Eric Isaacson

Augenmusik Today

Introduction

My title is a play on a term used to describe music notated with unusual graphical techniques. The practice is found most often in the Renaissance and Baroque periods of music, for example in Baude Cordier's *Belle, bonne, sage*, an early 15th century piece on the subject of love. The musical notation is arranged in the shape of a heart and even includes a small red heart on the manuscript. More recent examples include selected movements from American composer George Crumb's four volumes of piano pieces titled *Makrokosmos* (1972, 1979). In volume 1, for example, notation for movement 4, "Crucifixus," is arranged in the shape of a cross, while in movement 8, "The Magic Circle of Infinity (Moto Perpetuo)," most of the music is written around a circle. Another example is in Figure 1, which recreates an image of unknown origin that depicts the surname of Johann Sebastian Bach using a single pitch that is read in each of four clefs, arranged on two staves in a cross shape. In treble clef on the left, the pitch is B-flat (B in German), in tenor clef above it is A, in alto clef to the right it is C, and in the treble clef below, B-natural (H in German). In representing music in graphically unusual ways, a composer expresses the music in a way that enriches the experience, though the meaning of such notation is of course obvious only when seen with the eye, which is why the term *Augenmusik* is fitting.

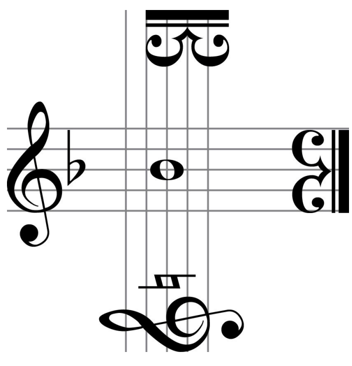


Figure 1: The name BACH spelled using four clefs

I am interested in a different kind of *Augenmusik*. I will explain using the children's song „Bruder Jakob" (known in French as „Frère Jacques," in English as "Are You Sleeping?," and familiar also in many other languages). The song has a simple four-phrase structure:

> Bruder Jakob, Bruder Jakob,
> Schläfst du noch? Schläfst du noch?
> Hörst du nicht die Glocken? Hörst du nicht die Glocken?
> Ding, dang, dong, ding, dang, dong!

None of the four text lines rhyme and each line contrasts with the others musically as well. A structure with four contrasting phrases might be represented very simply using letters: a b c d. The contrast is more visually obvious, however, if we represent each phrase using a differently colored block (Figure 2).

The song is often sung by school children as a four-part round. We could describe the process in prose: "Divide the group of singers into four groups. Group 1 sings the song. As they begin the second phrase, group 2 starts with phrase 1. Group 3 enters when group 2 starts the second phrase. Group 4 enters when group 3 starts the second phrase. Each group may sing the entire song once or twice." The structure when the song is sung through twice as a round can again be represented as text (Figure 3) or using colored blocks (Figure 4).

Rendering what is effectively a performance script using colored blocks makes the cascading effect as each phrase is passed from one group down to the next stand out more obviously because of the addition of color, which the brain processes more readily than the text alone. This represents well the experience of performing this (or any other) round. It does not necessarily reflect the listening experience, however, which, once the fourth part has entered, feels more static, as if the same thing occurs over and over. The representation in Figure 5 captures this more effectively. Text has been added to the blocks, while numbers now indicate which of the four groups is singing a phrase at each moment.

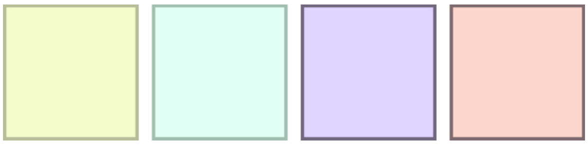


Figure 2 : Form of the tune “Bruder Jakob”

1:	a	b	c	d	a	b	c	d			
2:		a	b	c	d	a	b	c	d		
3:			a	b	c	d	a	b	c	d	
4:				a	b	c	d	a	b	c	d

Figure 3: Structure of a four-part round, as text

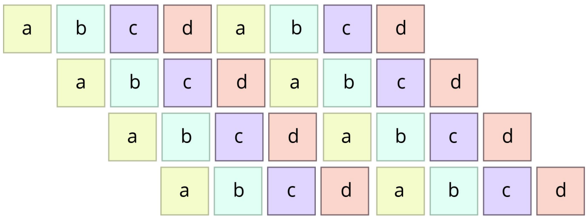


Figure 4: Structure of a four-part round, using blocks

Figure 5: “Bruder Jakob” from the listener's perspective

Here we see the power of even a simple visualization to shape musical understanding. The example also illustrates that, while our perception of music is aural, our conception of it is not entirely so. In fact, much of how we understand music derives from the human capacity to draw analogies[1]**.** In the case of Figure 5, you were invited to hear contrasting melodic phrases as analogous to blocks with contrasting colors, to associate each of four groups of singers with a number (1, 2, 3, 4), and, by associating left with earlier and right with later, to associate passing time with changes along the horizontal dimension.

While some aspects of musical thought are truly abstract—our emotional response to a piece, how it triggers social engagement, and so on—many aspects of musical thought have an embodied quality—which we think about using spatial metaphors. These include pitches as objects and time as motion along a continuum. Both of these metaphors, which are explored at length by a number of scholars,[2] invite and enable us to create visual representations of music that illuminate and inform.

This impulse is the source of my adoption of the term *Augenmusik* in this article’s title. In my forthcoming book, *Visualizing Music,*[3] I explore the art of communicating about music through graphical images. The word “communication” is key, in that it implies that there are two agents—an image’s creator and its viewer. (I use the word image to mean any visual representation, whether a musical example, a graph or table, or anything else graphical in nature.) Because visualization can be a powerful tool in discovery, it is even possible for researchers to use visualization as a tool to communicate to themselves, but I focus here on visualization between two parties: the one creating a visualization and the person who views it. The intentionality of this communication is important because it suggests that an image’s creator must be sensitive to how the viewer will perceive and understand a visualization. That is, an image cannot only reflect the producer’s understanding. It should be created in a way such that the intended viewer will reach the same understanding.

In my book, I interpret the phrase “about music” quite broadly. An image might be pertinent to a single musical work, or even a small segment of it, to different editions of it, to a live or recorded performance, or to the set of all recorded versions of the song. It might refer to the collected works of a group or a composer. It might refer to an entire genre, such as North Indian Raga, Amazonian folk music, or Classical-era string quartets. It might refer to abstract music theoretical concepts like scales, the overtone series, instrumental timbres, or harmonic syntax. It might refer to style evolutions, such as the way blues evolved into the almost innumerable subgenres of jazz and rock. This article will ignore metamusical visualizations (instrument ranges, historical, etc.), however, and instead will focus on visualization of theoretical musical spaces, musical works, and sometimes their combination.

