), 103.



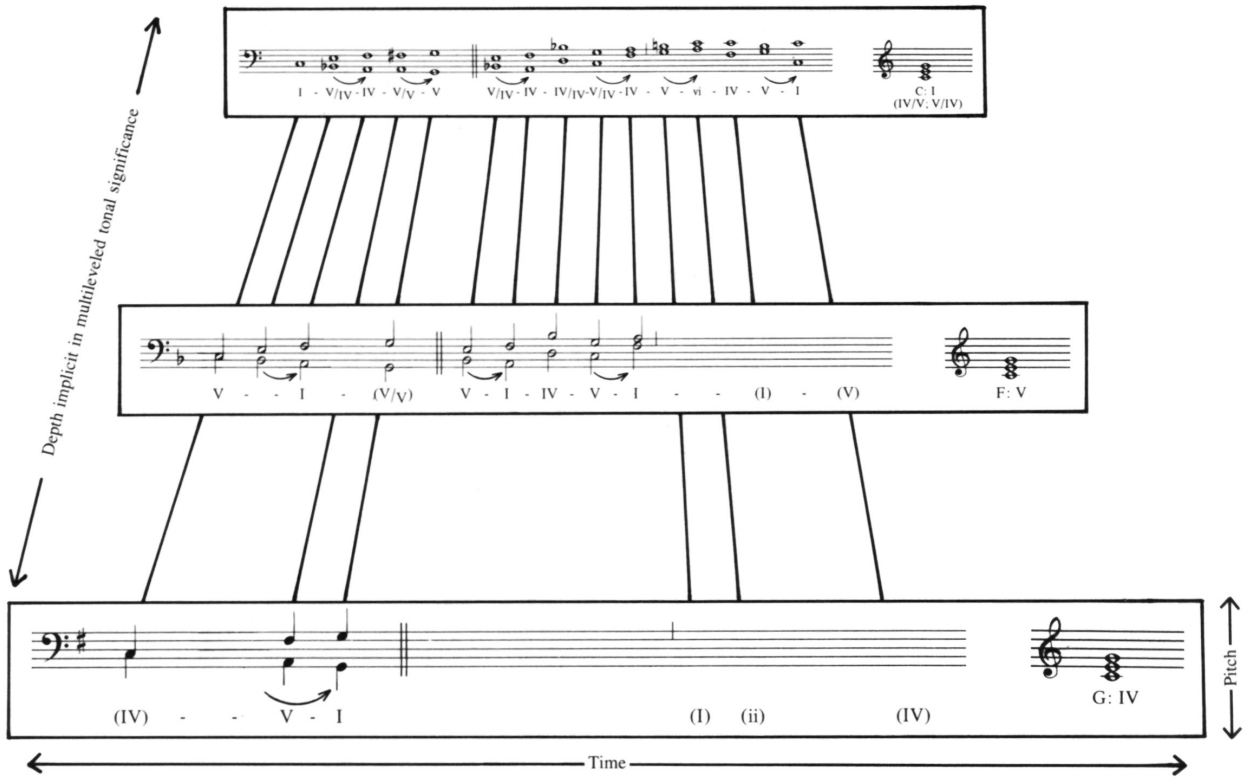
Like figure 47.21, this image (which we looked at in chap. 26) employs a two-dimensional design, with time flowing left to right and then top to bottom. The design elegantly exposes the work's palindromic proportional scheme, notwithstanding the fact that the long sections in the center are actually considerably longer than shown here.

Online Figure 48.3 Fred Lerdahl, "The Sounds of Poetry Viewed as Music," in *The Cognitive Neuroscience of Music*, ed. Isabelle Peretz and Robert J. Zatorre, 413–29 (New York: Oxford University Press, 2003), 425.



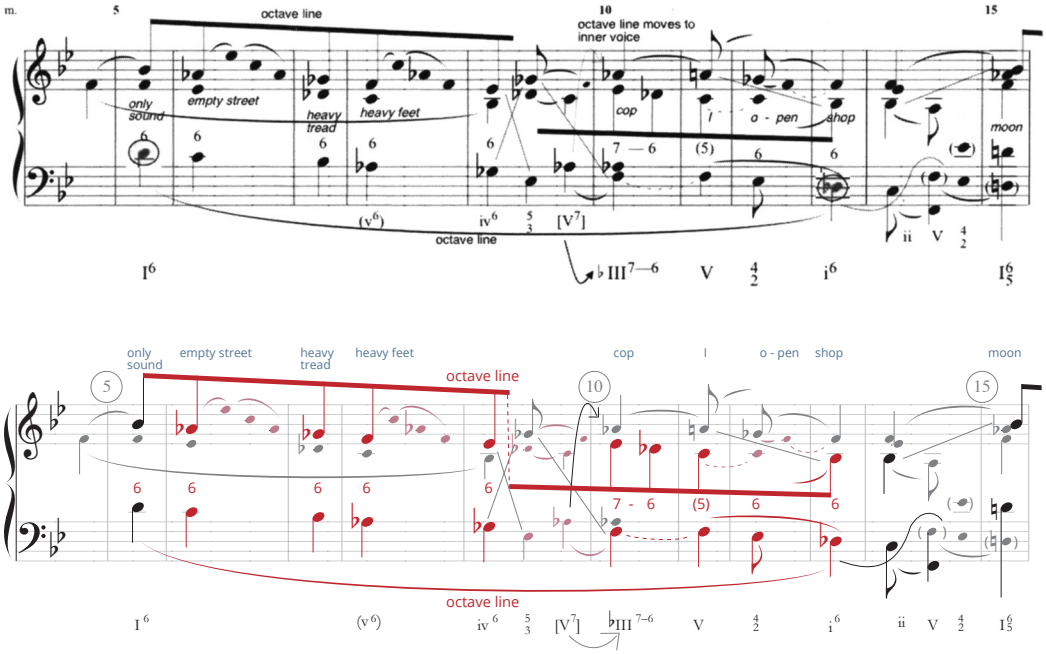
This representation of the prolongational structure (after Lerdahl and Jackendoff 1983) of a line of poetry by Robert Frost repurposes durational values as markers of structural hierarchy, with longer durations signaling deeper structural significance. Stemless noteheads are the most "decorative." Three types of slur depict three kinds of connection: the dashed slur indicates strong prolongation (signifying repetition or rhyme), dotted slurs indicate weak prolongation (partial repetition, alliteration, or assonance), and solid slurs indicate nonrepetition. Even though the musical symbols do not mean what they normally do, it is relatively simple to metaphorically map *longer* onto *structurally deeper*. A modest improvement would be to lengthen the dashes of the dashed slur to make it less likely to be confused with the dotted slurs.

Online Figure 48.6 Wallace Berry, "On Structural Levels in Music," *Music Theory Spectrum* 2 (1980): 41.



This image employs visual depth to make an explicit point about structural depth. The technique adds little. It, like the additional boxes and lines, is distracting and could be eliminated. See online figure 2.7 for another image with a perspective representation.

Online Figure 48.10 *Above*, Michael Buchler, "Every Love but True Love: Unstable Relationships in Cole Porter's 'Love for Sale,'" in *PopMusicology*, ed. Christian Bielefeldt and Rolf Grossman, 184–200 (Luneburg, Germany: Transcript, 2008), 195; *below*, redrawing.



The upper image is a Schenkerian sketch of a passage from "Love for Sale," a song by Cole Porter. The redrawing below it proposes treatments that might inform the design of Schenkerian diagrams. The first set of changes could apply to any reductive image:

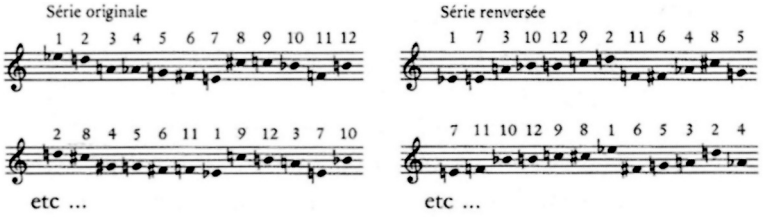
- Staff lines and bar lines are drawn in gray as is always appropriate for gridlines.
- To highlight the octave lines that are the focus of the sketch, the notes that participate in those lines, along with the stems, beams, slurs, ties, figured bass, and analytic text that go with them, are rendered in a highly saturated shade of red.
- Embellishments of those octave lines are in lighter red.
- The "inner" voice (which becomes the soprano in m. 9) is in gray, to make its subsidiary role clearer.
- The embellishing and inner voice pitches are rendered with smaller noteheads to allow the primary pitches to stand out more.

