Timbre as Harmony—Harmony as Timbre

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Link to sound examples (active as of September 10, 2020):
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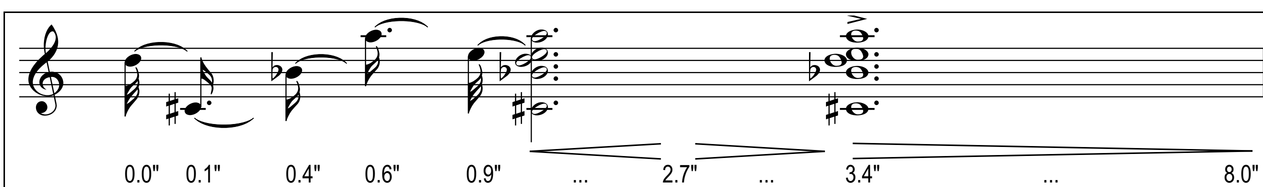
Standard definitions of timbre associate it with the sound color of a single note: according to the *Oxford Dictionary of Music,* for example, timbre is "that which distinguishes the quality of tone or voice of one instrument or singer from another" (2012). However in contemporary music, particularly music that is sound-based rather than note-based (Landy 2007), the definition of timbre as a property of a single note is no longer sufficient. We encounter many composite events—sound-mass textures, complex chords, synthesized acoustic spectra, etc.—in which the constituent sounds fuse together to create a unified effect with its own global timbre.

Instead of conceptualizing timbre solely as a property of single notes, we can reimagine timbre more broadly as an emergent property of composite events. Viewed this way, timbre involves much more than just instrumentation. Of course, the timbre of a composite event will be affected by the individual timbres of its constituent sounds, but also by their amplitude, register, temporal unfolding, and even their specific pitches—a consideration traditionally considered part of the timbre-neutral domain of harmony. By rethinking timbre to include composite objects, timbre is promoted from a secondary role—the decorative coloring of a work primarily defined by its pitches and rhythms—to a central category of musical perception. While the "integration of harmony and timbre within a single entity" (Grisey 2000) is particularly associated with the French spectral school, examples of such integration abound in the music of the twentieth and twenty-first centuries. This chapter will explore some of the intersections between the concepts of timbre and harmony, making the case for a broadened understanding of timbre that encompasses composite musical events, not just the tone color of a single note from a single sound source. Reevaluating both timbre and harmony, each through the lens of the other, can suggest new ways of understanding both concepts in twentieth-century and contemporary music.

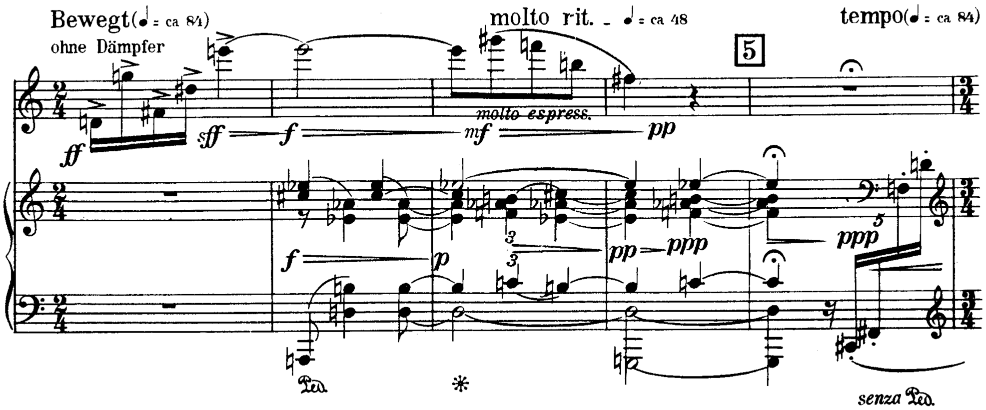
i. Risset—Webern—Schoenberg

Example 1 transcribes the opening of Jean-Claude Risset's 1969 electronic work *Mutations.* Individually presented notes sustain into a chordal swell, which then is rearticulated (at 3.4") by a sharp attack to become the sound of a bell (Chowning 2008). This transformation from chord to bell is one of the many "mutations" of the work. The bell consists of exactly the same pitches as the preceding chord—it is their simultaneous attack that makes the previously distinct notes cohere into a single unified sound with a bell-like timbre. The individual overtones or partials that make up the frequency spectrum of a Western church bell do not follow the familiar harmonic series: rather, they are characterized by the intervals of the minor third (or its complement, the major sixth) and the perfect fourth, both of which are represented in Risset's chord.



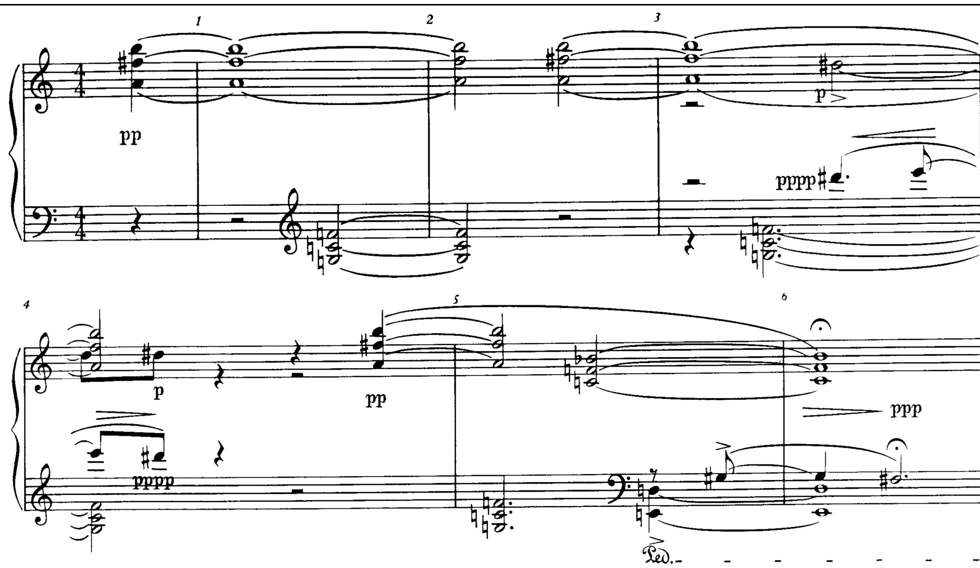
Example 1: Jean-Claude Risset, *Mutations* (1969). Based on transcriptions in Chowning (2008, 5) and Solomos (2013, 1459).

Bell sounds are ubiquitous in twentieth-century music, from Debussy's "La Cathédrale engloutie" to atonal works by Anton Webern and Arnold Schoenberg. **Example 2**, from Webern's 1910 *Vier Stücke* for violin and piano, includes the pealing of bell-like chords in the piano, starting in measure 2 under the violin's sustained E. Robert Craft remarks that "[t]he presence of the mountains can be felt in all of [Webern's] work. And overtly, bell sounds are imitated, not only in such nature and color pieces as Opera 6 and 10 (which actually use cowbells) but in the last work he was to complete. Bell sounds in clear mountain air are evoked in almost every Webern opus" (Moldenhauer 1961, 4).



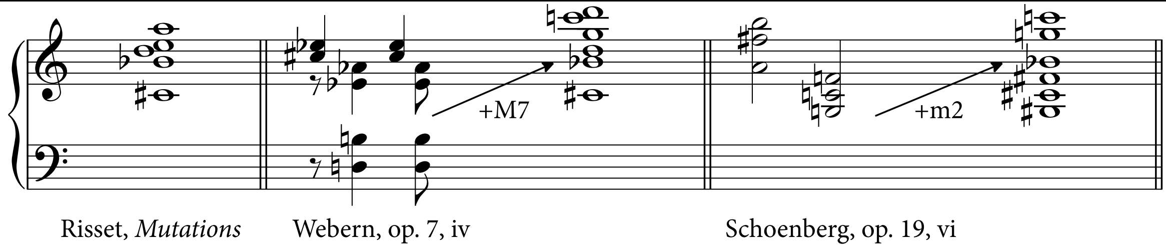
Example 2: Anton Webern, *Vier Stücke* for violin and piano, op. 7, iv (1910). © Copyright 1922, 1950 by Universal Edition A.G., Wien/UE 6642. Used by permission.

The last of Schoenberg's *Sechs kleine Klavierstücke* contains one of the best-known evocations of bells in the works of the Second Viennese School (**Example 3**). Egon Wellesz, Schoenberg's pupil and biographer, indicates that the piece emerged from the composer's impressions of the funeral of Gustav Mahler. As Brian Simms describes, "The outer sections (measures 1–6 and measure 9) are characterized by reiterations of a six-note chord, whose prominent intervals of the fourth evoke the sound of bells" (2000, 85).