Music is ephemeral—it truly exists only in our minds, sometimes, though not necessarily, with input from our ears. Above we alluded to the value of the pitch-as-object metaphor. The metaphor allows for more complex analogies such as contour, size, texture, density, and more. As useful as visualization is for representing music's pitch dimension, it is even more powerful when it comes to musical time. While we see in two spatial dimensions, plus parts of a third made possible by our binocular vision, we do not see time, we only experience it. It turns out that, as with pitch, many of our conceptions of musical time are tied to the physico-spatial realm. Basic temporal ideas like beats, beat groupings, tempos, and cadences have direct analogs to walking, marching, and dancing. We talk about musical time "flowing" as if it were a river, and discuss musical proportion in direct analogy to spatial proportion. All of these features have readily available visual representations in the field of data visualization. Musical drawings have the power to fix the ephemeral into something more concrete, allowing us to ponder music in *our* time, not *its* time.

In this article, I describe four music visualization strategies that have proven effective at enhancing musical understanding. The first involves collapsing the musical score into a single pitch space in which music is represented like a piano roll. Next, I discuss how the pairing of music analysis and the representation of abstract musical spaces can add meaning to music analysis. The third strategy highlights the importance of comparison for facilitating understanding in musical contexts. The fourth section discusses musical narratives—how images can be constructed to tell a story about the music it represents. It is useful to consider not only design strategies but also design techniques, about which many readers of this journal are already more expert than I am. Nevertheless, I believe it will be informative to close with a brief appreciation of the system of Western music notation. I have tried to keep advanced music theoretical jargon to a minimum, though a knowledge of the rudiments of music will be helpful. Where possible, I have provided links to performances on YouTube.

Collapsing the Score

One of the most powerful metaphors Western listeners employ when listening to music is the mapping of sonic frequency to spatial height; for example, we describe the tuba as "low" and the flute as "high." The metaphor is so automatic to musicians that they use the word "contour" to characterize the overall shape of a melody. Figure 6 shows the opening melody of Ludwig van Beethoven's third symphony (the "Eroica"). While the violins are reading from the notated music, the listeners are more likely simply hearing a series of pitches that are higher or lower than the previous ones as suggested by the lines shown in green. Here the notes are stepped as if marking the tops of buildings in an urban skyline. This representation also strongly resembles the perforations on a piano roll, which is used to mechanically control a player piano. In a piano roll, perforated regions in a paper scroll encode pitches in one direction and the onset time and duration in the other. (A video article by Stephanie Probst, one of the few scholarly articles that discusses piano rolls, is worth a few minutes of your time[4].)

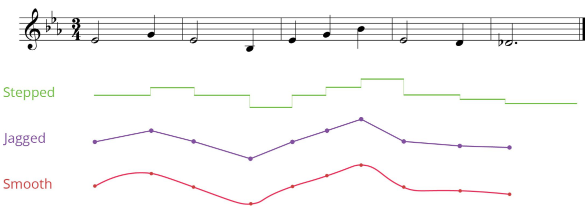


Figure 6: Theme to Beethoven's Symphony No. 3, "Eroica," movement 1

But many hear melodic notes as connected more than the little vertical lines might suggest. The jagged purple contour makes the connections between pitches more explicit and gives more emphasis to the shape of the melody as a whole than to its individual notes and is perhaps more similar to a mountain range. Some may find that the third version (red) even better reflects how they hear the melody—smoothed out as it would be if we were to trace the melody in the air with our hand. For those who hear the melody this way, it feels closer to how we actually experience it in our bodies. All three are reasonable visualizations of the contour of Beethoven's melody, reflecting "truths" from different vantage points.

While the one-to-one mapping between pitches and the contours in Figure 6 is clear, the picture is far less tidy in a typical musical score. Musical scores are designed for performers or, in the case of music for large ensembles like an orchestra, for conductors. A score for symphony might have 20 or more staves aligned across each page, each representing the music for a section of the orchestra, and while the notes on a single staff will be mapped low-to-high as in Figure 6, the parts themselves are sorted by instrument family, not pitch. In other words, a musical score functions in much the same way as Figure 4, which makes clear which phrase of “Bruder Jakob” each group is singing. Like Figure 4, a score often does not effectively convey the overall listening experience. For this, something like Figure 5 is more effective.

Visualizations inspired by the piano roll do this. In a physical piano roll, lower pitches are on the left and higher ones on the right. Piano-roll-style images, meanwhile, typically represent pitch vertically, while time proceeds left-to-right, as in standard notation. This form of piano-roll notation differs from traditional notation in two important ways. The first is that it collapses all the many parts of a musical texture onto a single grid. This can be especially helpful when reducing scores that otherwise present pitch information out of registral order, as in an orchestral or band score as described above. The second is that time is represented more proportionally than the notated rhythms, which can provide a more visually consistent sense of musically measured time than notated meter does.

The piano roll informs a truly remarkable collection of more than one thousand videos created by Stephen Malinowski. They can be found on his YouTube channel (https://www.youtube.com/c/smalin) and are described on his Music Animation Machine website (http://www.musamin.com). In each video, a synthesized performance of a work is accompanied by an animated piano-roll-like visualization. (Malinowski’s work is discussed in detail in an article by Gabriele Groll elsewhere in this issue.) The screenshots in Figure 7 are taken from 3:32 and 10:35 of Malinowski’s animated score of Igor Stravinsky’s *Rite of Spring*. Pitch is represented on a faint grand staff that has been adapted so the space between staff lines a major third apart is greater than those a minor third apart. This makes the vertical grid chromatic (like a real piano roll) rather than diatonic as it is when displayed on a standard staff. The image assigns each pitch class a different color, so all Cs are in one color and all Fs in another, regardless of which octave they are in. It represents instrument families by different shapes: flutes are oval, double reeds are concave diamonds, clarinets are pointed rectangles, brass are rectangles, and strings are regular diamonds. The fills are translucent, so the bright note outlines show through, making it apparent when two or more instruments are playing the same note, as in the central chord in the upper image and in much of the second image’s first half. Attacks by percussion instruments are rendered as fuzzy shapes.