The next set of changes are specific to this image, though they would generalize to other situations:

- The two pieces of the beam break in m. 9 are connected with a dashed line, eliminating the need for the original's explanatory text.
- The song's text has been moved above the music to declutter things, set in a contrasting color, and aligned vertically. I changed the font from Myriad to the similar but slightly more legible Open Sans and also to roman text, which is more legible than italics.
- Measure numbers are larger and circled but rendered in the same gray as the gridlines.
- The figured bass symbols between the staves are aligned vertically, except where they need to jump down in m. 10 to avoid the beam.
- The roman numerals have been aligned vertically to make it easier to follow them across the image.

The changes are both subtle and significant. The layers of musical information are pulled farther apart to let the image's story speak with a clearer voice.

Online Figure 49.6 Michael Polth, "Dodekaphonie und Serialismus," in *Musiktheorie*, ed. Helga de la Motte-Haber and Oliver Schwab-Felisch, 421–40 (Laaber: Laaber, 2005), 435.



Ce qui donne, en chiffres, l'organisation sérielle double suivante:

A

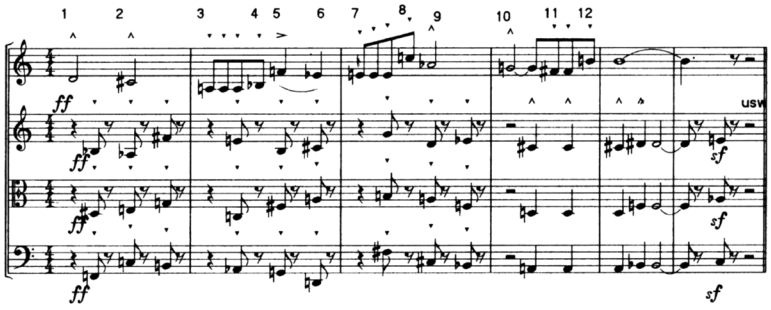
1	2	3	4	5	6	7	8	9	10	11	12
2	8	4	5	6	11	1	9	12	3	7	10
3	4	1	2	8	9	10	5	6	7	12	11
4	5	2	8	9	12	3	6	11	1	10	7
5	6	8	9	12	10	4	11	7	2	3	1
6	11	9	12	10	3	5	7	1	8	4	2
7	1	10	3	4	5	11	2	8	12	6	9
8	9	5	6	11	7	2	12	10	4	1	3
9	12	6	11	7	1	8	10	3	5	2	4
10	3	7	1	2	8	12	4	5	11	9	6
11	7	12	10	3	4	6	1	2	9	5	8
12	10	11	7	1	2	9	3	4	6	8	5

B

1	7	3	10	12	9	2	11	6	4	8	5
7	11	10	12	9	8	1	6	5	3	2	4
3	10	1	7	11	6	4	12	9	2	5	8
10	12	7	11	6	5	3	9	8	1	4	2
12	9	11	6	5	4	10	8	2	7	3	1
9	8	6	5	4	3	12	2	1	11	10	7
2	1	4	3	10	12	8	7	11	5	9	6
11	6	12	9	8	2	7	5	4	10	1	3
6	5	9	8	2	1	11	4	3	12	7	10
4	3	2	1	7	11	5	10	12	8	6	9
8	2	5	4	3	10	9	1	7	6	12	11
5	4	8	2	1	7	6	3	10	9	11	12

The matrices in this image are not especially informative. Throughout, the numbers 1 through 12 represent the order numbers of the main row form (E♭ is 1 throughout, D♯ is 2, and so on to B♮, which is 12). The matrix on the left shows the twelve rotations of the row (that is, the forms beginning in turn on order numbers 1, 2, 3, etc.), while the matrix on the right shows the twelve rotations of the inversion form, all rendered on the basis of the order number of a pitch in the original row. If the matrices contain any useful information, it is not highlighted in any way. Using the matrices to track row forms in the music would require keeping them at hand, since the mapping of pitch class to number is unique to this piece.

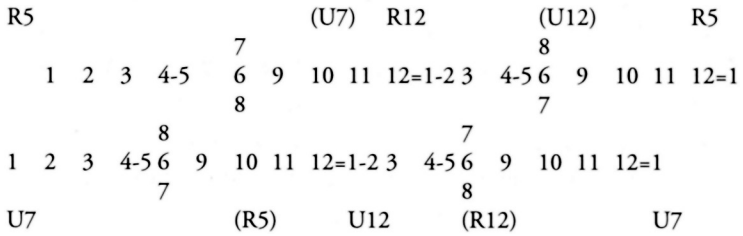
Online Figure 49.10 Werner Krützfeldt, "Polyphonie in der Musik des 20. Jarhhunderts: Die Logik der Linie," in *Musiktheorie*, ed. Helga de la Motte-Haber and Oliver Schwab-Felisch, 311–34 (Laaber: Laaber, 2005), 323.



4	9	11	7	12	2	10	1	6	2	6	7
6	7	10	8	11	3	12	3	5	1	5	9
5	8	12	9	10	1	11	2	4	3	4	8

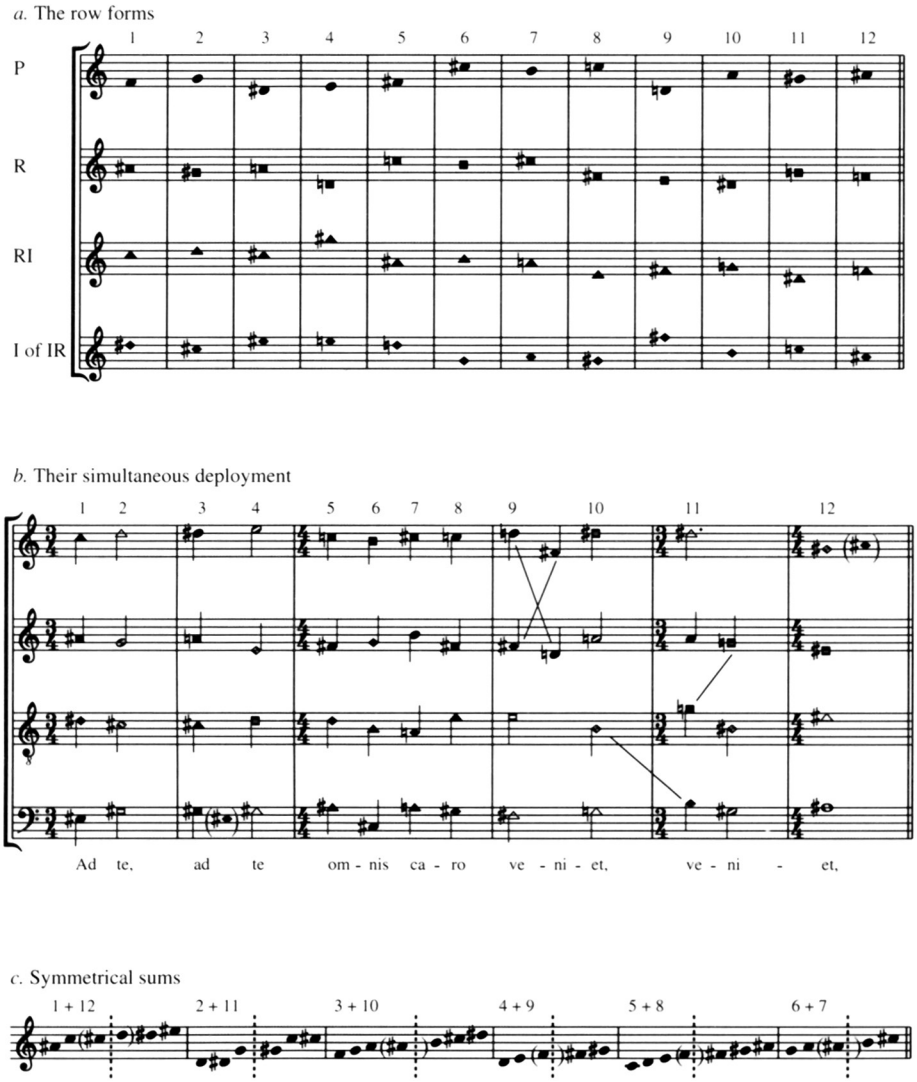
Compared to figure 49.8, it is easier to see the numbers in this image. Pulling the numbers for the accompanying voices below the music makes it easier to see that each chord contains one of the row's discrete trichords. It would be better, of course, if the numbers aligned with the chords in the notation. Also, why not use the same size font for the violin 1 line as the other three? Finally, since the grouping of the chords into threes seems intended to clarify that the three trichords are the complements of the melodic trichord, this could be conveyed with minimal additions to the notation. Pulling the pitch-class numbers outside the staves makes it slightly harder to connect an individual pitch to its order number. That may be justified in this case.

Online Figure 49.11 Werner Krützfeldt, "Polyphonie in der Musik des 20. Jarhhunderts: Die Logik der Linie," in *Musiktheorie*, ed. Helga De la Motte-Haber and Oliver Schwab-Felisch, 311–34 (Laaber: Laaber, 2005), 328.