Example 3: Arnold Schoenberg, *Sechs kleine Klavierstücke,* op. 19, vi (1911). © Copyright 1913, 1940 by Universal Edition A.G., Wien/UE 5069. Used by permission.

Indeed, the perfect fourth and fourth-based chords are two common ways that composers imitate the particular frequency spectra that give bells their characteristic timbre. In the right hand of Schoenberg's chord, we hear the same major sixth as in the Risset and Webern harmonies (here, A–F♯). The major sixth is capped by a perfect fourth (F♯–B), and the left hand adds a pair of stacked fourths (G–C–F). **Example 4** summarizes the "bell" chords in all three works, transposing them to the same pitch level for ease of comparison. Note that while the chords differ in exact pitch content, all include a major sixth (C♯–B♭) plus a varying number of additional notes in combinations that emphasize the stacking of perfect fourths.



Example 4: Summary of harmonic relationships among "bell" chords in Examples 1–3.

These examples blur the line that typically separates the notions of harmony and timbre. We find in all three cases that a bell-like timbre is evoked, with various levels of verisimilitude, by a chordal construction that would seem to belong, strictly speaking, to the domain of harmony.

Schoenberg: tone color and pitch

This blurring of harmony and timbre is implicit in Schoenberg's notion of *Klangfarbenmelodie.* Throughout his career, Schoenberg was fascinated by the complex inner life of the musical tone. As he wrote in his *Harmonielehre,* "The primitive ear hears the tone as irreducible, but physics recognizes it to be complex. In the meantime, however, musicians discovered that it is *capable of continuation,* i.e. that movement *is latent within it.* That problems are concealed within it, problems that clash with one another, that the tone lives and seeks to propagate itself" (1978 [1922], 313). Schoenberg seemed to view this "movement" within the tone as a microcosm of musical motion at the more familiar scale of melodies and harmonies. In the final pages of the *Harmonielehre,* as Schoenberg is concluding his discussion of "chords with six or more tones" and introducing the idea of *Klangfarbenmelodie,* he questions the very concept of dividing timbre from pitch:

> The distinction between tone color and pitch, as it is usually expressed, I cannot accept without reservations. I think the tone becomes perceptible by virtue of tone color, of which one dimension is pitch. Tone color is, thus, the main topic, pitch a subdivision. Pitch is nothing else but tone color measured in one direction. (1978 [1922], 421)

Tone color, to Schoenberg, is a more central and immediately apprehensible quality than pitch, which is demoted to a more abstract "subdivision" of a tone's essential features. Schoenberg's final sentence is even more striking when we return to the original German: when he contrasts tone color and pitch, he is really talking about *Klangfarbe* and *Klanghöhe,* two attributes (color and height) of a single phenomenon, the *Klang.* Late in his life, Schoenberg looked back at the legacy of his concept of *Klangfarbenmelodie* in a 1951 letter to Josef Rufer. The term, he felt, had too often been equated with Webern's pointillist orchestrations.

> My conception of *Klangfarbenmelodie* would have been fulfilled in Webern's compositions only in the slightest part. For I meant something different by *Klänge,* and especially, though, by *Melodie.* [*Klänge*] are never merely individual tones of different instruments at different

> times, but rather combinations of moving voices. (1951 letter to Josef Rufer, translated in Cramer 2002, 4)

Schoenberg describes his own conception of *Klangfarbenmelodie* as based on "combinations of moving voices," suggesting that the timbres involved are not properties of "individual tones" but rather features of complex chords or textures. Alfred Cramer has noted that for a German-speaking music theorist writing in the early years of the twentieth century, the notion of *Klang* could easily encompass a compound sound rather than a single tone: in the theories of Hugo Riemann, for example, a *Klang* is a major or minor triad. Cramer writes: "The timbres of *Klangfarbenmelodie,* then, result from pitches heard alone or in harmonic combination; such *Klangfarben* are not attributes of discrete tones, and they are not distinct from pitch" (2002, 2). As Jennifer Iverson has observed, composers of the next generation were intrigued by the unfulfilled promise of Schoenberg's conception (2009, 156–58). In his 1965 article "Komposition mit Klangfarben," Ligeti distinguishes between two ways of "composing with *Klangfarben*":

> On the one hand the form can be structured through contrasting instrumental colors, in which the different structural elements stand out against one another and therefore the formal plan is perceived as plastic. On the other hand, timbre can appear as coalescing: originally heterogeneous sonic elements merge into a higher, embracing entity, and gradual timbre changes, gradual timbre mixtures build the foundation of the musical formal events. (translated in Iverson 2009, 156)

Iverson notes that Ligeti associates composition *with* timbres (*Komposition mit Klangfarben*) with the practice of Anton Webern, perhaps best exemplified by his orchestration of Bach's Ricercar from *The Musical Offering* or the slow movement of the opus 24 Concerto. The alternative, composition *of* timbres (*Komposition der Klangfarben*), is concerned with compound events as in Schoenberg's orchestral piece *Farben* (op. 16, no. 3). Such pieces are based on "coalescing" and slowly changing timbres, built from the merging of "originally heterogeneous sonic elements." This idea of fusing individual timbres into more complex, composite entities capable of gradual change and development is realized, of course, in Ligeti's sound-mass works of the early 1960s such as *Atmosphères.*

The fuzzy boundary between timbre and harmony is permeable in both directions: on one hand, the individual notes of a harmony may fuse together into a single object with its own global timbre (what music psychologist Stephen McAdams calls "synthetic listening")—on the other, the individual partials of a complex timbre may separate in our perception to take on an independent existence—this is a mode of "analytic listening" (McAdams 1982, 280). A related opposition is recognized in the writings of Pierre Boulez: "Timbre does not function on its own, but the acoustic illusion of timbre is brought out by the way the music is composed. From this I deduce two notions of timbre used in instrumental music: raw timbre and organized timbre. In the first case composition acts from the outside. In the second case it works from the inside of the sound-object" (1987, 169). Timbres can be treated separately as a collection of isolated, "raw" sounds placed into juxtaposition with one another (the Webern model), or composed "from the inside," as in Schoenberg's moving sound masses. Boulez associates small instrumental ensembles with clear articulation of timbres and "the world of immediate reality and analysis" while the use of timbral fusion in the orchestra makes the ensemble the model "instrument of illusion, of phantasm" (167). Denis Smalley makes a similar distinction, framed as an "integration-disintegration continuum" (1994, 42).

Notions of fusion and fission permeate the curious poetic text, "Totentanz der Prinzipien" ("death-dance of the principles"), written by Schoenberg for a projected choral symphony begun in 1914. The text sketches the outline of musical events, with a brief introduction culminating in the tolling of an offstage bell. The bell rings on past twelve strokes, growing louder and faster into a "frenzied pealing." After the sound stops, an unnamed narrator describes a mysterious sound appearing out of the silence, in a peculiarly detached series of introspective observations.

> Twelve chimes—Thirteen! fourteen—fifteen!—Oh! What does it mean? Sixteen, seventeen!—Shall it be midnight twice today? Or still more often? The midnight of midnight? The blackest? Darkest?—(The ringing stops.) […]
> The paleness and flatness now dissolving into colors and forms; one calls this unification… (descriptively). It crumbles more and more and is in motion. (More devoutly.) So many and each single thing seems important… (warmer). Now it sings; each sings something different thinking that it sings the same thing; and, in fact, sounds in one dimension together (surprised) in another diverse. In a third and fourth it sounds still otherwise, which one cannot express. It has countless dimensions and each one is perceivable (increasing). And all disappear to some place where they could be found. It would be easy to pursue them, for now one has their conception. […]
> A sound? Or is it no sound? Or are there many sounds? All? Is it infinite or nothing? Impossible!
> The multiplicity before was easier to understand than the oneness now. It is overwhelming. It is magnificent, because it is overwhelming. Each sings something different, thinking that it sings the same thing, but it actually sounds multi-voiced, five-, six-, or only three-voiced. Or are there more? (Making a transition.) Or fewer? or nothing? (translated in Auner 2003, 130–33)

What is the narrator actually hearing? We find that his experience crosses from one modality of perception to another: what starts out as a visual observation ("paleness, flatness") gradually becomes an aural one ("now it sings"). The narrator seems torn between different modes of perception, hearing the sound as unified, but simultaneously, in another dimension, "diverse." In an unbroken stream of consciousness, the narrator shifts fluidly between synthetic and analytic listening. He even recognizes the possibility of consciously directing his perception in one direction or another: "it would be easy to pursue them, for now one has their conception." The evasive nature of timbre, and particularly its reliance on the vagaries of perception and attention, is foregrounded here: the narrator seems both awed and puzzled by the mutability of the sound between many separate voices and just one. The real object of the text, to adapt a quote from Helmut Lachenmann, "is listening, that is, perception perceiving itself" (2003, 29).

ii. Auditory scene analysis and chimeric percepts

The ideas in Schoenberg's text of fusion and fission—or alternately, synthetic and analytic listening—are essential to the contemporary subfield of psychology called auditory scene analysis, developed by Albert Bregman. His research asks how we make sense of the air pressure waves detected by our ears, sorting a jumble of information into a mental representation of discrete sources with particular characters, locations, and movements. In a striking analogy, he compares the raw aural information received by our ears to the ripples of water that lap against the edge of a lake. To match the achievements of our auditory cortex in analyzing sound, we would need to be able to deduce the position, size, and movement of boats in the lake from nothing more than these ripples (1990, 5–6).