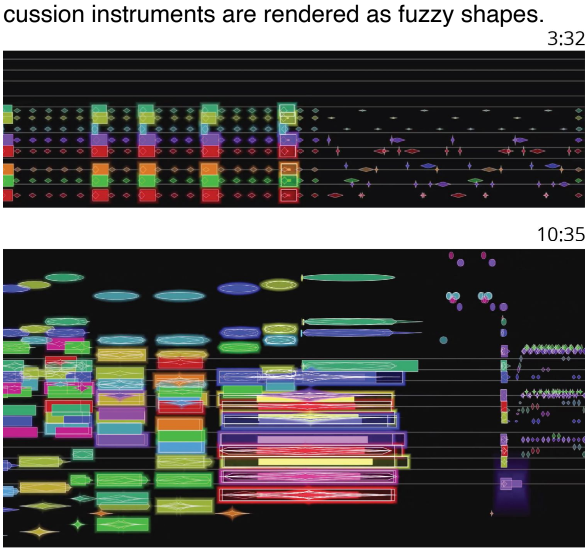


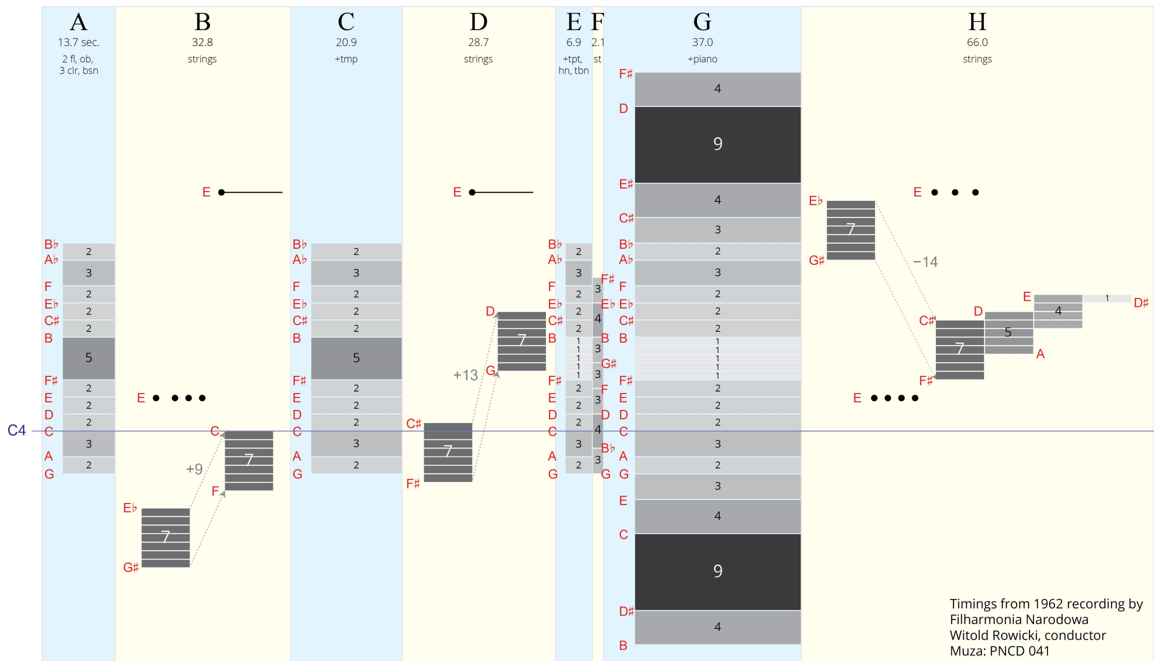
Figure 7: Screen shot of Stephen Malinowski, Animated Graphical Score of Stravinsky, *Rite of Spring* (2013), accessed 10 February 2015, https://www.youtube.com/watch?v=5IXMpUhuBMs, time index 3:32 (above) and 10:35 (below). Used by permission.

During playback, the image glides right to left, with the center point always representing “now.” A shape flashes when it is played and, over the duration of the note, the “fill” shrinks to nothing, while the outline remains (in the lower image, traces of this process can be seen in the notes just left of center). The flashes representing an attack sometimes drift to the next note in the melody as it shrinks, vanishing just at the point the next note sounds. This motion, which is an animated version of the purple lines in Figure 6, can help the listener trace individual parts of the texture. The animation appears to have been designed to correspond to a “humanized” synthesized version of the score, so attack and release points are rarely perfectly aligned. No horizontal grid is drawn, nor are rhythmic values shown, so it is not possible to get more than a gross sense of rhythm, except insofar as one can of course both see and hear the rhythm as the music plays.

The visual/aural analog and its explicit pairing is the most powerful element of the animation. Different aspects of the musical textural are easy to see as the animation plays. The upper image, for example, shows the moment when the famously dissonant chords from the “Dance of the Adolescents” give way to the triple ostinato at rehearsal number 14 in the score. Dynamics appear to be represented by vertical thickness. This contributes to some imprecision in pitch. In the lower image, bars on the left side that represent single pitches nevertheless occupy the vertical space of a fourth. Partly as a result, pitch details are hard to discern visually. The problem is exacerbated by the lack of ledger lines (short lines drawn as extensions when the music extends above or below the staff). In addition, without a metrical grid, familiar Stravinskian rhythmic techniques such as syncopation and polymeter are not visually apparent. Finally, because color recognition is more immediate than shape recognition, the image privileges pitch over timbre. Given the important role of orchestration in the work, it would not have been inappropriate to use color to represent instrument family and (say) shape for pitch. It would have led to a less varied color experience, however. The animation is a sophisticated advance on the piano roll and the viewing experience illustrates the distinct advantage to the collapsed view of the piano roll, particularly in complex scores.

The attitude of the piano roll is also present in Figure 8. The image visualizes the first movement of Witold Lutosławski’s *Venetian Games* (composed 1960–61). It is a reconceptualization of a similar drawing by Miguel Roig-Francolí[5]**.** The movement is highly modernist and employs a number of unconventional techniques. (The recording on which this visualization is based is available at
https://www.youtube.com/watch?v=XxsRMvlbEvQ).
The movement consists of eight sections, which are labeled in the score using letters A through H. These sections alternate between two types of music. The first involves a technique known as aleatoric counterpoint (described below). This occurs in sections the composer labels in the score A, C, E, and G. I will refer to these as the “odd-lettered” sections. The second

Figure 8: Representation of Lutosławki, *Venetian Games*, movement 1, inspired by a drawing in Miguel Roig-Francolí, *Understanding Post-Tonal Music* (New York: McGraw-Hill, 2007), 290.



type of music features quiet, sustained string-dominated music, labeled B, D, F, and H, which I will refer to as the “even-lettered” sections. The beginning of each section is marked by a *fortissimo* percussion strike (not shown in the image), which also initiates the closing of the movement.

The score indicates the durations of the odd-lettered sections in seconds: 12, 18, 6, and 24. Section A features seven unmetered, rhythmically active, and texturally independent lines played by woodwinds (two flutes, oboe, three clarinets, and bassoon), whose pitch material collectively contains each of the twelve notes of the chromatic scale, except that each of these pitches occurs only in a single octave, and these pitches are vertically symmetrical. The image, below A, shows the pitches of this chord and lists the number of semitones between adjacent pitches. This music repeats in each of the odd-lettered sections. The C section adds timpani, whose three pitches are not specified in the score and therefore do not change the chord. The E section adds three brass instruments (trumpet, horn, trombone), which draw from the four pitches that chromatically fill in the twelve-note chord’s central interval (5), preserving its vertical symmetry. The piano that enters in the G section adds eight additional pitches, four above and four below, which expand the sonority to 24 notes. Each of the twelve pitch classes sounds exactly twice, and this chord, like the sonorities in the other odd-lettered sections, is registrally symmetrical.

Sections B, D, and H feature eight-note pitch clusters that span seven semitones. These are transposed note-by-note up nine semitones in B, up 13 in D, and down 14 in H. The transpositions sometimes involve an intervening note that falls outside the transposition interval. These are not shown on the image. During the last section, after the seven-note cluster has completed its transposition, it contracts to five, then four, then finally one semitone. Repeated or sustained Es are played in each of these three sections. The very brief F section (ca. 2 seconds, according to the score) also features the strings, but its eight-pitch sonority is made up of stacked minor (3) and major (4) thirds, which are arranged symmetrically, like the sonority of the odd-lettered sections.