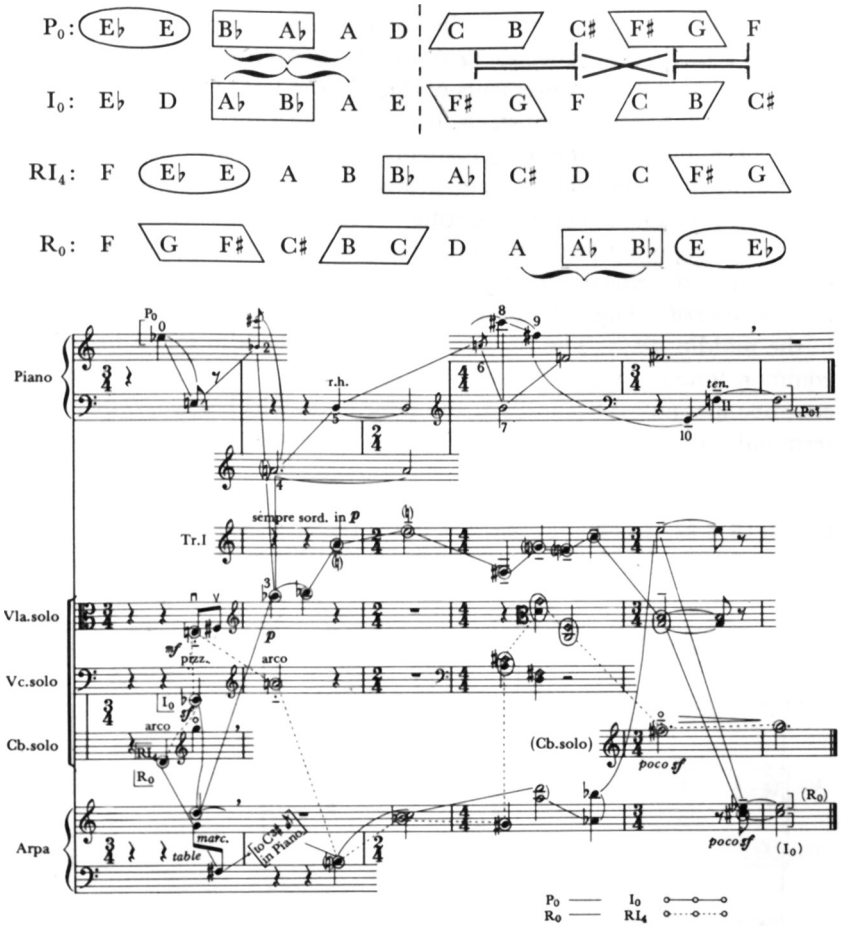
Pulling a twelve-count away from the music notation entirely is rarely successful.

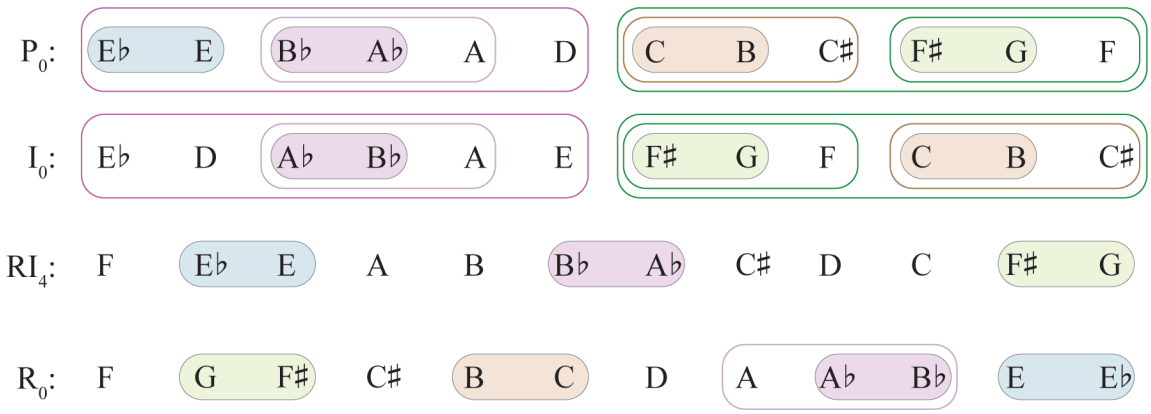
Online Figure 49.13 Richard Taruskin, "The Traditional Revisited: Stravinsky's *Requiem Canticles* as Russian Music," in *Music Theory and the Exploration of the Past*, ed. Christopher Hatch and David W. Bernstein, 525–50 (Chicago University of Chicago Press, 1993), 530.



Shape notes represent the four row forms that make up this music. Though novel, the approach is visually ineffective as the shapes are insufficiently differentiated to make them pop out from one another. It would be clearer to simply draw lines to follow row forms as they jump from one voice to another. Doing so with a line style (and possibly color) that is distinct for each row type would add to the effect.

Online Figure 49.17 *Above*, Gary E. Wittlich, "Sets and Ordering Procedures in Twentieth-Century Music," in *Aspects of Twentieth-Century Music*, ed. Gary E. Wittlich, 388–476 (Englewood-Cliffs, NJ: Prentice-Hall, 1975), 419; *below*, partial redrawing.

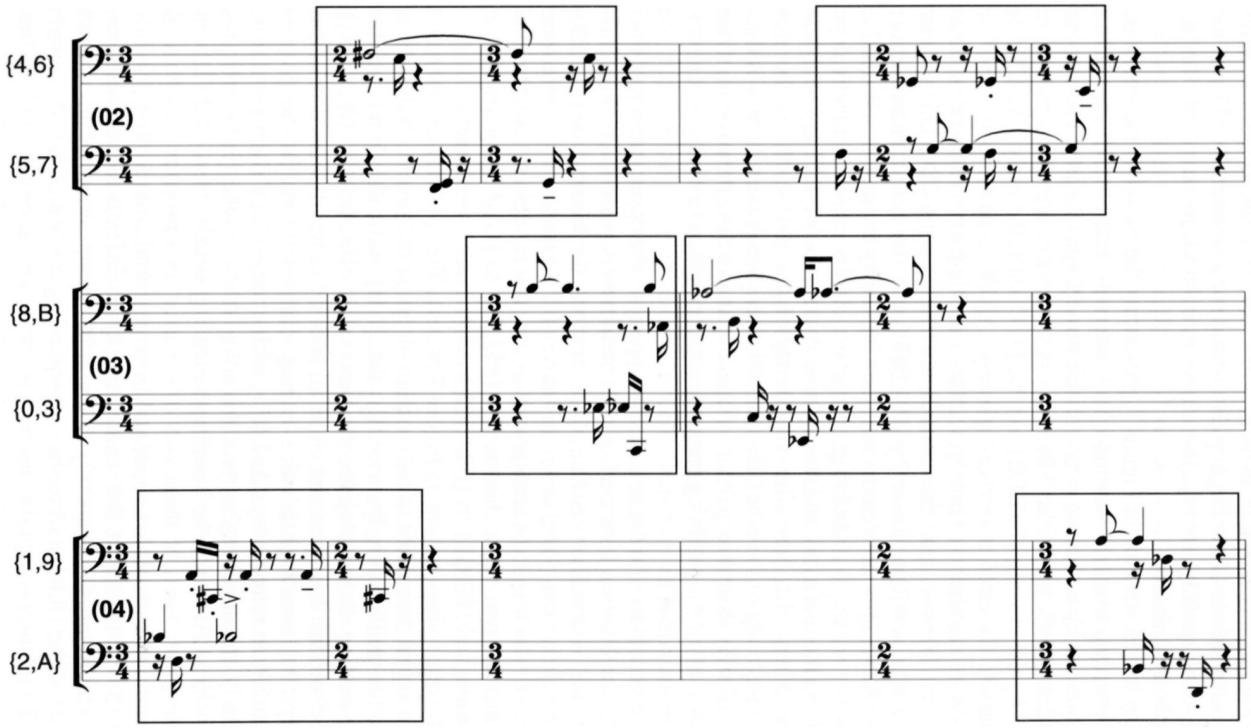




The image at the top does something similar to figure 49.16, with the row from Igor Stravinsky's *Movements for Piano and Orchestra*. A different shape encloses each invariant dyad, while brackets or braces connect a couple of invariant trichords. The invariance (via combinatoriality) between the first half of P_0 and the second of I_0 is suggested by the dashed line between the two hexachords. The multiplicity of shapes, while informationally valuable, gives the image a busy feeling.