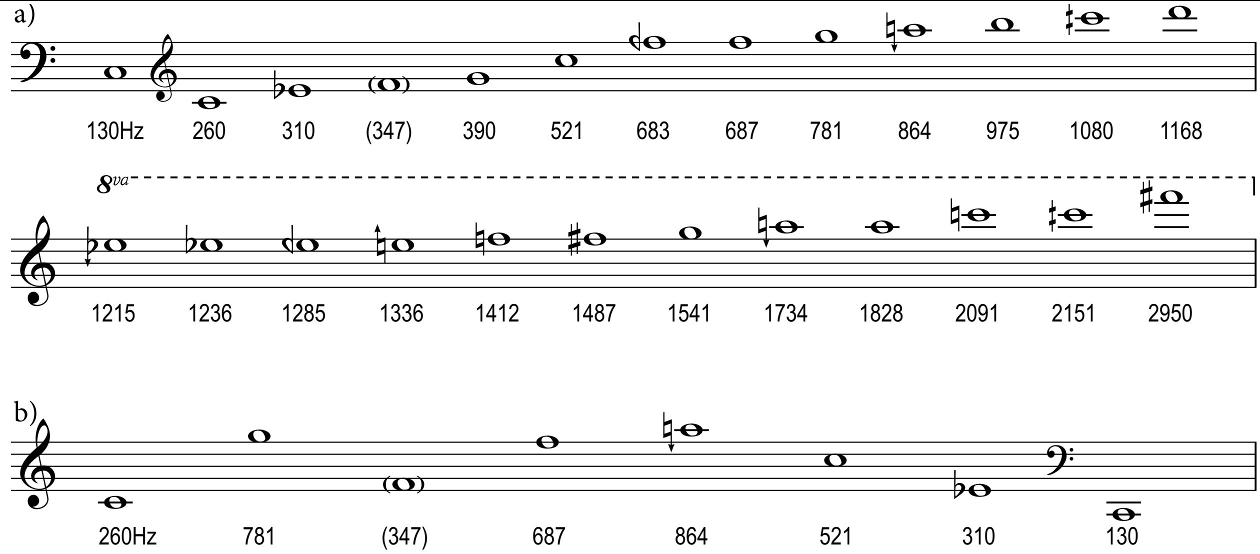
The ear must reconstruct a mental image of external sound sources by correctly grouping together sonic information that comes from the same source. For example, it must be able to recognize all of the simultaneous overtones of a cello sound as coming from a single source, and then examine the spectral profile of those overtones to determine that it fits the pattern typical of a cello. Stephen McAdams, who has extended the work of Bregman, identifies the "process by which simultaneous things are grouped into single entities" as "perceptual fusion" (1982, 280).

When our brains determine that a number of vibrations come from the same source, it "fuses" those sounds together into a compound event with a particular timbre, amplitude, and global pitch. Detailed "auditory images" can be created in our minds only when incoming data is correctly parsed: in the complex aural environment of a string quartet performance, for example, we need to be able to sort out the overtones of the cello from those of the viola and violins, and also to separate all of these from the room and audience noise.

However, perception is mutable and in constant flux: our processes of auditory scene analysis, as ethnomusicologist Cornelia Fales has observed, are based on a number of best-guess heuristics, not failproof algorithms (2002, 62). As in Gestalt theories of visual perception, auditory scene analysis applies the principle of *Prägnanz* or economy—the brain prefers the simplest solution that fits the available data. Aural perception uses some of the same principles that underlie visual grouping, such as closure and continuity, as well as purely sonic principles such as harmonicity (grouping together vibrations that fit into the same harmonic spectrum) and co-modulation (grouping vibrations with a similar temporal profile). Co-modulation can make even inharmonic spectra fuse into a single auditory image: Risset's bell chord, for example, which does not even remotely fit into a harmonic spectrum, nonetheless fuses together because of the simultaneous attack of all the partials. We use these Gestalt principles constantly and unconsciously to make sense of the jumble of information sent from our ears to our brains.

The mutation stops of the organ are a familiar example of fused sounds. Smaller, higher organ pipes, tuned to upper partials of the fundamental, merge seamlessly with the fundamental tone, creating an impression of a changed timbre rather than separate pitches in parallel motion. The addition of the *tierce* or *septième* stops, for example, produce what is usually described as a "reedy timbre" (Howard and Angus 2009, 257). This "organ stop" concept has been adapted to orchestral writing as well, as in the last few minutes of Ravel's *Bolero* where parallel doublings reinforce the overtones of the melody, fusing the diverse instruments together into a single, composite timbre.

We are beginning to engage with the issues that make timbre perception such a complex phenomenon. Timbre emerges from fusion: the Risset chord's particular quality of "bell-ness", for example, is only possible when all of the partials are mentally grouped together as emanations of a single source. Compared to simpler auditory categories such as pitch, amplitude, and duration, timbre is curiously elusive: as Cornelia Fales writes, "perceived timbre exists in a very real sense only in the mind of the listener, not in the objective world" (2002, 62).



Example 5: Spectrum of Winchester cathedral bell in Jonathan Harvey's *Mortuos Plango, Vivos Voco.* Based on an analysis and transcription by the composer reproduced in Harvey (1981, 23).

Issues of fusion and fission became a central concern among French spectral composers such as Gérard Grisey and Tristan Murail, as well as other composers working at IRCAM in the late 1970s and early 80s. The spectral aesthetic proposed a continuum between harmony and timbre, often creating chords which mimicked the frequency spectrum of a particular timbre: the replication of a trombone sound at the beginning of Grisey's *Partiels* is a well-known example of such instrumental synthesis (Donin 2015).

An iconic tape work of the early spectral movement is Jonathan Harvey's 1980 *Mortuos Plango, Vivos Voco*. **Example 5** shows Harvey's own transcription of the acoustic spectrum of one of the two sound sources of the work, the great tenor bell of Winchester Cathedral: frequencies of each partial are indicated in Hz (vibrations per second). The bell's inscription gives the piece its title: "Horas Avolantes Numero, Mortuos Plango: Vivos ad Preces Voco (I count the fleeing hours, I lament the dead: the living I call to prayer)" (Harvey 1981, 22). The section of the example marked "a" shows the complete spectrum, while "b" illustrates the eight most prominent partials, selected by Harvey as a model for both small- and large-scale features of the work's form. The note F4, marked by parentheses in the example, is a curious psychoacoustic phenomenon called the "secondary strike tone"; though it is not acoustically present in the audio signal, our ears and brains infer the presence of the F due to the presence of many of its overtones. Note that in many ways, the spectrum of the Winchester bell resembles the bell chords examined in Examples 1 to 4: the pitches C and E ♭ (with their octave doublings) produce a prominent minor third/major sixth, and the pitches G, C, and F yield the characteristic stacked fourths.