The image is a useful complement to both the score and the recording. While it completely smooths away the sonic chaos of the odd-lettered sections in particular, it uncovers the movement’s pervasive pitch symmetries. While the pitches that make up the chords are listed, the image emphasizes the symmetrically arranged intervals, coding them not only with numbers (measured in semi-tones), but using a luminosity scale (darker = larger). This allows the symmetry to pop off the page; numbers alone would not be nearly as effective. The symmetry could not be visualized without collapsing the texture (up to twelve instruments in the odd-lettered sections) onto a single vertical grid.

In the horizontal temporal dimension, by differentiating odd and even sections by color, the underlying alternation of sections is clear. The durations of the sections are referenced in the score in very small print. Tying the visual section widths to durations in a recorded performance reveals the irregularities of their lengths. These durations, along with instrumentation, are included below the section headers. In the final section, the slow collapsing of the final tone cluster from a span of seven semitones, to five, four, and finally one corresponds directly to the listening experience. Because of the intense activity of the aleatoric passages, a true piano roll representation of the piece would be visually indecipherable (at least in the odd sections), but its attitude is central to the image’s design.

Visualizing Musical Spaces

Music theory is among the oldest of Western intellectual disciplines. The ancient Greeks included music as part of the quadrivium, along with arithmetic, geometry, and astronomy. Graduate courses in the history of music theory often begin with readings by Pythagoras, Aristoxenus, Euclid, and others. Early music theoretical writings (at least those that survive) tend to explore musical phenomena in abstract, mathematic terms, with comparatively little reference to musical practice. While references to musical practice can be found with increasing frequency over the last thousand years, interest among music theorists in abstract musical structures remains strong today.

Many basic conceptions of musical pitch spaces have simple visual representations that reveal their structures in elegant ways. The *Tonnetz* (Figure 9), versions of which can be found as far back as 1739[6], arranges the twelve pitches of the Western chromatic scale into a geometric space with minor thirds (three semitones) in one dimension and major thirds (four semitones) in another, with their composite (seven semitones or perfect fifth) added along a diagonal. This simple structure has inspired substantial interest in recent music scholarship. Central among its features is that each triangle formed by adjacent pitches in the space spells a major or minor triad (for example, G-B-D). Furthermore, holding two pitches steady and inverting the third across the colored line that connects the first two will generate a chord of the opposite quality (G-D plus B is major, G-D plus B-flat is minor; D-F plus A is minor, D-F plus B-flat is major). When implemented in music, these "inversional transformations" lead to maximally smooth voice-leading between chords (each involves two repeated notes and the third moving by only a half or whole step). Purely theoretical images like this help enrich one's understanding of the details of the underlying musical system.

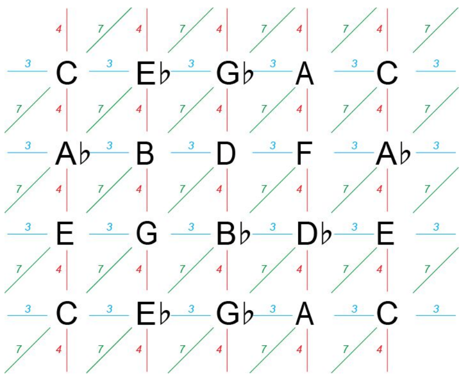


Figure 9: The *Tonnetz*

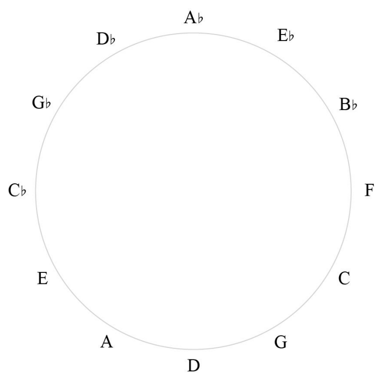


Figure 10 : Circle of Fifths

Another simple theoretical structure found in Western music is the circle of fifths (Figure 10). The figure is formed by moving clockwise by ascending perfect fifth (seven semitones) until the first pitch is reached. Because the number of pitches (12) and the interval size (7) are mutually prime, the interval cycle touches all twelve pitch classes. Representation on a circle conveys the modular nature of the pitch space. A circle of fifths can represent individual pitches or keys (corresponding to major scales in this case). If we think of these as representing keys, each key shares six of its seven notes with each neighboring key on the circle. Keys closer together on the circle are thus considered more closely related than those farther away. Keys on opposite sides of the circle have only two notes in common and are considered quite remote from each other. We will return to this image in a moment.

Figure 11 shows the series of keys that are visited in the first movement of Beethoven's "Appassionata" Sonata, opus 57 (written ca. 1805), derived from an analysis by Patricia Carpenter.[7] The image uses open noteheads to signify major keys and solid noteheads to signify minor keys. The representation effectively reveals the frequency with which Beethoven employs shifts from the major to the parallel minor keys (A-flat major to A-flat minor, E major to E minor, and so on for C, G-flat/F-sharp, and F). It is less effective, however, in conveying how far from the tonic key the movement ventures.

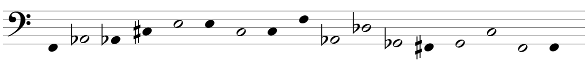


Figure 11: Tonal plan of Beethoven's "Appassionata Sonata," Op. 57, based on an analysis in Patricia Carpenter, "Grundgestalt as Tonal Function," *Music Theory Spectrum* 5 (1983).

Figure 12 is a redrawing of an image produced by Carpenter that maps the key sequence onto a circle of fifths expanded form the one shown above.[8] The inside of the circle now includes the relative minor keys ("relative" keys share the same pitches in their scales, but start on a different note, which changes the pattern of whole and half steps; relative keys are considered very closely related, like those adjacent laterally along

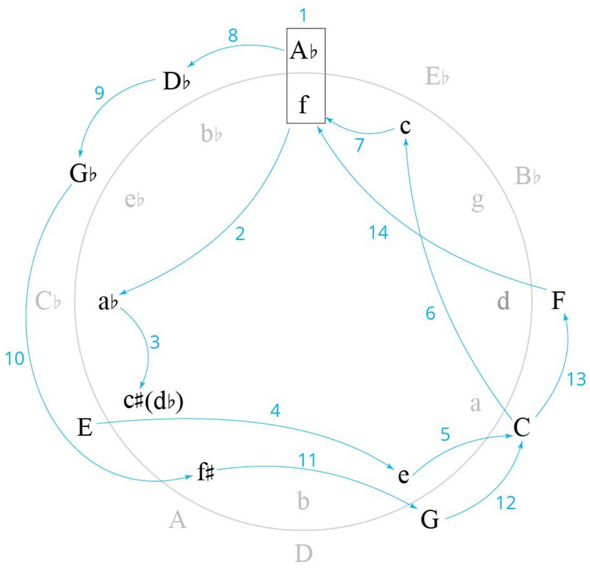


Figure 12: Tonal plan of Beethoven's "Appassionata" Sonata, Op. 57, inspired by an image in Patricia Carpenter, "*Grundgestalt* as Tonal Function," *Music Theory Spectrum* 5 (1983), 19.

the circle of fifths). The image shows keys that are visited in the movement in dark letters. Keys that are not visited are also indicated, since they complete the pitch space within which the music is being analyzed, but they join the circle in a background gray. The image reveals just how harmonically adventurous Beethoven's movement is, much more so than many from the era, which tend to stay much closer to their home keys. This insight is made vivid by mapping Beethoven's key path on the purely theoretical circle of fifths image.