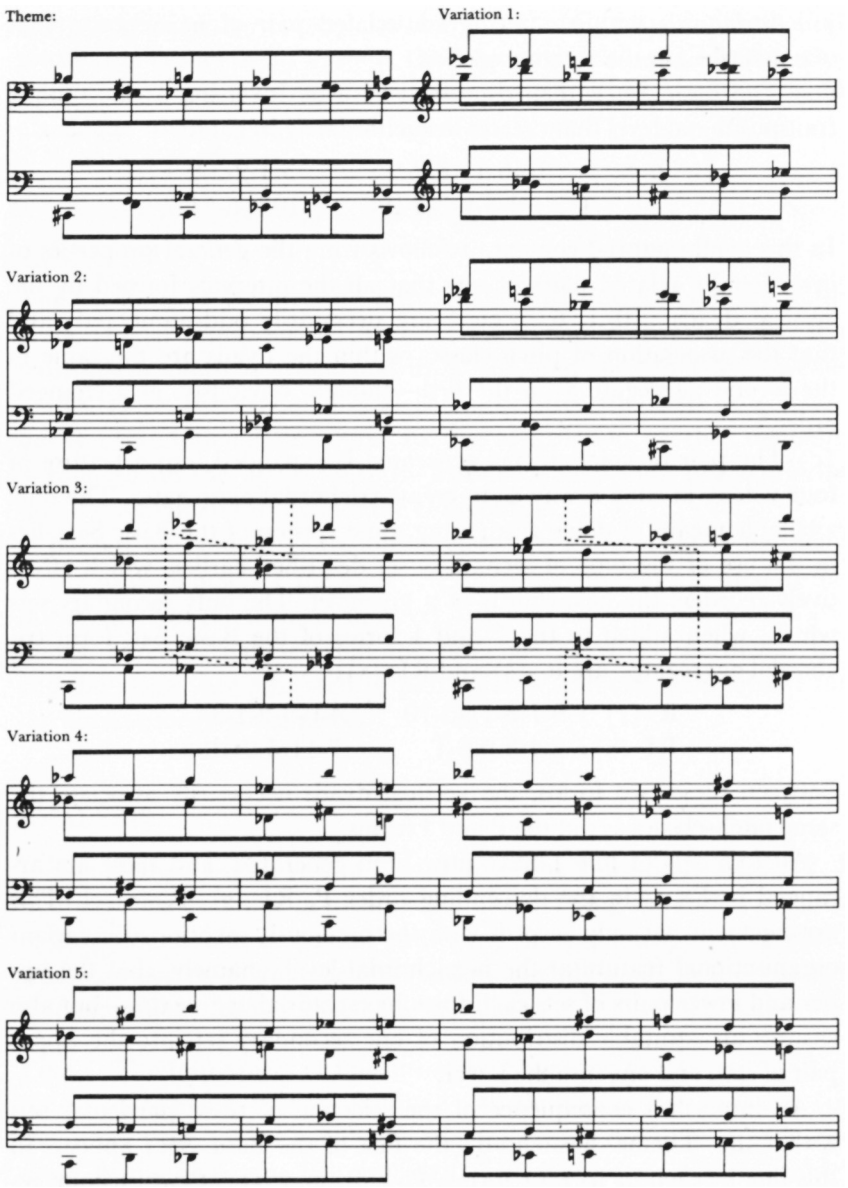
The modest redrawing below replaces the enclosures with color-coded rounded rectangles, filled for dyads and open for larger collections. The uniform shape makes the image feel more cohesive and less cluttered. Color-coding makes it easy to locate recurrences of each collection in other row forms.

Online Figure 49.18 Richard Kurth, "Partition Lattices in Twelve-Tone Music: An Introduction," *Journal of Music Theory* 43, no. 1 (1999): 49.



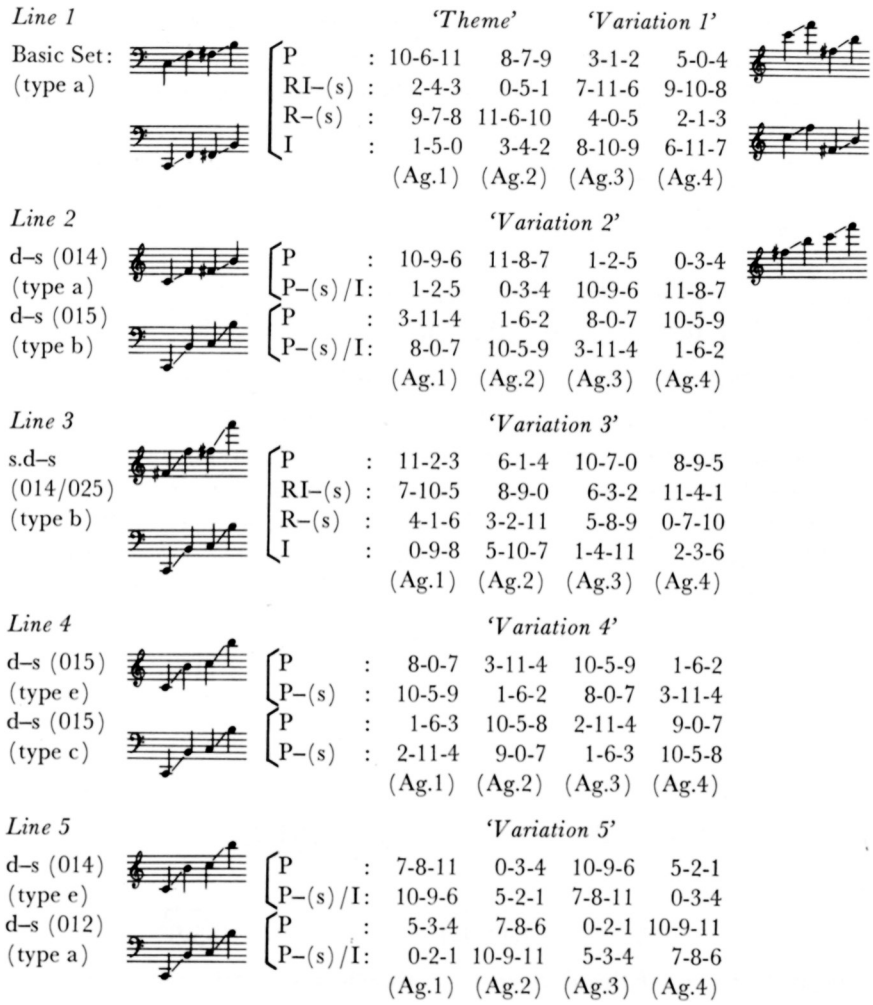
This image partitions the row from Milton Babbitt's *Semi-Simple Variations* into dyads, two each of (02), (03), and (04). In a way similar to figure 49.15, it segregates the dyads by type and puts each dyad instance on a separate staff. It would be better if the dyad types were more prominent—for example, larger and in the left-most position in the image.

Online Figure 49.19 Christopher Wintle, "Milton Babbitt's *Semi-Simple Variations*," *Perspectives of New Music* 14/15 (1976): 128 (*this page*), 129 (*following page*).



Like online figure 49.18, this image involves Babbitt's *Semi-Simple Variations*. (Figures 49.1 and 49.2 are from the same source.)

The work, while rhythmically activated, can be viewed as four-voice homophony throughout, as in the first image (above). The layout subtly (perhaps too



subtly) suggests the work's thoroughgoing combinatorial organization. Each voice in the texture completes the twelve-note aggregate across each system. Together, each pair of voices completes the aggregate every six chords, which is indicated by the beaming of hexachords together. And all four voices together complete the aggregate every three chords, as subtly suggested by bar lines. This organization could be made explicit on the image rather than in the prose.