The other sound source for the work is the recorded voice of Harvey's own son, at the time a chorister at the cathedral. The opposition of the two sources gives rise to a number of compelling dualities: bell and boy, ancient and young, inanimate and living. At its first appearance in the piece, the boy's voice appears in several simultaneous layers, at pitches selected from frequencies of the bell spectrum. The result fuses into a kind of "bell of voices," as the vocal harmonies imitate the timbre of the bell. Eventually, a melody emerges built from the selected harmonics of the bell shown in Example 5b: the bell's spectrum has decisively broken apart into individual, temporally separated notes. Harvey is eloquent on the aesthetic potential of such effects of fusion and fission. In a discussion of the aesthetic achievements of the spectral movement, he locates its greatest potential precisely at these moments when fused percepts disintegrate into individual frequencies, or vice versa:

> [T]he fascination of spectral thinking is that it, too, can easily shift into the realm of linear time, into melodic thinking: there is a large borderland of ambiguity to exploit. It is not a question of forsaking harmony and regarding everything as timbre, as some French composers do, but rather of harmony being subsumed into timbre. Intervallicism can shade into and out of spectralism, and it is in this ambiguity that much of the richness in the approach lies. In several of my own works, to offer a simple example, violins provide upper harmonics to a louder, lower fundamental, but at a given moment they cease to fuse, begin to vibrate, begin to move with independent intervals, and then ultimately return to their previous state. They are by turns faceless team members and distinguished individuals. The images of union and individuation are powerful ones, with both psychological and musical implications (Stravinsky's "the many and the One"). (Harvey 1999, 40–41)

Chimeras

One of the most fascinating and (as we shall see) most musically significant concepts to emerge from Bregman's auditory scene analysis is the notion of the auditory *chimera*. The chimera is a monstrous creature from Greek mythology, described in Homer's *Iliad* as "a thing of immortal make, not human, lion-fronted and snake behind, a goat in the middle, and snorting out the breath of the terrible flame of bright fire" (translation by Richmond Lattimore). By analogy, an auditory chimera combines elements of different sonic sources into a single, unified percept (Tsang 2002, 27–28). As already discussed, Bregman describes the constant activity of our auditory cortex to make sense of the raw sense data received by the ears. Gestalt-based scene analysis processes group together vibrations that seem to come from the same source to construct an auditory image that identifies, if all goes well, the correct external sound source. "However," Bregman writes, "if scene analysis processes fail, the emergent perceived shapes will not correspond to any environmental shapes. They will be entirely chimerical" (1990, 5).

Timbre is one of many emergent features that our brains can assign to a particular auditory image. An emergent timbre is not a property of any of the individual elements of a composite sound: "we can compose a sound that is voice-like, despite the fact that not one of the sine waves that compose it is voice-like" (459). As Bregman notes, while our auditory system "tries to avoid chimeric percepts" (which are essentially errors in source detection), "music deals in chimeras"—whether composite, fused effects like "the simultaneous roll of the drum, clash of the cymbal, and brief pulse of noise from the woodwinds", or more simply, musical chords, which though comprised of separate tones are "treated at least partly as a global whole in perception," with particular emergent properties (459–60, 508). An auditory chimera, then is a result of our mechanisms of auditory perception being fooled. Properties that belong to different sources are erroneously fused together into a single "monstrous" percept, giving rise to emergent timbral properties that are more than the sum of their parts. A familiar literary example of a chimeric percept is the fairy tale "The Musicians of Bremen," collected by Jacob and Wilhelm Grimm.

> How were they to drive the robbers away? The animals talked it over and at last they hit on a plan. The donkey stood up on his hind legs and put his forefeet on the window ledge; the dog jumped up on the donkey's back, the cat climbed on the dog, and finally the cock flew up in the air and perched on the cat's head. At a certain signal they all struck up their music: the donkey brayed, the dog barked, the cat miaowed, and the cock crowed. Then they leaped through the window and burst into the room in a shower of glass. The robbers, who thought

> a ghost had attacked them, jumped up with bloodcurdling yells and fled to the woods. (Grimm 1977 [1814], 103–04).

As in an auditory chimera, the ghost perceived by the robbers is the result of the combination of elements from different entities, perceived as a single uncanny being because they have not been correctly parsed into individual creatures. Like the bray-bark-miaow-crow of the "ghost," the bell-like composites in the works by Risset, Schoenberg, Webern, and Harvey are also examples of auditory chimeras: the emergent property of "bell-ness" does not belong to any single one of the constituent piano notes or partials of the spectrum, but is a property only of the chord perceived as a whole. It is characteristic of such chimeric percepts in music to blur the traditional lines between harmony and timbre. It is particularly striking to find such timbral chimeras in piano music, since in Western art music the piano is the archetypically harmonic instrument, with a consistent timbre commonly characterized as neutral compared to the nasal twang of the harpsichord or the varied colors of the organ. To explore the variety of chimeric timbral effects possible even within the timbral constraints of the piano, I turn now to three very different piano compositions by Michael Harrison, Olivier Messiaen, and Peter Ablinger.

While a pianist has relatively little control over the timbre of each note, sophisticated pianists think endlessly about issues of *voicing:* they change the color of a harmony through subtle variations in the amplitude of each of its notes. These variations in touch shape the emergent properties—the color or timbre—of the composite sound. This kind of careful shaping is evident in pianist-composer Michael Harrison's performance of *Revelation,* his 2007 work for solo piano retuned in a customized just intonation. Harrison, a disciple of La Monte Young, uses purely ringing fifths (a frequency ratio of 3/2) and natural minor sevenths (7/4) to produce a unique, piece-specific tuning that includes several "commas," tiny intervals with the just intonation ratio 64/63, equivalent to about 27 cents (hundredths of a semitone). These "celestial commas" occur between F↓–F, C↓–C, and G↓–G (see **Example 6**). The harmonic use of these small intervals in carefully voiced textures is central to the unique harmonic writing of *Revelation*—Harrison calls this "the emancipation of the comma." The complex interference between the close-spaced notes "creates undulating waves of shimmering and pulsating sounds, with what sound like 'phase shifting' and 'note bending' effects and other acoustical phenomena. Sometimes the overtones are so audible that it sounds as if many different instruments are resonating from the piano" (Harrison, 2007). These chimeric, illusory instrumental sounds are particularly striking in the climactic final movement, titled "Tone Cloud IV," in which the strings are left free to vibrate while excited by constant attacks.

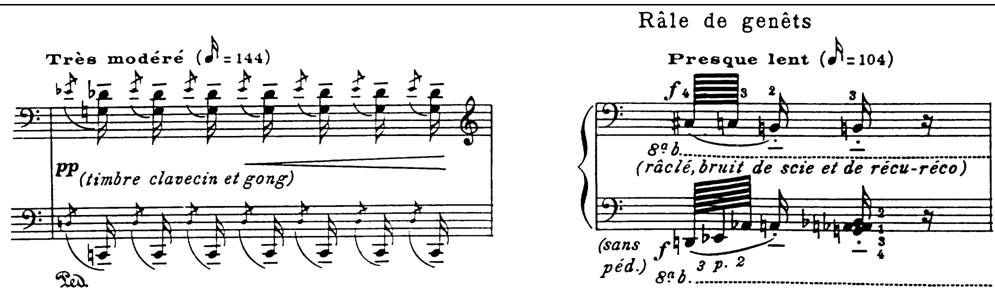
E♭↓ —	B♭↓ —	F↓ —	C↓ —	G↓		
267	969	471	1173	675		
|	|	|	|	|		
F —	C —	G —	D —	A —	E —	B
498	0	702	204	906	408	1110

C	D	E♭↓	E	F↓	F	G↓	G	A	B♭↓	B	C↓
0	204	267	408	471	498	675	702	906	969	1110	1173

Intervals: 9/8, 28/27, 243/224, 28/27, 64/63, 567/512, 64/63, 9/8, 28/27, 243/224, 28/27, 64/63