Insight from Comparison

We understand things better when they are contextualized. Archaeologists place a ruler next to artifacts when they take photographs in the field so people know how to interpret their findings. Seeing an artist's pencil sketch next to a completed painting helps the viewer better understand the finished artwork. Educators use the technique of "scaffolding," which encourages students to learn new things in relation to things they already know. In music, if I play a chord on the piano, our understanding of its function is shaped by the chord that follows it. Likewise, graphical images are more powerful when they invite comparison. Putting information alongside other information helps give it meaning.

Figure 13 is an adaptation of a figure published in an educational text by Walter Breckoff.[9] It shows the Javanese Pelog and Slendro scales. By aligning the pitches of these scales with the locations of notes in the diatonic and pentatonic scales, respectively, Western viewers can relate the new information to their existing knowledge.

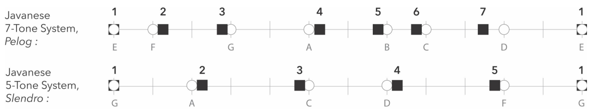


Figure 13: A comparison of the Pelog and diatonic collections and of the Slendro and pentatonic collections, inspired by an image in Werner Breckoff, *Musik Aktuell: Informationen, Dokumente, Aufgaben* (Kassel: Bärenreiter, 1971), 252.

Figure 14 shows the thematic organization of two works, the first movement of Beethoven's first symphony (1801) and Arnold Schoenberg's *Klavierstück*, op. 33a (1929). The first of these pieces is a prototypical example of a musical form called sonata-allegro, a form that is used for the first movement of nearly every sonata, symphony, and piece of chamber music from about 1760 onward. The form contains three large sections. First is the Exposition, which presents two (usually contrasting) thematic ideas, along with a transition between them, a "closing" section ("K"), and sometimes a short tail termed a Codetta). This section is often repeated, and it is in this case. Next is the Development, during which the two primary themes are explored through fragmentation, repetition, presentation in different keys, and other devices. Last is the Recapitulation, which repeats the themes from the Exposition, often with some alterations. (This is a simplified description, but it will do for our purposes.) This movement, like many such works, also has a slow Introduction section and a final flourishing section called a Coda. The diagram in Figure 14 is laid out proportionally to a recorded performance of the work, whose timings are provided below. The visualization makes it clear that, as is frequently the case in works written around this time, the three primary sections are of almost equal length. (The fact that the Exposition is re-

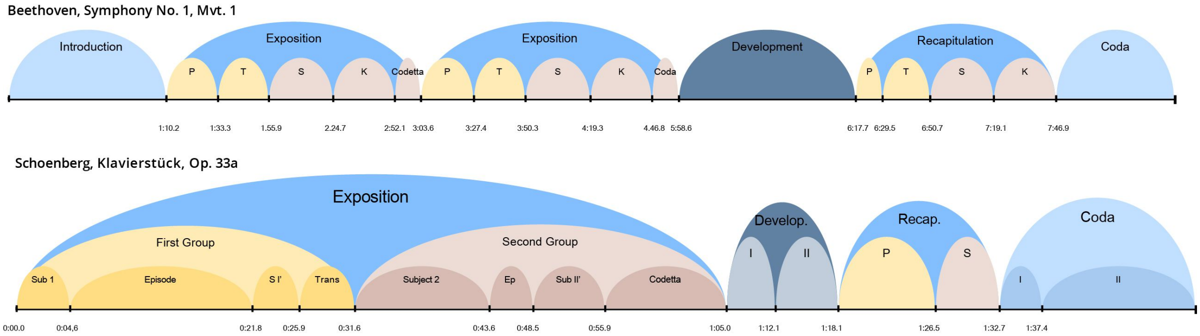


Figure 14: Formal diagrams of Ludwig van Beethoven's Symphony No. 1, movement 1, and Arnold Schoenberg's *Klavierstück*, opus 33a.

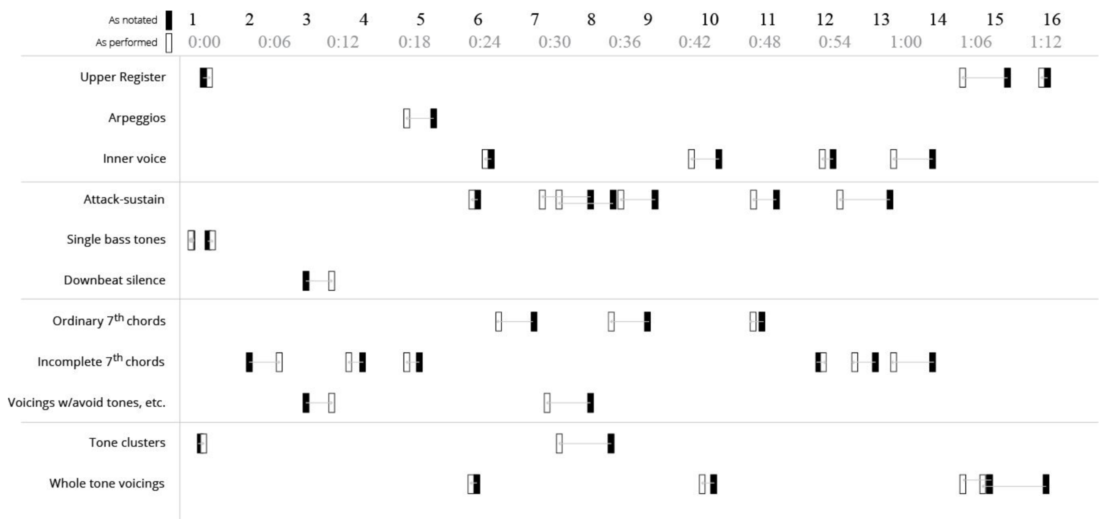
peated is not considered to affect the proportions of the work's sections. In fact, in many symphonies of Haydn and Mozart, Beethoven's immediate predecessors, the development and recapitulation were also repeated as a unit, reflecting an essentially two-part structure.)

The second diagram, which is based on an analysis by George Perle[10], interprets the structure of Schoenberg's work as a variant of sonata-allegro form. (Differences in terminology in the smaller formal units relative to the Beethoven diagram needn't concern us; I have used colors to indicate corresponding sections.) Overall, Schoenberg's piece is not long, lasting under two minutes. The visual proportions of the image are again tied to a performance, whose timings are shown.

Using the same visualization tool to examine both works makes it clear just how strikingly unusual the proportions in Schoenberg's piece are. The Exposition is comparatively enormous, while the Development and Recapitulation sections are extremely brief in proportion, not even a quarter the length of the Exposition. The deviation from the classical model is all the more striking when it laid next to it.