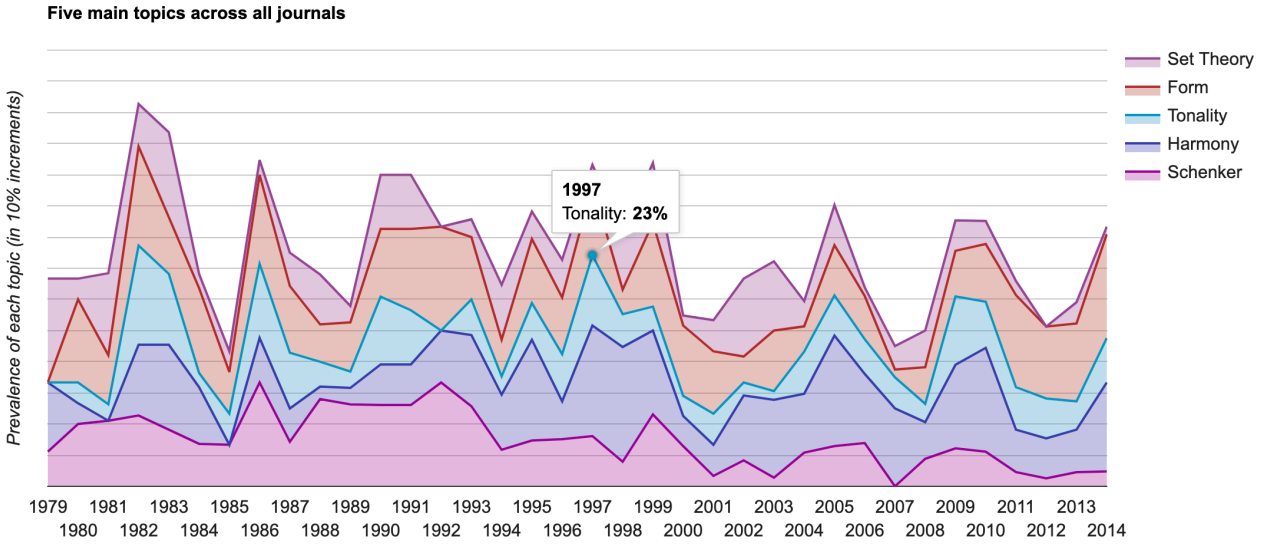
The organization is more explicit in the second image (above), but even there not fully so. Row labels to the left of each voice strongly imply aggregate completion by each row, while "(Ag. 1)" labels aggregate completions by the four voices together across groups of three chords. Aggregates by paired hexachords are not indicated here at all, however. This second image helpfully adds the registers within which each voice is contained in each row (or half row in the top one and a half lines).

Online Figure 49.20 Zachary Bernstein, "The Seam in Babbitt's Compositional Development: *Composition for Tenor and Six Instruments*, Its Precedents, and Its Consequences," *Perspectives of New Music* 56, no. 1 (2018): 196.

Measures	8–9	10–11	11	12	12–13	13	14	14–15	15	15–16	16	17–18	18
Strings	S_1: 132045	e6t	798	RI_t: 32	4	1		506		7e	9	8	t
Winds	I_t: t89e76	051	423	R_1: 89	7	t			6e5	40	231		
Percussion and Brass		R_8: 342	51	60			e7	9t8		I_5: 53	46	21	
Strings and Winds		RI_3: 879	6t	5e			04	213		S_6: 68	75	9t	
Winds and Percussion			S_e: e	1	0		t23						9
Strings and Brass			I_0: 0	t	e		198						2
Percussion and Strings				R_9: 4	5	362		7		1			0
Winds and Brass				RI_2: 7	6	859		4			t		e
Three timbre groups					S_8: 8t9	7		e	0			(0e)	
Four timbre groups					I_3: 312	4						[0e]	
Percussion						R_4: e0			t192		8	73564	
Brass							RI_1: 65		7483	9t2	0e		1 S_4: 465378
Partitioning	(6^2)	(3^4)	$(3^2 2^2 1^2)$	$(2^4 1^4)$	$(3^2 1^6)$	$(3^2 21^4)$	$(3^2 2^3)$	$(3^3 1^3)$	$(4^2 31)$	$(32^4 1)$	$(32^3 1^3)$	$(52^3 1)$	(71^5)

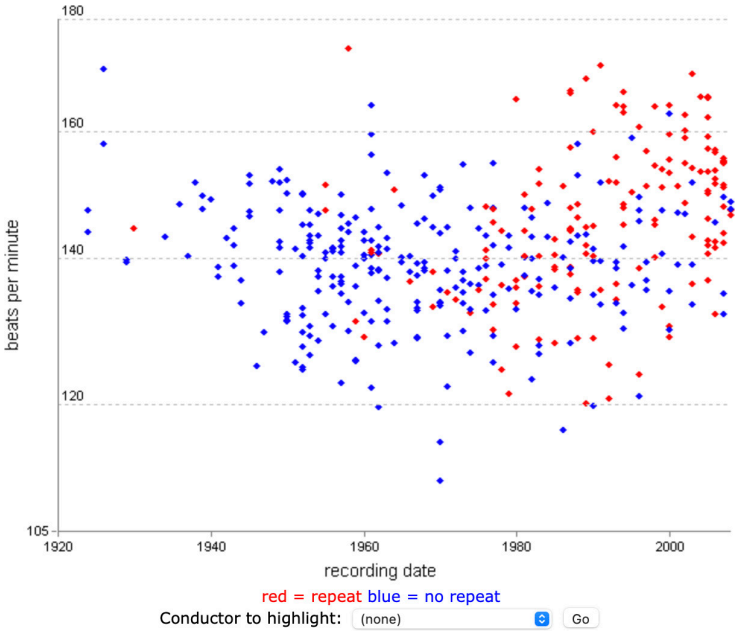
Compared to online figures 49.18 and 49.19, here the formation of aggregates is laid out explicitly. Despite the lack of notated pitch, information on the image is not terribly far from the musical surface. The (instrumentation) × (measure-number) grid makes reference to the score relatively easy.

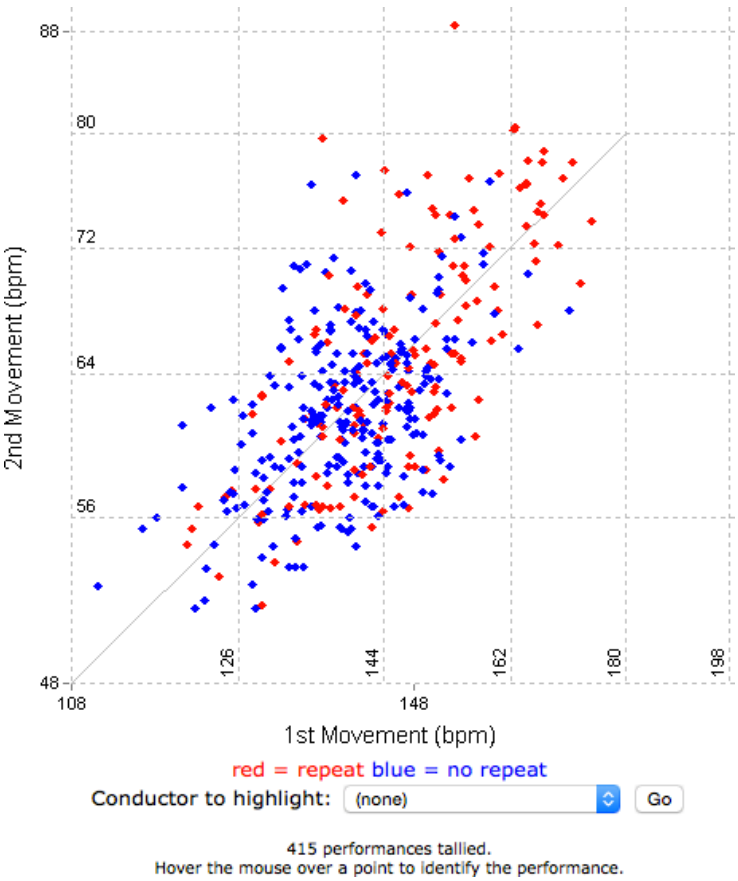
Online Figure 50.9 Ben Duinker and Hubert Léveillé Gauvin, "Changing Content in Flagship Music Theory Journals, 1979–2014," *Music Theory Online* 17, no. 4 (2017): ex. 3, https://mtosmt.org/issues/mto.17.23.4/mto.17.23.4.duinker.html.

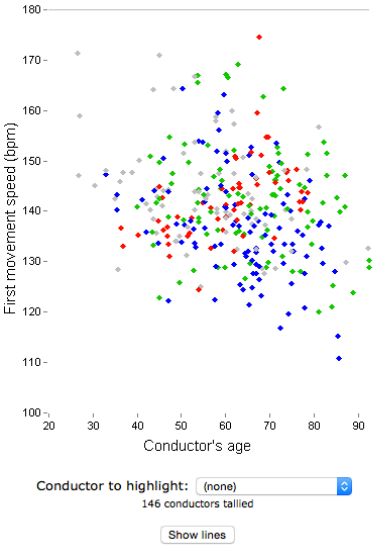


This image above graphs the prevalence of five broad topics in articles published in major music theory journals across a thirty-five-year period. In a stacked graph like this, the top line shows the aggregate of all five values, while different colors represent the share of those values made up each year by the individual topic areas. One can readily perceive only the shape of the lowest set of values and the aggregate. Changes in the other categories require more effort to tease out. This is an evitable byproduct of the design. In the live version of the image, it is possible to see the individual values by pointing with the mouse, as was done for the image captured here. Better would be to integrate the information directly, for instance by including the data value for each node.

Online Figure 50.10 Eric Grunin, "An Eroica Project," accessed December 27, 2009, http://www.grunin.com/eroica/index.htm, site discontinued.