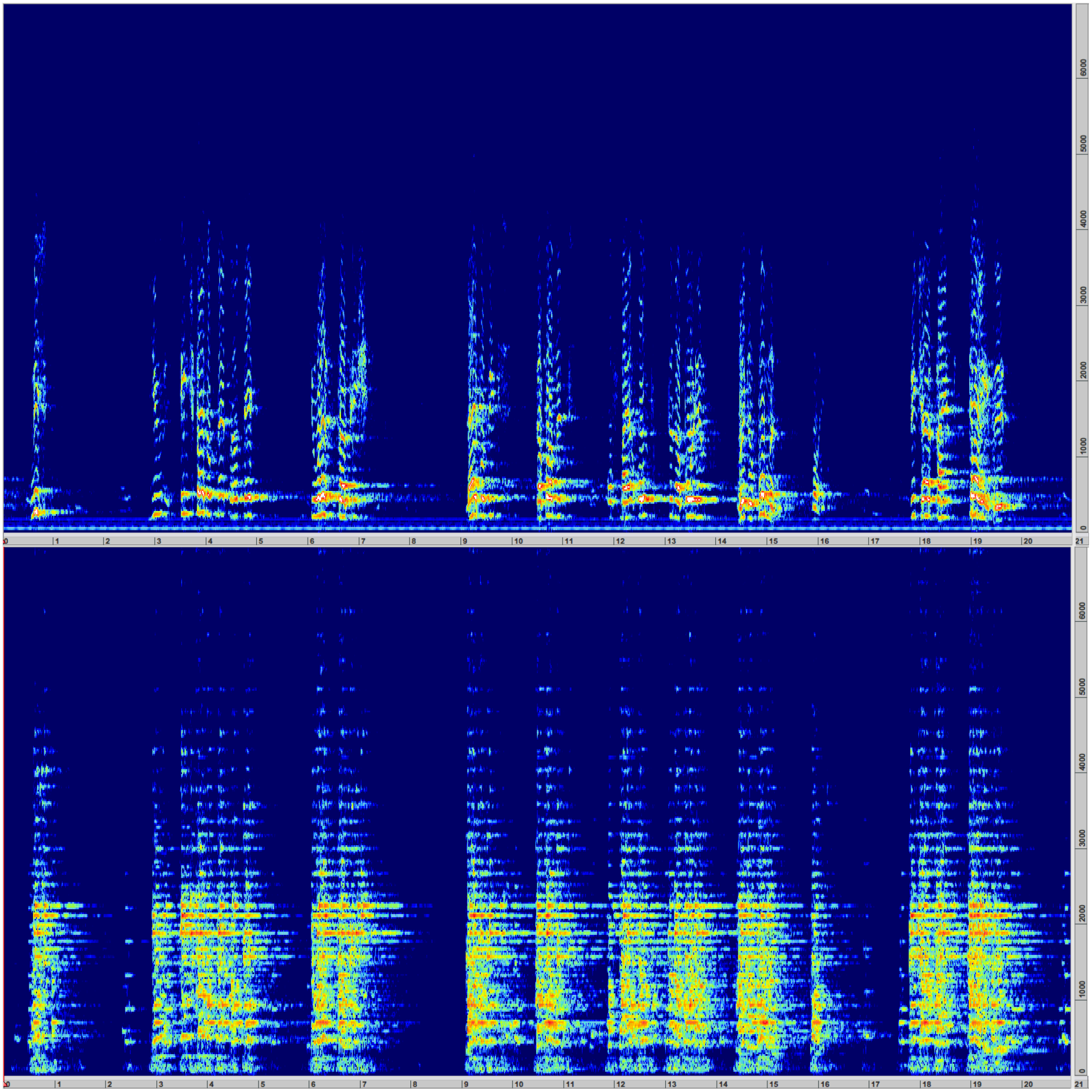
Example 6: Michael Harrison's "Revelation" tuning (Harrison 2007). The upper diagram shows the tuning on a two-dimensional lattice, with just fifths on the horizontal axis and natural minor sevenths on the vertical axis. Arrows indicate the flattening of these sevenths by about a third of semitone. Tunings are given in cents (hundredths of a semitone), measured relative to the reference point C♮ (0). The lower diagram shows the scale in ascending order, with the intervals between pitches labeled as just intonation frequency ratios.

In the tone clouds of *Revelation,* our mechanisms of auditory scene analysis, swamped with a surfeit of confusing and overlapping overtones, do the best they can to resolve the tone cloud into discrete sources, which can include illusory, chimeric auditory images. In this case, the just intervals of the tuning make chimeric perceptions particularly likely, since overtones of the sounding pitches can easily merge into chimeric harmonic spectra. With the sustain pedal depressed, the retuned piano is also particularly predisposed to sympathetic resonance of the undamped strings, enhancing the ambiguity of the chimeric sounds' source.



Example 7: Olivier Messiaen, excerpts from *Catalogue d'oiseaux* (1956–58).). © Copyright 1964 by Alphonse Leduc et Cie. Used by permission.

However, this does not mean that the standard, equal-tempered piano is incapable of producing remarkable timbral effects as well. We find a striking use of solo piano harmonies to produce a timbral effect in Olivier Messiaen's transcriptions of birdsong in the *Catalogue d'oiseaux* of the late 1950s—two brief excerpts are reprinted in **Example 7**. Messiaen himself stated: "When I reproduce a birdsong, every note is provided with a chord, not a classified chord but a complex of sounds which is designed to give the note its timbre" (Messiaen 1986, 102). Olivier Mille's Messiaen documentary, *La Liturgie de cristal,* features an archival video of the composer introducing the songs of the *rossignol* (nightingale) and the *râle de genêts* (corncrake) by imitating them vocally, followed by the corresponding excerpts from *Catalogue d'oiseaux* are played by the composer's second wife, Yvonne Loriod. This demonstration shows a double translation of the timbres of the original birdsongs, imitated both with the human voice and by conversion into piano chords. The piano writing captures the alternating notes and "combination harpsichord-gong timbre" of the nightingale, and even the rough, unpitched call of the corncrake: dissonant intervals and a chromatic cluster push the composite timbre of the piano away from recognizable pitch and towards noise.



Example 8: Peter Ablinger (1959–), *A Letter from Schoenberg* (2006). Spectrograms of Schoenberg's recorded voice (top) and its resynthesis by Ablinger's computer-controlled piano (bottom).

Peter Ablinger's *A Letter from Schoenberg* was first presented as a gallery installation in 2008. A visitor to the gallery, Haus am Waldsee in Berlin, would see a grand piano with a complex electromechanical system mounted above the keyboard: once each hour, the apparatus on top of the piano would explode into life, striking the keys and triggering irregular bursts of massive pitch clusters. The full effect of the piece would only be grasped, however, on approaching closer and reading the accompanying text (Barrett 2009, 159–63). The work is entitled *A Letter from Schoenberg* ("for player piano and an audience reading the text while hearing the piece") and sets—if that's the correct word—the text of an angry letter from the composer to Ross Russell, director of Dial Records in New York. The piano's pitches, amplitudes, and timings are derived from the computerized spectral analysis of an archival recording of Schoenberg's voice, castigating Russell for publishing René Leibowitz's recording of *Ode to Napoleon* with a female narrator rather than a male one as Schoenberg preferred. The replication of the recording by assigning each partial of the spectral analysis to an acoustic instrument is an instance of the familiar spectral music technique of instrumental synthesis (Donin 2015, 325–26). **Example 8** compares spectrograms of the original 1948 Schoenberg voice recording (top), made on a Webster-Chicago "Electronic Memory" wire recorder (Moseley 2016, 114–17), and the resynthesis of the voice through notes played on the piano. The piano's temporal profile is identical to that of the voice, and similarities can also be seen between the lower partials (though the piano's richer tone results in a spectrum much richer in high frequencies). Despite these resemblances, though, the first-time listener is unlikely to recognize the resultant sound as a voice, hearing instead a rather chaotic composition for solo piano.[2]

With the accompanying text at hand as a suggestive guide to focus the attention, the violent bursts of piano notes magically resolve into recognizable words: "*Mister: You, in spite of my protest, you have published Leibowitz's performance of my Ode to Napoleon with a woman's voice, which I find terrible.*" Reading along, we can easily differentiate between different vowels, which have different spectral profiles as represented by changing piano chords, and even hear the articulation of different consonants. Most listeners find that reading the text is necessary to "snap" the words into intelligibility—though after the text is familiar, it becomes difficult *not* to recognize it and to return to hearing just the piano. The profound impact of viewing the words along with the music points to how great a role *perceptualization*—to borrow a term from Cornelia Fales—plays in our hearing of timbre. Fales writes: "If one conceives of the perceived world as shared responsibility, the result of contributions from the acoustic world and the perceiver's mind, then perceptualization is the process by which necessary interpretive elements are identified, created, and combined with acoustic properties of the environment to create auditory percepts" (2002, 63). Ablinger's piece draws attention to the ways that expectations fueled by the visual stimulus of the text bring the Schoenberg text into focus. As the composer writes, "my main concern is not the literal reproduction itself but precisely this border-zone between abstract musical structure and the sudden shift into recognition" (2006).

With these three piano examples in mind, I'd like to return to this chapter's overall project: considering how we can broaden the definition of timbre to include complex, composite objects like harmonies and textures, not only individual, isolated notes. Many of these examples have already cast significant doubt on whether the *note* can still be considered the central building block of music. Leigh Landy (2007, 17) has suggested a useful distinction between *note-based* and *sound-based* music, and Tristan Murail cites as "a fundamental contribution of electroacoustic music… the very essential idea that the musical 'atom' is not the notehead written on staff paper" (2005, 123).