A final example showing the virtues of comparison is Figure 15, which is derived from an image by Evan Ziporyn and Michael Tenzer.[11] It shows deviations between the notated rhythm of a sixteen-measure musical passage and its performance by jazz pianist Thelonious Monk. The location of various musical characteristics ("inner voice," "tone clusters") relative to a strict "musical" time are shown with black boxes. The image scales Monk's performance across the sixteen measures and overlays the actual timing of the events in white boxes. Arrows show how far ahead (usually) or behind a musical event is relative to a "square" performance. Overlaying the two images in this way draws a clearer picture of Monk's artistic decisions.

Figure 15: Features of a performance by Thelonious Monk, mapped in both "score" and "performance" time, inspired by an image in Evan Ziporyn and Michael Tenzer.



Telling Musical Narratives

One of the most powerful strategies in a music visualization is to express a work's narrative structure. While we typically associate storytelling with prose, there are many ways to convey graphically a sense of narrative. Indeed, some of the most compelling images are those that express cause and effect, antecedent and consequent, or a sense of process—in short, images that tell a story.

The visually appealing outline of George Crumb's *Black Angels* in Figure 16, from an article by Blair Johnston, tells a complex narrative with clarity[12]. See https://www.youtube.com/watch?v=etHtCVeU4-I for a recording with score.) Among the image's strengths is its careful layering of information. The image's core is at the vertical center, where the most prominent lines and text in boldface caps anchor the rest of the image. The work's thirteen pieces form three groups with differing programmatic significance. Roman numerals invite a sequential reading that guides the viewer from departure to absence to return. The numbers of the pieces within each grouping are given immediately below.

Below this, the image shows the dynamic contour of the entire work, not just with traditional dynamic markings, but also in graphic form. A double line that differs in style from other lines in the image provides a visual fulcrum around which the dynamics flip. Five movements that feature dynamics of *ff* (fortissimo—very loud) or stronger, but which contrast in character (as indicated by brief quotations from the score) are then the subject of the narrative(s!) sketched at the top of the image. Here, visually contrasting line styles and enclosures depict two kinds of structure in the work: a solid line connects pieces that form the central and end points of a palindrome, while a dotted line traces a trajectory through the Devil-music movement to the programmatically climactic God-music (note the use of the inverted triangle for the former, subtly implying moral inversion of the latter). A squiggly dashed line falls irregularly from this climax, in a visual denouement. The image efficiently presents multiple layers of meaning in a simple, easily understood design.

Figure 17 traces motives in the opening "Promenade" section of Modest Mussorgsky's *Pictures at an Exhibition*, a movement with a great deal of motivic unity (a recording is here: https://www.youtube.com/watch?v=kkC3chi_ysw). The image is based on a design by Eero Tarasti.[13] The music reads from top to bottom. The image breaks the music into 51 rhythmic figures, which are drawn from just eleven unique rhythmic motives. The way the patterns recur is easily assessed by scanning the length of the image. The opening three-quarter-note motto (motive 1) occurs twelve times in the short piece. Because each statement feels like a new beginning, the image sets it off with a thin horizontal line. Inspection of the image also reveals a clustering of motives 2–5

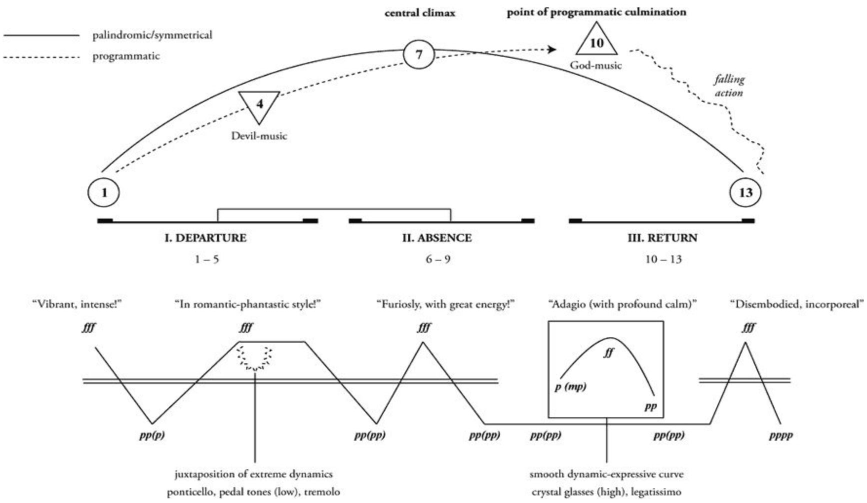
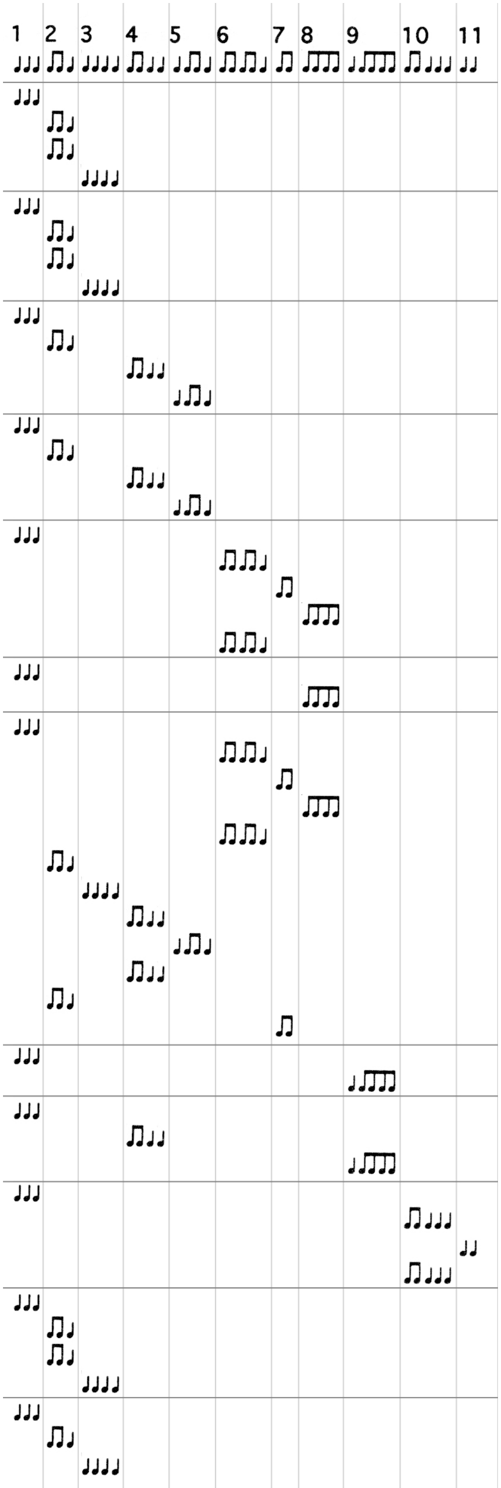


Figure 16: Blair Johnston, "Between Romanticism and Modernism and Postmodernism: George Crumb's Black Angels," *Music Theory Online* 18, no. 2 (June 2012), http://www.mtosmt.org/issues/mto.12.18.2/mto.12.18.2.johnston.html, example 2. Used by permission.

in the beginning, middle, and end of the piece, the contrast of motives 6–8 in a middle section and of 9–11 toward the end. The image's design allows one to scan downward to see where each figure occurs, but also to appreciate, particularly when paired with a recording, the seemingly endless variety of ways Mussorgsky spins music out of motive 1.