16 faster		29 neutral		25 slower	
Abbado	13.6	Abendroth	0.6	Barenboim	-3.5
Ansermet	3.7	Asahina	1.1	Bernstein	-5.3
Blomstedt	5.8	Böhm	-1.8	Dohnanyi	-7.4
Ferencsik	5.8	Boult	-2.8	Fricsay	-8.6
Frühbeck de Burgos	3.5	Brüggen	1.2	Furtwängler	-3.4
Haitink	5.5	Celibidache	-1.5	Gardiner	-7.8
Herbig	4.9	Davis	2.7	Giulini	-3.0
Horenstein	9.5	Dorati	-1.2	Jochum	-3.0
Karajan	8.5	Gielen	-0.7	Kegel	-5.1
Kletzki	5.1	Ivanov	2.3	Keilberth	-6.3
Masur	5.5	Kempe	0.7	Kleiber	-3.0
Munch	3.6	Konwitschny	0.4	Klemperer	-18.1
Ozawa	11.6	Koussevitzky	2.7	Knappertsbusch	-15.7
Scherchen	4.7	Maazel	-0.0	Kubelik	-14.0
Solti	8.3	Markevitch	0.4	Leinsdorf	-6.0
Stein	3.4	Mengelberg	0.0	Mackerras	-5.9
average	*6.4*	Monteux	-0.7	Mitropoulos	-8.5
		Morris	-0.9	Mravinsky	-4.3
		Norrington	-2.5	Ormandy	-6.1
		Otterloo	-1.4	Sawallisch	-5.9
		Rattle	-0.9	Schuricht	-6.7
		Steinberg	2.2	Serebrier	-4.5
		Tennstedt	-1.5	Swarowsky	-3.9
		Tilson Thomas	0.8	Szell	-5.2
		Toscanini	-2.9	Walter	-6.5
		Vonk	-0.3	*average*	*-6.7*
		Wakasugi	-1.5		
		Wand	2.2		
		Wislocki	1.7		
		average	*-0.1*		

Neutral = last performance within 3% of their first.

These images are from a marvelous but now-defunct website that explored tempos taken in 415 performances of Beethoven's Symphony no. 3.

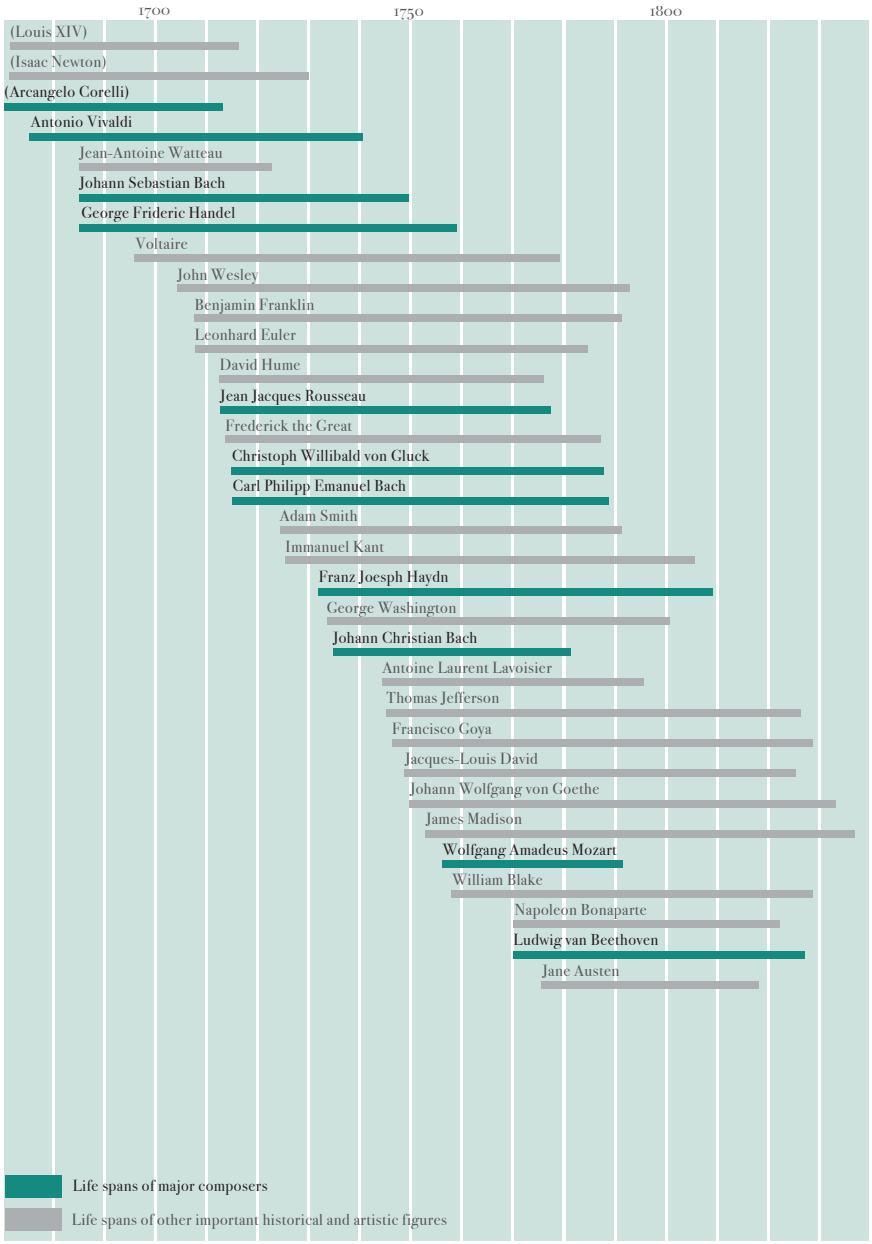
The first traces first-movement tempos by recording date. An additional data point, whether the exposition repeat was taken, is encoded by color (red means yes). Only 38 percent of performances logged here take the repeat, though the image makes clear that the practice became much more common later in the period. In the original website, one could highlight performances by a selected conductor. Images like this would benefit from trend lines that track tendencies over time.

The second image graphs the tempo relationship between the first and second movements. The gray line shows the relationship between Beethoven's notated tempos, 180 bpm and 80 bpm, respectively. The image suggests that performances tend to be roughly equally distributed around this proportion, though with some notable outliers. The color-coding suggests that the fastest performances tended to be those in which the first movement repeat was taken (shown in red). The image would be enhanced with additional lines showing deviations that were, say, 10 percent faster or slower than this proportion.

For conductors with more than one recorded performance in the database, the final image plots first-movement tempo against the conductor's age for the first and last performances. Conductors whose last performance was faster than their first are in red, those who got slower are in blue, and those whose last performance

was within 3 percent of their first are in green. Names of those who omitted the exposition repeat on their first performance but took it subsequently are in cyan, while those who took the repeat earlier in their career but abandoned it later are in brown (unfortunately hard to distinguish from black). There is a lot of information here, and the trees mask the forest to a considerable extent. The ability to highlight all performances by a conductor in the full interface helped, though. A designer creating such an image with today's improved web tools could make it possible to highlight any combination of conductors, to draw lines between their performances, and to add trend lines to show the general tendency of conductors to take slower tempos as they age.

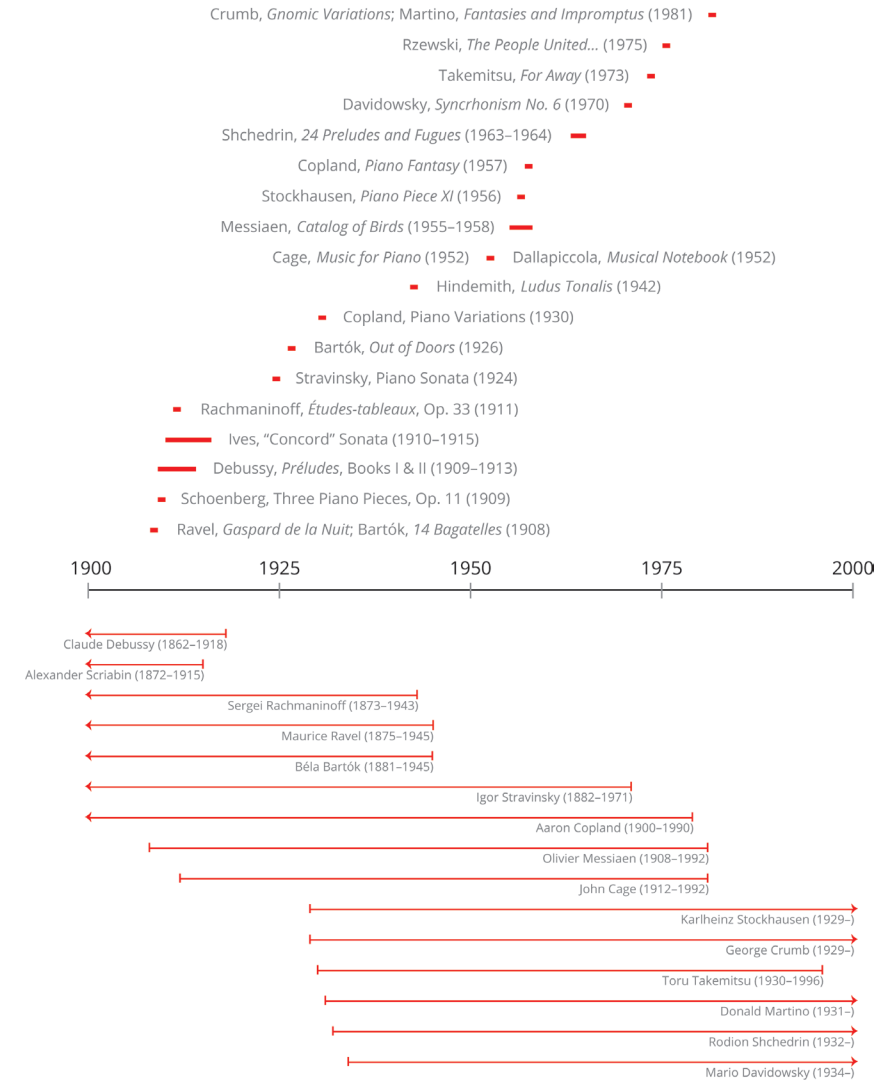
Online Figure 51.2 Joseph Kerman, *Listen*, 3rd brief ed. (New York: Worth, 1996), 98.