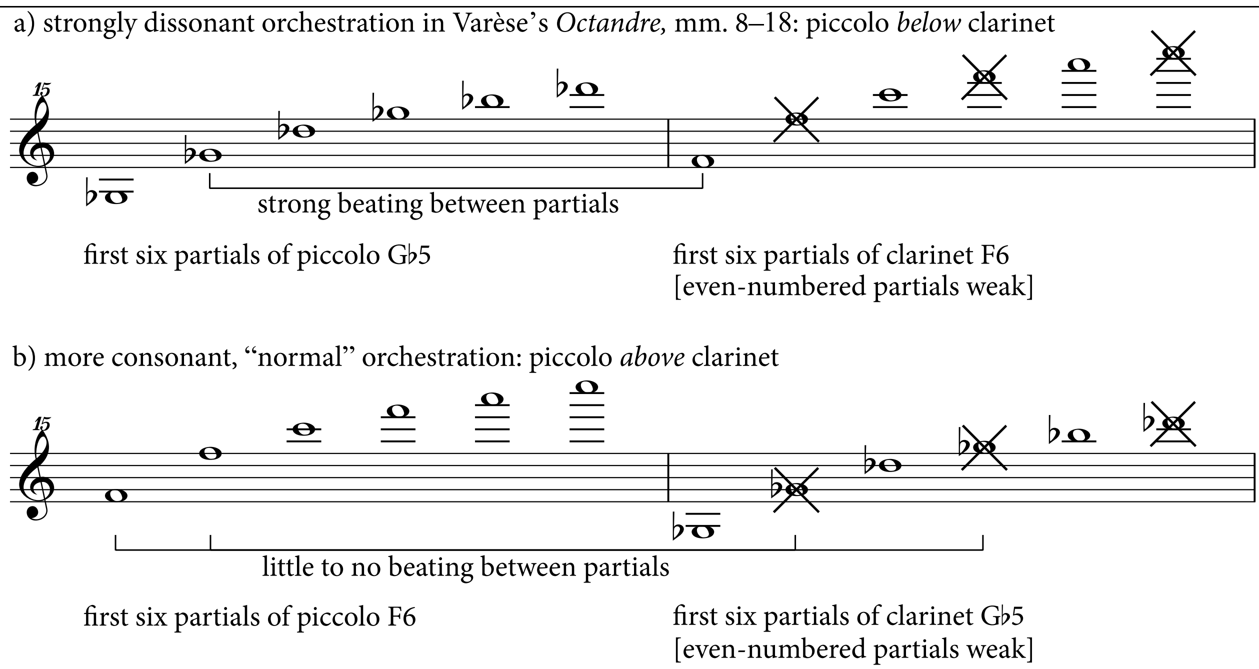
As we start thinking of the timbre of composite events, we will need to change some of our habits in talking about pitch and harmony. First, we will need to abandon the conception of a note in the abstract, isolated from its timbre and acoustical spectrum. We will find that once we include timbre in our conceptualization of notes, the particular timbres assigned to the notes of an interval or chord may have a profound effect on the composite result. The overall perceived effect of a harmony can be a product, in large part, of its constituent timbres. Second, once we begin to think about combinations of individual pitches as composite events with global, emergent properties, we need to conceptualize harmonies as more than the sum of their pitches. It's often pointed out that pitch is a one-dimensional,

[2] A digital copy of the original Schoenberg recording is held by the Arnold Schönberg Center in Vienna: see http://schoenberg.at/index.php/en/archiv-2/schoenberg-spricht?id=983:vr01. Ablinger's website includes a video that presents a transcription of the source text simultaneously with a recording of the piano resynthesis: http://ablinger.mur.at/txt_qu3schoenberg.html. Audio excerpts from the Schoenberg recording and the Ablinger piece are reproduced here with the generous permission of Belmont Music Publishers and Peter Ablinger/Zeitvertrieb Wien Berlin.

"linear" attribute of sound while timbre is "multidimensional"—it can be measured along many different axes, including bright-to-dark, noise-to-pitch, or rich-to-hollow, and also can be described by a number of source-related descriptors: wooden, metallic, vocal, brassy, etc. While pitch may be one-dimensional, the combinations of pitches that make up harmony—when considered as unified wholes with emergent properties rather than just collections of notes (as in pitch-class set theory)—also imply a multidimensional space. Harmonic constructions can be understood as more than just chords or pitch sets, but rather as ways of creating emergent timbres. As we move on from piano music to mixed combinations of instruments, I would like to keep this broadened conception of timbre and harmony in mind. We will see cases in which the specific timbres of individual notes affect how they combine into a particular harmonic effect, and also further examples of global timbral properties produced by strategic harmonic writing.

iii. Harmony mediated by timbre…

Composer and music theorist James Tenney made a substantial step towards acknowledging the effect of constituent timbres on the overall quality of composite events in his discussion of the "wonderfully searing dissonance" from Varèse's *Octandre,* a major seventh between the piccolo's G♭5 and the E♭ clarinet's F6 sounding from measures 8 to 18 (**Example 9**). Tenney presents this example in his book *A History of "Consonance" and "Dissonance,"* which traces the interrelated development of the two terms through the history of Western music. The most recent conceptualization of the terms, which he refers to as "consonance-dissonance-concept 5" (CDC-5), is concerned strictly with dissonance as a sensory phenomenon, not a syntactical one as in earlier definitions. Tenney views CDC-5 as a result of the ideas of Hermann von Helmholtz, who described dissonance as the result of interference between the partials of instrumental or vocal spectra. This type of sensory discordance or roughness emerges from the beating of one partial against another within the same critical band. Dissonance, like timbre, is another example of an emergent property: only the combination of two or more entities can be dissonant, and none of the constituent parts are dissonant on their own.



Example 9: Edgard Varèse (1883–1965), *Octandre* (1923), ii, mm. 8–18. Comparison (after James Tenney) of (a) Varèse's dissonance-maximizing orchestration of the major seventh G♭5–F6 and (b) a

more conventional, consonant orchestration of the same interval.

The influence of Helmholtz on Varèse has been amply documented (Lalitte 2011). Helmholtz himself offered particular recommended voicings for combinations of wind instruments, each designed to minimize dissonance and create the smoothest possible result (Helmholtz 1885 [1863], 210-11). Tenney proposes that Varèse seeks the exact opposite—that he wants to *maximize* the dissonance by placing the clarinet above the piccolo, so that the piccolo's strong second partial can beat against the fundamental of the clarinet. The dissonance, he writes, "would have been far less effective (assuming, as we may, that a strong dissonance is what Varèse wanted here) if the parts had been arranged in the more "normal" way, with the piccolo above the clarinet, since the latter has very little if any energy in its second partial (i.e. at the octave) for the production of beats with the high F, whereas *most* of the energy in the piccolo's tone is probably concentrated precisely in that second partial" (Tenney 1988, 91). The clarinet is unusual among the wind instruments as its vibrational energy is spread among the odd-numbered partials only, with the even-numbered partials weak or non-existent—this is essential to the instrument's unique timbre. Varèse's harshly discordant orchestration juxtaposes the loud second partial of the piccolo (G♭6) with the equally strong fundamental of the clarinet (F6) for a maximum of beating. In the more "normal" orchestration, the lack of prominent clarinet partials at G♭6 and G♭7 reduces the effect of dissonance, as there is not enough vibrational energy at these frequencies to beat against the powerful F6 and F7 of the piccolo. This is a compelling illustration of how particular timbre choices can affect the evaluation of consonance and dissonance, a distinction more often framed in the supposedly timbre-neutral discourse of harmony.

Another passage in which an essentially harmonic structure is transformed by the assignment of timbres is the excerpt from Elliott Carter's *Esprit Rude/Esprit Doux* reproduced in **Example 10**. Again, the example features the flute (top staff) and B♭ clarinet (lower staff, sounding a whole tone below the written pitch). In this passage, the characteristically dense and virtuosic texture of the work gives way to long sustained notes, changing only to articulate a slow, large-scale polyrhythm that stretches through the whole piece. With the virtual cessation of melodic activity, we are free to concentrate on the harmonic and timbral combinations of the two instruments. The slow pace makes it possible to concentrate on each sound, and the lack of any motion that would help segregate the partials into separate sources creates ideal conditions for hearing perceptual fusion.