An Appreciation of Western Music Notation

While many of the world's music practices follow oral traditions, some employ complex notational systems. Such systems sometimes exist to preserve a cultural heritage, but in Western art music, it exists primarily as a way for composers to communicate to performers as much information as they choose about how to perform a musical work. Musical notation is then enacted, and interpreted, by a performer as they wish, ordinarily governed or at least influenced by some kind of culturally determined performance practice.

The system of Western music notation is one of the richest notational systems for music in the world. This is in part because so much music we might label as "classical" is pre-composed rather than improvised, to an extent that is unusual. I have elected to conclude this article with a discussion of Western notation because many of its features represent excellent models of information design. The system features an elegant and efficient set of conventions intended to provide direction for the performance of a musical work. Over many centuries, many factors have prompted changes in notational practice. Changes in musical style or blendings of concurrent styles are responsible for the most significant developments. Other factors include the desire for more, or sometimes less, specific direction from composer to performer about performance practices; matters of convenience to instrumentalists (such as those playing transposing or fretted instruments); the desire to better facilitate coordination among performers; and because composers, calligraphers, or typesetters found more effective ways to communicate the composers' intentions visually. Sometimes these interests are at odds with each other, and the system in many ways balances competing factors. On the whole, however, notational practice has evolved in the direction of an efficient system for the communication of complex, multivariate information. Distinctive treatment of shape, size, graphic versus text, font characteristics, as well as consistency in

Figure 17 (left): Rhythmic paradigms in the "Promenade" from Modest Mussorgsky's *Pictures at an Exhibition*, inspired by an image in Eero Tarasti, A *Theory of Musical Semiotics* (Bloomington: Indiana University Press, 1994), 219.

lay-out, allows for the display of an immense amount of varied information. A representative, and notationally complex, musical example is provided for reference while reading the following discussion (Figure 18), though I will not refer to it specifically.

Western music is notated left-to-right, top-to-bottom, in the same way as the prose of European languages whose speakers are responsible for the system's design, and thus requires no special scanning strategies. In fact, music notation evolved from annotations of text.

The modern five-line musical staff is a perceptually optimized basis for the visual representation of musical pitch. Its design represents a compromise between two aims. One is to allow for the representation of as many notes as possible. Its lines and the spaces between them can accommodate eleven diatonic pitches. Adding three ledger lines (ad hoc extensions of the five-line staff) increases this range to 23, just over three octaves or nearly half the 52-step range of the piano. Putting bass and treble staves together in a grand staff with up to three ledger lines extends the representational range to 35 notes, nearly five octaves, or two-thirds of the piano's gamut.

The staff's second aim is to facilitate reading by performers, who need to be able to interpret music quickly. We can perceive notes on a five-line staff holistically, as a kind of Gestalt, without having to count lines to identify where a note lies. The five-line staff allows a trained musician to scan a musical score with virtually the same fluency as an experienced reader can scan printed text, which would not be the case with, say, a ten-line staff. I propose that the five-

Figure 18: Cécile Chamenade, Menuet, op. 23 (1881). CC BY-SA 4.0

line staff became conventional because it balances the aims of perceptual efficiency and representational completeness.

Staff lines serve as a grid and are thus generally thin and, ideally, gray. The symbols that make up the note heads are clearly distinguishable from the staff lines. Note heads are slightly elongated and most of them are angled at a diagonal, which helps them pop out from the horizontal staff lines visually even more than they already would if they were round.

Accidental shapes stand out from noteheads and the staff lines by the rounded shape of the flat, and the fact that the horizontal components of both the natural and sharp are slanted slightly and are thicker than the staff lines. Stems serve as visual stopping points as we scan left to right, alerting us to the presence of noteheads. Because they are perpendicular to the staff, stems are easy to distinguish from the staff lines. Because stems generally carry no musical meaning themselves, it is appropriate that they be thin, so they remain unobtrusive.

Beams and flags provide information about duration. Each additional flag or beam halves a note's duration. I will focus on beams here. The design and use of beams lends itself to rapid cognitive processing. Because it is rare to use more than three beams at a time, it is easy to quickly ascertain the number present. Beams are used to gather notes into groups. Because our visual processing system can quickly recognize patterns of three to five objects, the use of beams facilitates more efficient cognitive processing, not only of durations, but also of rhythmic patterns. That the groupings are usually made in a way that aligns with the underlying metrical grid (that is, they reinforce rather than obscure the division of measures into beats) is an added bonus for cognitive processing. Because beams carry so much useful information, it is important that they stand out visually. This is likely why they are drawn thicker than all other lines and are generally slanted, to ensure that they contrast with the orientation of staff lines.

Because barlines have a consistent orientation and are not attached to noteheads, they are easy to distinguish visually from other shapes. It is thus appropriate that they be thin. Barlines that have special meaning (repeat signs and final bars) have an extra thick line, which ensures they stand out from other barlines in particular, and from other lines in general. Ties and slurs both use curved lines to connect notes together. They are easy to distinguish from other lines in the music because they differ by shape (tapered and curved vs. flat), thickness, and typical length (they are shorter than staff lines which extend the width of the page and longer than ledger lines).

Some categories of performance direction can be indicated through either graphical or textual means. Although articulations are sometimes indicated using words, particularly when they are assigned to a span of music (*stacc.*, *ten.*), they are more often specified through pictograms that are evocative of duration (˙) or intensity (>), which are drawn immediately above or below the notehead or chord. Fixed dynamics are displayed in a bold italic font (***ff***) that is distinct from other notational elements, using abbreviations based on Italian terms. Hairpins provide graphical direction to gradually grow louder or softer over a specific period of time. Changes of dynamics are sometimes indicated with words set in a non-bold italic font (*cresc.*, *dim.*, *morendo*, etc.). Each category of information is thus visually unique compared to the others.

There is of course much more that could be said about the notational system, but the foregoing should make clear that the system seems to have evolved to take maximum advantage of how our visual system works, at both the lower perceptual level and the higher cognitive level. As noted above, our notational system involves trade-offs and compromises. For instance, it is more sensible for some instruments than others. Brass and stringed instruments (both fretted and otherwise) are not naturally diatonic in the same way as keyboards, woodwinds, or harps are. In the case of lute and guitar, composers sometimes used tablature rather than pitch notation. A diatonic notational space would also seem a less obvious choice for fully chromatic music, though in the more than 100 years since the introduction of free atonality, no chromatic notation system has arisen to threaten common Western notation. It is worth pointing out that the system is optimized for quickly communicating performance information, not musical information of the sort that is often gleaned through analysis. In a sense this is very much like spoken language, for which its printed "instruction" is also made up of symbols of varying visual, physical, and phonological similarity, little of which has any bearing on the meaning of words into which they are grouped.