This image displays the life spans of major composers and some of their important contemporaries during the period 1670–1850. The inverted color grid used here (a shaded background with white lines) is sometimes an attractive alternative to the traditional grid. The consistent placement of name below the time span makes the extent of the bars unambiguous, compared to figure 51.1. Although the layout here is in many ways more precise than in figure 51.1, it does not reflect the depicted figures' periods of professional activity.

Online Figure 51.4 Redrawing of fig. 51.3.

This redrawing of figure 51.3 borrows features from figure 51.1 and online figure 51.2. The text is softened a bit, and the lines and work markers appear in a contrasting color. The work markers are also heavier, and because their accompanying text labels are a little farther away, they stand out more. In the lower part of the image, a whisker has been added to endpoints that fall within the century and arrows replace underscores to represent a date range extending beyond the image's 1900–2000 time frame. While in figure 51.1 it was unclear whether text was an extension of a line, the color contrast and the new endcaps on the lines here make that less ambiguous. Nevertheless, the redrawing places the composers' names and dates below the red arrows to eliminate any possible confusion. It also aligns the composers' names with the end of their lifeline, recognizing that composers are more likely to be professionally active at the end of their lives than at the beginning.

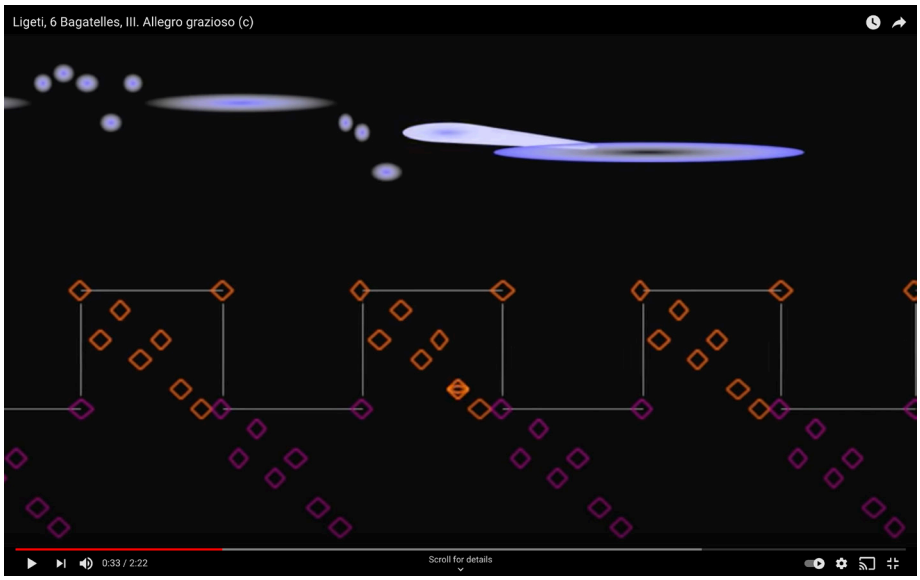


Online Figure 52.2 Screenshot from Michal Levy, "Giant Steps," YouTube, 2001, animated short set to the tune by Charlie Parker, 1:29, https://www.youtube.com/watch?v=rh6WTAHKYTc.

The video that this screenshot comes from exudes joy. Although it visually responds to musical cues in Charlie Parker's immortal recording, it does not in itself presume to communicate about the music.

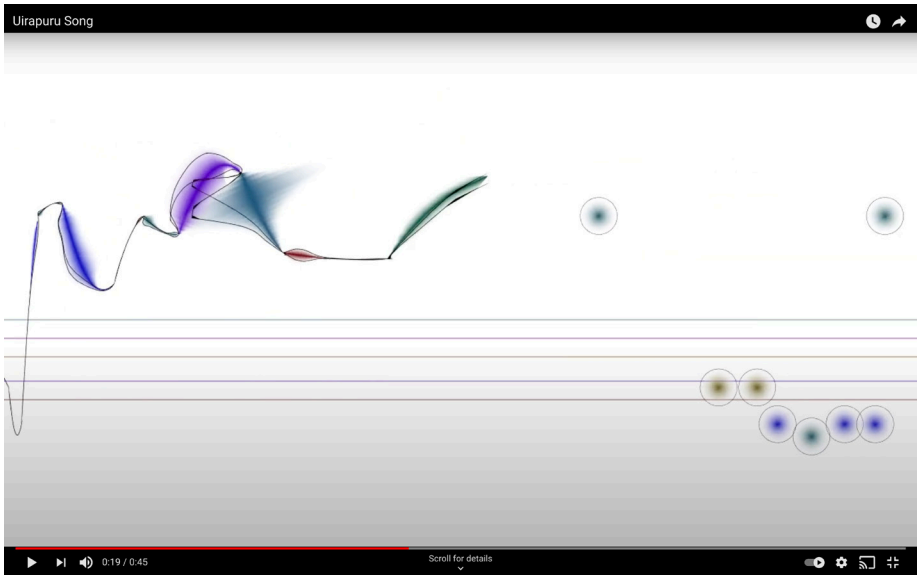
Online Figure 52.4 Screenshots from various animated graphical scores by Stephen Malinowski:

"Ligeti, 6 Bagatelles, III. Allegro Grazioso," smalin, video, July 19, 2013, 0:33, https://www.youtube.com/watch?v=LufirJIGzo0.

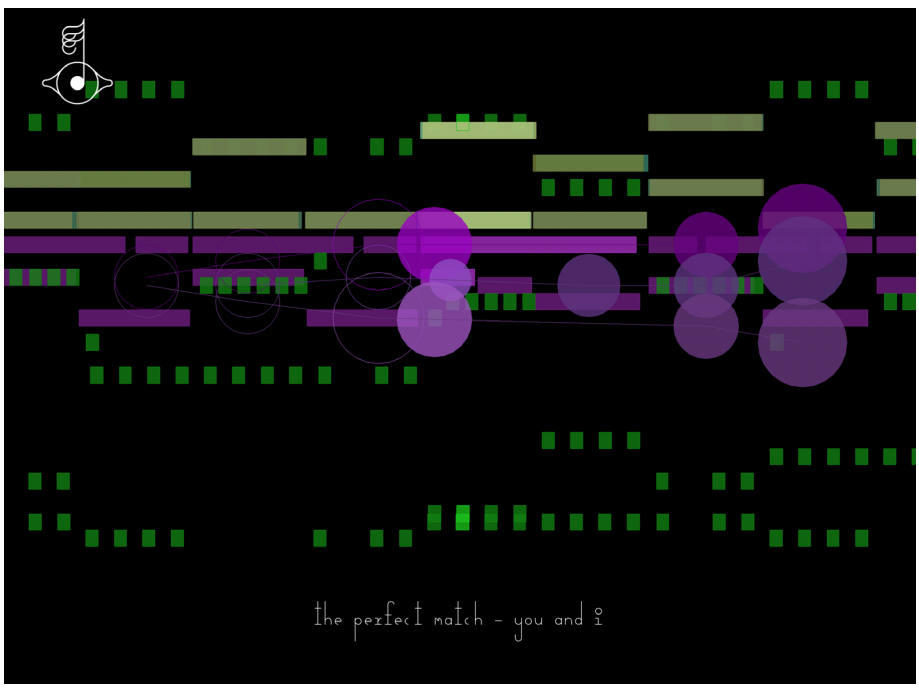


"Gesualdo, Moro, lasso! Al mio duolo," smalin, video, November 17, 2018, 0:45, https://www.youtube.com/watch?v=TFJpgdZmUzQ.