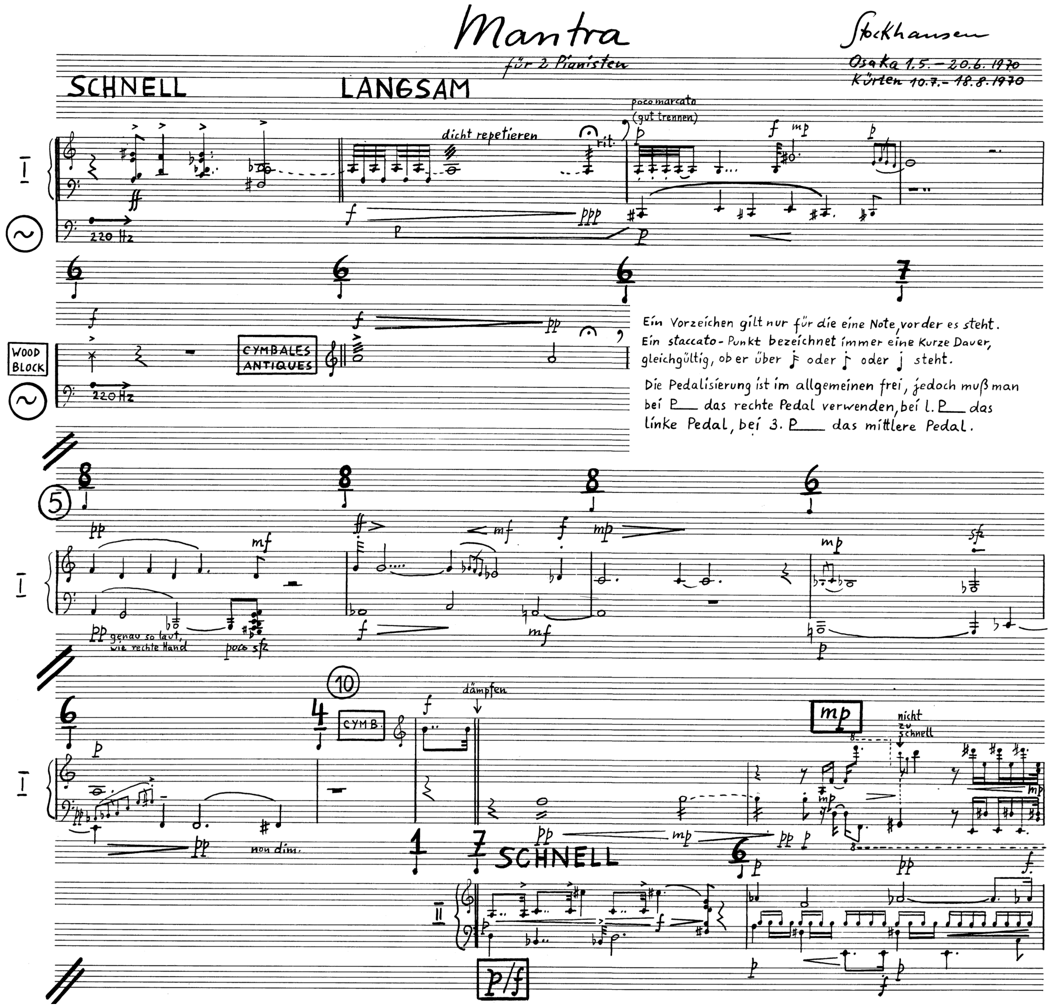
Example 10: Elliott Carter (1908–2012), *Esprit Rude/Esprit Doux* (1984), mm. 50–64. © Copyright 1985 Hendon Music, Inc. Reprinted by permission of Boosey & Hawkes, Inc.

We can identify some effects stemming from the particular overtone structure of the instruments, particularly the clarinet, with its spectrum of odd harmonics only. In the first interval G–C♯ (a tritone plus an octave), the strong third harmonic of the clarinet, D, lies just a semitone above the flute's fundamental, creating subtle yet distinct beating. By contrast, the perfect fifth B♭–F at the end of the second system, which places the clarinet's third harmonic in unison with the second harmonic of the flute, produces a fused, glassy timbre. The effect of timbre contrast is neutralized as both instruments move into their highest registers, where it becomes more difficult to make distinctions between spectra as fewer overtones fall within the instruments' characteristic formants. The seconds B♭–C (measure 55) and E–F (measure 58) are particularly striking: the closeness of the pitches places many of their partials within a single critical band, allowing masking and interference effects to emerge between the two instruments as their sounds fuse together. The result is a curious, electronic-sounding composite timbre, often impossible to separate into two independent sources. The timbral quality of these shifting two-note simultaneities, highly dependent on register and the relative arrangement of the instruments, offers an alternative narrative to the abstract, set-theoretic logic of Carter's pitch-class choices, which are based on the interlocking of all-interval tetrachords. With an effort, it's still possible to hear these structures of pitch-class harmony, but they occur in a context where the emergent properties of the composite timbre are foregrounded instead.

iv. … and timbre as a product of harmony

The Varèse and Carter examples have shown how a harmonic structure, typically considered timbre-neutral, can be thoroughly transfigured by the choice of timbres for each of its individual components. We can also observe cases in which a complex timbre is built up from individual elements, with the guidance of essentially harmonic concepts. A final pair of musical examples from works by Karlheinz Stockhausen and Claude Vivier explores the timbral and harmonic effects of electroacoustic sound processing and what Peter Niklas Wilson has called a “technomorphic” approach to spectral composition (2000). Both pieces make use of striking timbral effects that emerge from the careful design of the frequency structure of a complex sound—a consideration more often considered the domain of harmony.

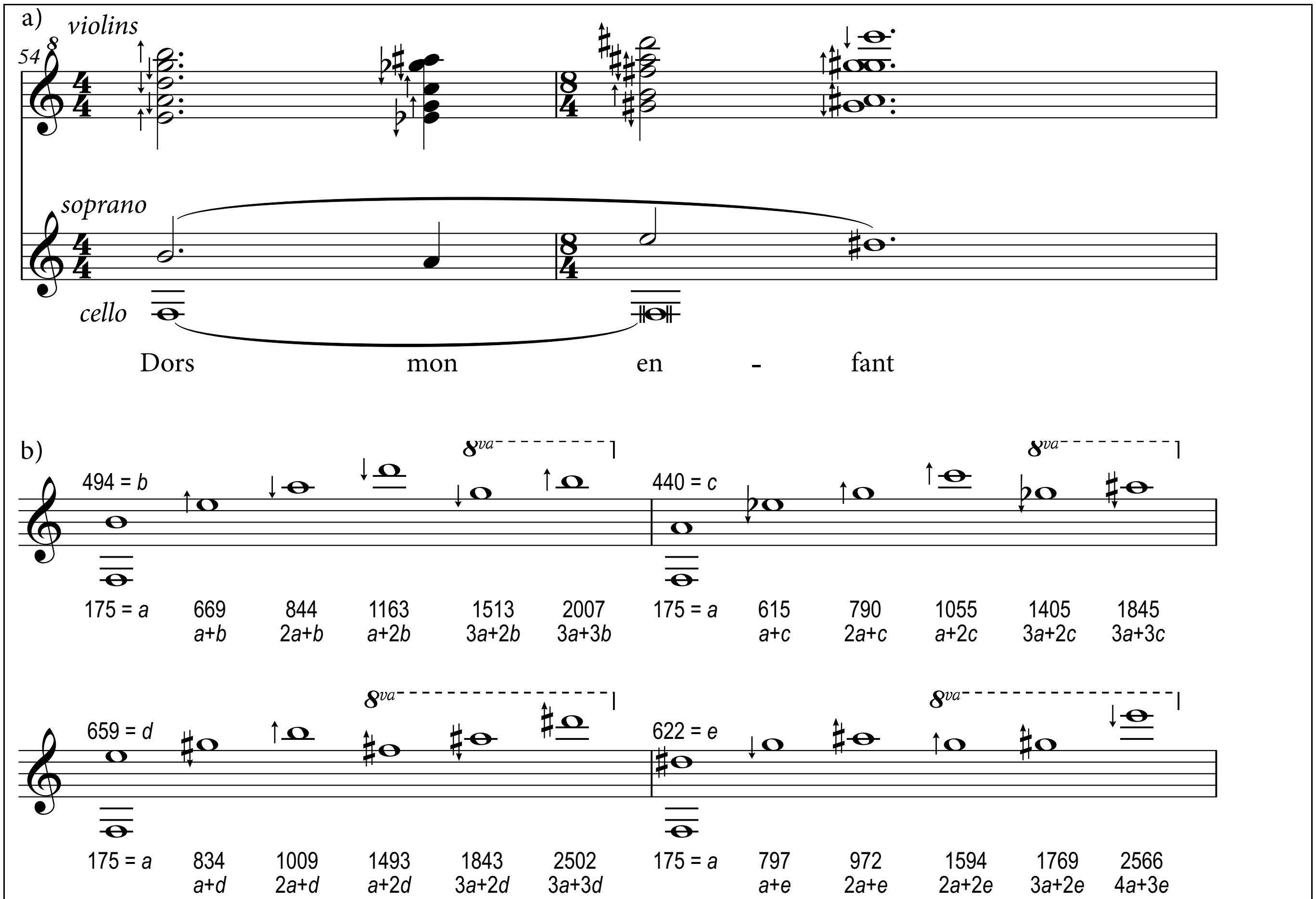
Stockhausen’s 1970 *Mantra* is scored for two pianos (each playing auxiliary percussion instruments) and live electronic processing. It is the first of Stockhausen’s pieces to use the “formula” approach characteristic of so much of his later work. In the opening passage shown in **Example 11**, the sounds of the piano are transformed by a ring modulator, part of a custom electronics module designed and built for the piece. A ring modulator outputs the sum and difference of all the frequencies of the two input signals, in this case the piano sound and a steady sine wave at 220 Hertz (the A below middle C). Since the sound of a piano note is a complex timbre with a rich overtone series, the ring modulator adds and subtracts 220 Hz not only from the fundamental frequency of each note, but also from all of its overtones. The result is a complex harmony-timbre hybrid, which has a different effect depending on the piano note played: it is relatively concordant for pitches related to A by simple frequency ratios (for example an octave A, or a perfect fifth E), but quite discordant for more distant pitches such as A♭. The ring modulation, in effect, makes audible the harmonic consonance or dissonance of each of the piano’s notes in comparison to the unplayed (but nonetheless central) pitch of A. We tend to think of such electronics “effect boxes” as operating primarily on the timbre of the input sounds—the BBC Radiophonic Workshop, for example, used a ring modulator to create the robot-like voices of the *Doctor Who* Daleks. However, by operating on the sounds’ spectra and introducing new frequencies, electronic processing can also have a harmonic effect. The ring modulator of *Mantra* became the model for what Claude Vivier called *les couleurs,* a central compositional technique in his last works of 1980 and 1981.