Conclusion

My interest in music visualization was inspired by becoming acquainted with the work of Edward Tufte, whose books on information visualization are well known in the world of data design[14]. The impact of Tufte's writings here and in my book will be obvious to anyone who knows his work. Over the past fifteen years, as I have examined thousands of musical images and taught numerous seminars on the topic of music visualization, I have become increasingly impressed with the power of the picture to reveal meaning in an art that we experience so intimately with our ears. I hope this article will help you to listen to music with new eyes.

Endnotes

1. See Douglas R. Hofstadter and Emmanuel Sander, *Surfaces and Essences: Analogy As the Fuel and Fire of Thinking* (New York: Basic Books, 2013).
2. See Lawrence Zbikowski, *Conceptualizing Music: Cognitive Structure, Theory, and Analysis* (Oxford: Oxford University Press, 2002), for a detailed explanation of cross-domain mapping in music; Michael Spitzer, *Metaphor and Musical Though*t (Chicago: University of Chicago Press, 2004), for a historical perspective, and Steve Larson, *Musical Forces: Motion, Metaphor, and Meaning in Music* (Bloomington: Indiana University Press, 2012), for a cognitive perspective.
3. Eric Isaacson, *Visualizing Music* (Bloomington: Indiana University Press, 2023). The book will be accompanied by an extensive online supplement.
4. Stephanie Probst, "Music Appreciation through Animation: Percy Scholes's 'Audiographic' Piano Rolls," *SMT-V: The Society for Music Theory Videocast Journal* (2021). https://societymusictheory.org/announcement/smt-v-volume-71-2021-01.
5. Miguel Roig-Francolí, *Understanding Post-Tonal Music* (New York: McGraw-Hill, 2007), 290. My version updates Roig-Francolí's in many ways. Most significantly, I have rendered the two kinds of sections in contrasting colors and made their widths proportional to their duration in a recorded performance. I have eliminated the graph paper on which the original was drawn. I have replaced thick lines representing pitches with negative space between boxes that represent the intervals between those pitches—which are one of the image's central concerns. I have also mapped the interval sizes to a luminosity scale that makes the symmetry of the chords more visually apparent than showing numbers alone. I have redesigned many of the remaining visual elements and added additional information (such as instrumentation and section duration).
6. Leonhardo Eulero, *Tentamen novae theoriae musicae: Ex certissismis harmoniae principiis dilucide expositae* (Petropoli: Ex typographia Academiae scientiarum, 1739). For more recent explorations of the Tonnetz, see also Hugo Riemann, "Ideen zu einer 'Lehre von den Tonvorstellungen'," *Jahrbuch der Bibliothek Peters* 21–22 (1914–15), Brian Hyer, "Reimag(in)Ing Riemann," *Journal of Music Theory* 39, no. 1 (1995); Dmitri Tymoczko, "The Generalized Tonnetz" *Journal of Music Theory* 56/1 (Spring 2012), and especially Julian Hook, *Exploring Musical Spaces: A Synthesis of Mathematical Approaches* (Oxford University Press, 2022).
7. Patricia Carpenter, "*Grundgestalt* as Tonal Function," *Music Theory Spectrum* 5 (1983): 15–38.
8. Patricia Carpenter, "*Grundgestalt* as Tonal Function," *Music Theory Spectrum* 5 (1983): 19. The original image used three concentric circles rather than one as used here. My version moves the names of relative major/minor keys closer together. It renders the arrows and sequence numbers in cyan rather than black, allowing them to occupy a different "information layer," which also eliminates the need for circles around the numbers as in Carpenter's version. Finally, Carpenter's version does not differentiate between keys are that actually visited in the music versus those simply holding their place in the conceptual circle-of-fifths, which mine renders in gray.
9. Werner Breckoff, *Musik Aktuell: Informationen, Dokumente, Aufgaben* (Kassel: Bärenreiter, 1971), 252. The original showed three pitch systems on separate lines, using the black squares shown here, the Western twelve-note system and the two Javanese systems. My version eliminates the twelve-note system and replaces it with open circles representing the seven-note diatonic and five-note pentatonic systems that most resemble the Javanese systems. Drawing them on the same line as I do rather than on a separate line makes comparisons easier.
10. George Perle, *Serial Composition and Atonality: An Introduction to the Music of Schoenberg, Berg, and Webern* (Berkeley: University of California Press, 1991), 113.
11. Evan Ziporyn and Michael Tenzer, "Thelonious Monk's Harmony, Rhythm, and Pianism," in *Analytical and Cross-Cultural Studies in World Music*, ed. Michael Tenzer and John Roeder (New York: Oxford University Press, 2011), 179. In Ziporyn and Tenzer's version, the visualization of notated and performance time are graphed separately. In their layout, it is all but impossible to see the interplay between the two kinds of measurement, since musical and clock time are not always different enough to realize that there any displacement at all. My version superimposes the two images, renders the performed events in open boxes, and adds the arrows which indicate both the direction and the magnitude of the performance displacement. My version makes additional graphical improvements, eliminating boxes around all of the musical features on the left edge and adding faint horizontal lines to help organize the vertical space.
12. Blair Johnston, "Between Romanticism and Modernism and Postmodernism: George Crumb's Black Angels," *Music Theory Online* 18, no. 2 (June 2012) , http://www.mtosmt.org/issues/mto.12.18.2/mto.12.18.2.johnston.html.
13. Eero Tarasti, *A Theory of Musical Semiotics* (Bloomington, Ind.: Indiana University Press, 1994), 219. My image adheres to Tarasti's basic layout but adds the sparse grid that helps to visually organize the image. I have added the eleven rhythmic paradigms at the top of the image. Vertical lines make it easier for the eye to then scan downward from these paradigms to where they occur in the figure. Horizontal lines mark places where motive 1 recurs, because statements of this motive are salient markers in the listening experience.
14. Edward R. Tufte. *Envisioning Information* (1995), *The Visual Display of Quantitative Information* (2001), *Visual Explanations Images and Quantities, Evidence and Narrative* (2003), *Beautiful Evidence* (2006), and *Seeing with Fresh Eyes: Meaning, Space, Data, Truth* (2020), all published (Cheshire, CT: Graphics Press).

Figures

All figures are produced by the author unless stated otherwise.

Abstract

Visual representations are a powerful tool for the understanding of musical structure. In Western cultures, they are made possible because of metaphors that underlie our conception of music. We conceive of notes as objects in space, particularly with the property of "height," which is easily graphed visually along a vertical axis. And we think of time as flowing along a different dimension, which is easily graphed visually along a horizontal axis. Music scholars in particular employ visualizations to communicate their musical understanding to others. Visualizations can be representations of abstract musical "spaces," or analyses of musical works or performances. This paper explains the power of music visualization and offers a sampling of strategies that music scholars have employed effectively to enhance musical understanding through images.

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Title

Eric Isaacson, *Augenmusik Today*, in: kunsttexte.de, Nr. 4, 2022 (15 Seiten), www.kunsttexte.de.
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