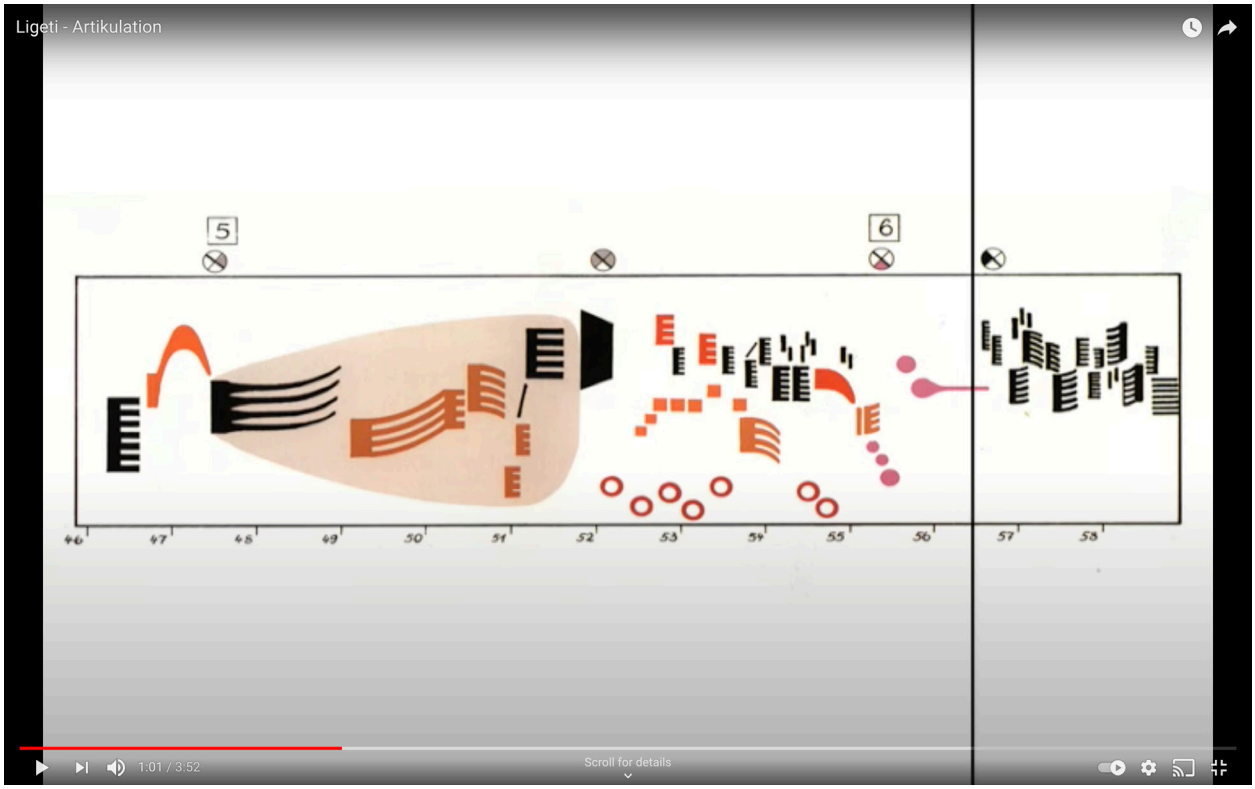
“Uirapuru Song,” smalin, video, January 12, 2021, 0:19, https://www.youtube.com/watch?v=9Pc1j5GqUsY.



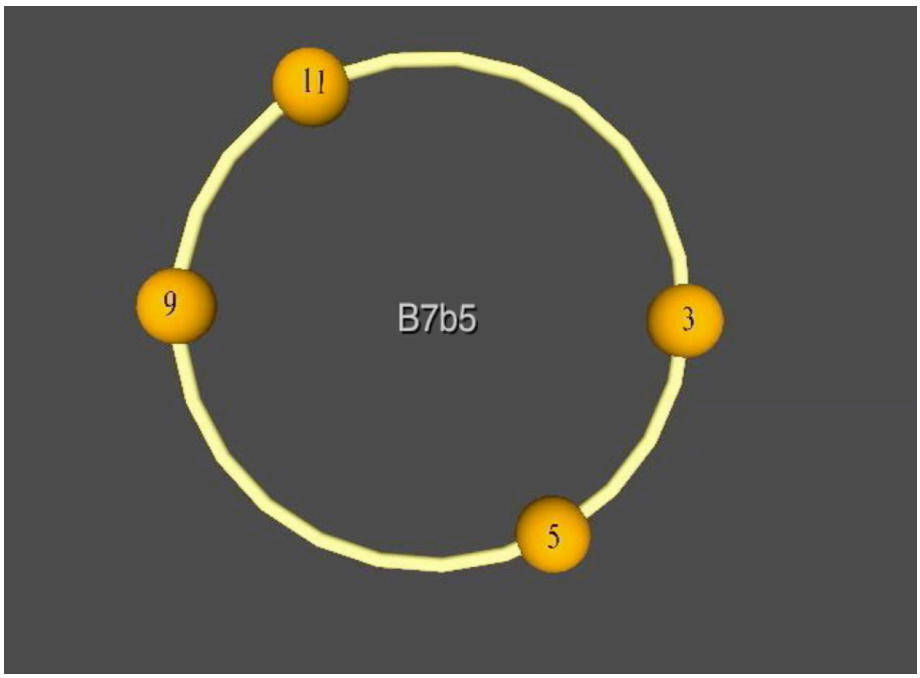
iPad app from Björk, “Virus,” *Biophilia* (One Little Indian. Records, 2011).

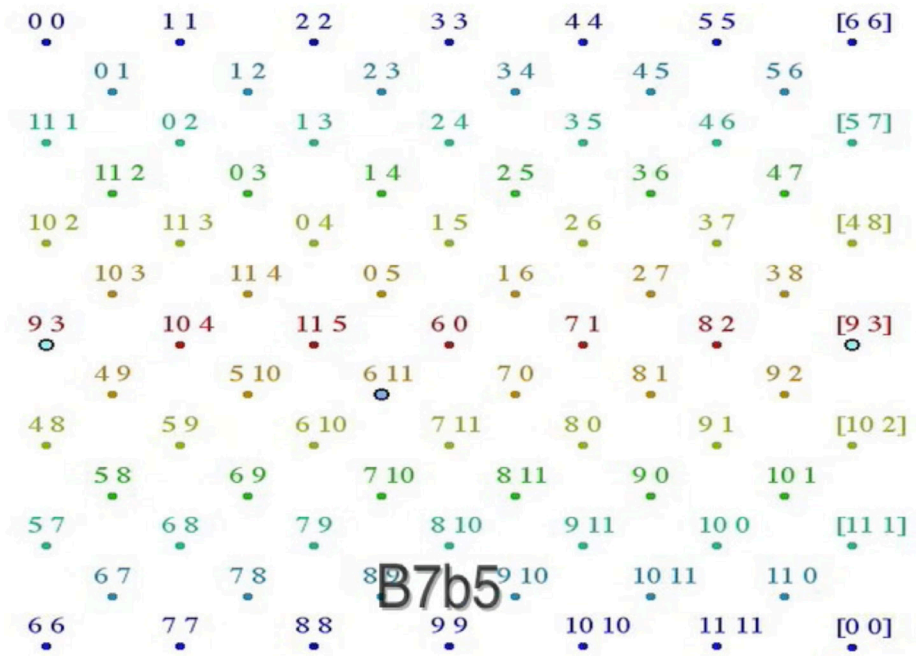


Online Figure 52.5 Screenshot from video based on score created by Rainer Wehinger for György Ligeti, *Artikulation* (Mainz: B. Schott's Söhne, 1970). "Ligeti—Artikulation," Donald Craig, video, May 28, 2007, 1:01, https://www.youtube.com/watch?v=71hNl_skTZQ.



Online Figure 52.8 *Above*, screenshot from Dmitri Tymoczko, "ChordGeometries Demo: Chopin—Circular 'Pitch Class Space,'" video, February 23, 2011, 0:12, https://vimeo.com/20300784; *below*, screenshot from Dmitri Tymoczko, "ChordGeometries Demo: Chopin on a Mobius strip," video, February 23, 2011, 0:14, https://vimeo.com/20301044.





Online Figure 52.9 John Roeder, "A Transformational Space Structuring the Counterpoint in Adès's 'Auf Dem Wasser Zu Singen,'" *Music Theory Online* 15, no. 1 (2009): animation 4, 0:18, https://mtosmt.org/issues/mto.09.15.1/roeder_space_examples.php?id=5.