Example 11: Karlheinz Stockhausen (1928–2007), *Mantra* (1970). © Copyright 1975 by Stockhausen-Verlag. Used by permission.

In works such as *Lonely Child* and *Bouchara,* Vivier augmented his characteristically dyadic musical language with rich ensemble chords similar in conception to ring modulation (Gilmore 2007, Christian 2014). **Example 12** analyzes a short passage from the first vocal melody of *Lonely Child,* measures 54–55. In this passage, the frequencies of the soprano melody and the held F3 in the cello are repeatedly added together in different combinations to create rich microtonal chords in the violins (*les couleurs*). The lower half of the example describes the derivation of these chords for each pair of cello-soprano frequencies. For example, in the first dyad the frequency of the cello's F3 (175Hz = *a*) and the soprano's B4 (494Hz = *b*) are added together to produce the new notes *a+b* (669 Hz), 2*a+b* (844Hz), *a+2b* (1163Hz), and so on. The resulting pitches, played by solo violins at a lower dynamic, create a timbral halo around the original dyad. As Vivier described it:

> If you make a sort of frequency addition of each of these intervals, you arrive at a timbre. So there are no longer any chords, and the whole orchestral body is transformed in this way into timbre. The roughness and the intensity of this timbre depends on the generative interval. Musically, I had one single thing to master which, in a way automatically, would give rise to the rest of the music: great beams of color! (quoted in Gilmore 2007, 10)



Example 12: Claude Vivier (1948–83), *Lonely Child* (1980), creation of *les couleurs* by frequency addition in mm. 54–55.

Vivier's "frequency addition," a procedure essentially harmonic in its manipulation of pitches, eventually "arrives at a timbre." Vivier sees these complex sonorities more as timbres than harmonies, presumably for their apparent indivisibility and strong sense of global color. As in Stockhausen's *Mantra,* the timbre's properties, its "roughness and intensity" are dependent on the harmonic characteristics of the starting interval: dissonant intervals are expanded into rough, inharmonic sonorities, while consonant intervals yield smoother, more consonant results. Both Stockhausen and Vivier start from a harmonic conception, based on individual pitches or frequencies, then augment their pitch constructions into complex sounds that cross the border from harmonies to timbres. This border, as Jonathan Harvey has noted, is the source of "much of the richness" of the spectral approach.

v. Future directions

This chapter has presented a number of examples in which the line separating timbre from harmony is blurred, if not altogether erased. I would propose that we can deepen our understanding of both timbre and harmony by considering each from the perspective of the other, viewing harmony from the perspective of timbre and vice versa.

An approach to harmony informed by timbre would have to recognize, first of all, the essential role of *perceptualization,* the active contribution of the mind in creating auditory percepts. Harmony does not arise simply from the sounds that reach our ear (or still less the notes on the page!), but from an interaction between complex sonic data and mental processes. Most approaches to harmonic analysis and theorization—from pitch-class set theory to neo-Riemannian models—have tended to take a "what you see is what you get" approach, identifying written notes as the primary units of musical sound, and ignoring the much more complex sonic reality represented by each notehead. Giving up the simplistic view of notes as isolated, timbre-neutral atoms means dealing in the messier but more vivid world of actual sounds, with their own timbres influencing the effect of any combination (as in the Varèse and Carter works discussed above). An increased awareness of perceptualization in harmony would draw our attention away from configurations of individual pitches and towards an acknowledgement of perceptual fusion and composite effects such as chimeras and sound masses. A timbral view of harmony would emphasize the emergent properties of harmony, the characteristics that make a harmony more than just the sum of its parts: this implies a greater role for synthetic, rather than analytical, listening.

While harmony does involve a one-dimensional attribute, pitch, we find that combinations of pitches rapidly complicate the picture with multiple dimensions—not of the geometries of abstract pitch space often discussed in contemporary theory, but rather multiple *perceptual* dimensions more difficult to quantify. One possible model for exploring such a multi-dimensional space is offered by the literature on timbre descriptors. Realizing that the multiple ways that timbre can vary are too diverse to be represented by any single axis, researchers including Geoffroy Peeters and Bruno Giordano have developed a "timbre toolkit" capable of describing different timbral properties through objective measurements (Peeters et al. 2011). A number of the descriptors give basic information about the overall temporal evolution of the sound, while others quantify timbre according to different criteria such as spectral centroid (closely correlated to timbral "brightness"), noisiness (defined as a ratio between the energy within and outside a harmonic spectrum), and even "odd to even harmonic ratio," a prime factor in distinguishing between a clarinet and a saxophone. Through these audio descriptors, Peeters writes, researchers "try to establish quantitative correlations between the position along a perceptual dimension and a value along an acoustic dimension derived from the sound signal" (2903). While a few of these audio descriptors could be transferred relatively easily directly from the analysis of timbres to that of harmonies—for example, spectral centroid, noisiness, fundamental frequency (virtual fundamental), it is likely that a number of specifically *harmonic* descriptors would need to be invented as well. A multidimensional approach to harmony could help to explain complex emergent properties like those of the "bell" chords explored above.

In its search for a descriptive and style-neutral theory of harmonic perception, this approach would share common ground with James Tenney's research project outlined in "John Cage and the Theory of Harmony" (1984). Bringing concepts from the world of timbre to the study of harmony could help to promote an understanding of the functional role of particular pitches or strategies of harmonic design in creating or denying particular emergent effects. Specific chord voicings would need to be considered, with attention to pitches-in-register, not just pitch classes. Concepts from auditory scene analysis including perceptual fusion and fission could be particularly valuable—research in this direction has already begun in articles by Alfred Cramer (2002) and David Huron (2001).

On the other hand, if we decide to view timbre as harmony, we need to do just the opposite: to focus not on the emergent effects of fusion—already our default mode for conceptualizing timbre—but rather on timbre as a composite event, which can be broken down into its individual components or partials by analytical listening. Analytical listening to timbre could include an awareness of the individual partials within a single-source or compound sound. As noted by Schoenberg, we can observe the existence of internal movement even in a single tone. Appreciating the role of specific partials in creating global timbral effects such as inharmonicity, tension, or brightness would suggest a functional role for partials comparable to that of notes within a chord or texture.

Viewing timbre more like harmony would also aid in the recognition of the role it can play as a determinant of musical form. Timbre has long been demoted to the role of a "secondary parameter in comparison to the primary parameters of pitch and rhythm (Nattiez 2007). However, as Kaija Saariaho and Stephen McAdams have noted, timbre can take on some of the traditional roles of harmony, particularly by creating tension and release structures comparable to those caused in tonal music by the contrast of consonance and dissonance (1985). One possible equivalent to consonance and dissonance in the domain of timbre is the "sound/noise axis" proposed by Saariaho: "In an abstract and atonal sense the sound/noise axis may be substituted for the notion of consonance/dissonance. A rough, noisy texture would thus be parallel to dissonance, whilst a smooth, clear texture would correspond to consonance. It is true that noise in the purely physical sense is a form of dissonance pushed to the extreme" (1987, 94). Such an approach could be particularly useful in the study of electroacoustic music, which includes a wide variety of pitched, quasi-pitched, and non-pitched sounds.

To conclude, I'd like to return to the excerpt from Schoenberg's *Harmonielehre* quoted above: "The tone becomes perceptible by virtue of tone color, of which one dimension is pitch. Tone color is, thus, the main topic, pitch a subdivision." Once we start examining timbre more closely, we find that it has a strong tendency to overlap into other musical dimensions previously considered distinct: a sound's perceived timbre is affected by its temporal envelope, for example, as well as by the frequencies or pitches of all its components and their relative amplitudes. If we take Schoenberg at his word and begin to explore timbre "as the main topic," we find that timbre can be promoted from its traditionally secondary role—the decorative coloring of a work primarily defined by its pitches and rhythms—to a central category, perhaps even *the* central category, of musical perception.

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