Musical Engagements with Technology: Analytical Explorations of Spectral Mixed Music

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Abstract

This thesis is an examination of how the interactions between acoustic and electronic components in mixed music pieces can be the source of both novel perceptual effects in listeners as well as semantically rich dialectics. In such instances, technology is not used solely as a means of sound production but its incorporation is crucial to the shaping of musical meaning. Mixed works of the spectralist tradition, pioneered by Gérard Grisey and Tristan Murail in the 1970s, are especially well-suited to such investigations because of an aesthetic interest in creating ambiguous musical sounds that exploit certain limitations of the human auditory system's perceptual mechanisms. Two spectral mixed works, Jonathan Harvey's *Tombeau de Messiaen* (1994) for piano and tape, and Joshua Fineberg's *The Texture of Time* (2006) for flute and electronics, form the basis of two analytical case studies on the perceptual and semantic effects of acoustic and electronic interactions in live music. The analyses incorporate a diverse methodology, including both poietic (creation-based) and esthesic (reception-based) approaches, the latter of which is more rare in scholarly literature on mixed music. I argue that esthesic analytical claims, when rooted in theories of music perception, can help to elucidate the perceptual effects of mixed works as well as new musical meanings created by these effects.

Résumé

Ce mémoire est une enquête sur les interactions entre les composantes acoustiques et électroniques dans les pièces de la musique mixte, et comment ces interactions peuvent être à l'origine des nouveaux effets de perception ainsi que des dialectiques sémantiquement riches. Dans ces cas, la technologie n'est pas utilisée seulement pour produire les sons, néanmoins son incorporation est intégrale à la formation du sens musical. Les pièces mixtes qui font partie de la tradition spectrale (crée par Gérard Grisey et Tristan Murail dans les années 1970) sont particulièrement aptes pour ces enquêtes grâce à une préoccupation esthétique, élaborant ainsi les sons musicaux ambiguës exploitant les limites des méchanismes de la perception. Deux pièces qui sont spectrales et mixtes, *Tombeau de Messiaen* (1994) par Jonathan Harvey pour piano et bande électronique, et *The Texture of Time* (2006) par Joshua Fineberg pour flûte et dispositif électronique, fournissent deux études analytiques sur les effets de perception et du sens musical des interactions entre les sons acoustiques et électroniques. Les analyses incorporent une méthodologie diverse, incluant à la fois des techniques poïétiques (concernant le processus de création) et d'esthésiques (concernant le processus de réception), dont le dernier est plus rare dans la littérature savante sur la musique mixte. Je soutiens que les revendications analytiques esthésiques, lorsqu'elles sont basées sur les théories de la perception, peuvent aider à élucider le potentiel de la musique mixte à créer des nouvelles perceptions et de nouveaux sens musicaux.

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MUSICAL ENGAGEMENTS WITH TECHNOLOGY: ANALYTICAL EXPLORATIONS OF SPECTRAL MIXED MUSIC

Chapter 1: Introduction and Background

.1 Introduction

While musical cultures and their means of producing musical sound have always been susceptible to changes or improvements over periods of time, the proliferation of technological innovations in recent decades has led to an unprecedented acceleration of this process. Technologies today evolve much more rapidly than the cultural institutions they have become intermeshed with, leaving little time for reflection on the shifts created by the changing dynamic between culture and technology, and the traces these shifts leave behind in language, social codes and cultural capital. The concert music tradition of Europe and North America has not been immune to such shifts, a simple example being how the invention of recording technology has simultaneously changed our relationship with live classical music and allowed for new modes of composition.

While an entire thesis could be written about the phonograph and how it has changed our relationship to music, my concern here is not to deconstruct how one specific technological innovation has changed the face of music in general or Western art music specifically. Rather, I'm intrigued with how technology has infiltrated the very language of live concert music itself; how it has mediated both compositional processes and live performance practices, and how these mediations leave their traces in the resultant sound and its impression on listeners. Put another way, what influence has technology had on the ability of live music to communicate or express meaning? What is new or different about technologically mediated compositions in comparison to purely acoustic ones? How can music actually engage technology on a *musical* level—on the semantic plane of how music comes to signify—rather than simply employing it as a tool or means of sound production?

These questions are open-ended, and the goal of my thesis is not to provide any quick and easy solutions to how we are to understand the complex relationship between music and technology. My aim is rather to demonstrate how specific compositions embody compelling dialectics with technology, in the hope that these findings may contribute to a larger theoretical discussion on the semiology of technologically mediated music. Approaching this topic from the field of music theory, my primary mode of interpretation will be musical analysis, what Ian Bent (1981, 341) refers to as "that part of music [discourse] which takes as its starting-point the music itself rather than external factors." Besides the fact that many traditional analytical techniques are not applicable to newer music, technologically mediated music poses its own set of methodological challenges in terms of the various analytical objects in play and the diverse skills required for their interpretation. In the past, these challenges have caused many theorists to shy away from electronic or mixed works (works that combine electronic sounds with acoustic instruments), leaving a wide gap in the theoretical literature and excluding many contemporary works from analytical consideration. Evidently, technology has not only left its mark on music itself but also on the academic institution of musical discourse. As a result, my project is as much an investigation on the discursive limitations of this branch of music as it is an active interpretation of it, exploring and interweaving several methodological options between and throughout my analyses.

The second half of my title, "analytical explorations of spectral mixed music," refers to a specific subset of contemporary compositions that intersect the mixed-format combination of electronic sounds and acoustic instruments with the spectralist tradition, a well-documented compositional movement pioneered in the 1970s by French composers Gérard Grisey and Tristan Murail. Spectralism (or spectral music) takes knowledge gained from the fields of acoustics and psychoacoustics as a direct source for inspiration, organizational models, and harmonic vocabulary, with an overall concern for "the way sound changes in time and the affects it produces in the human mind" (Fineberg 2000, 113). Mixed-format works have played a significant role in the output of spectral composers, and I believe these works offer a unique perspective for contemplating the role of technology in contemporary concert music. Technology and its residual effects permeate these works on multiple levels, from the compositional models of both the acoustic and electronic components, to the coordination of a live performance and its dramaturgic effects, to how the interactions between the two are perceived and understood by the human auditory system of a listener. At the same time, as will be argued shortly, I believe that many of these works are able to transcend many of the dualisms inherent in their very construction: technology versus nature, electronic versus acoustic, live versus recorded, etc., and that it is precisely in this transcendence that this genre of music uncovers new semantic terrain; where truly musical engagements with technology can be located.

I have selected two pieces from this specific genre of 'spectral mixed' works for in-depth analytical consideration, which together will demonstrate the unique semantic potential of this body of works as well as the analytical techniques required for their interpretation. The two pieces I have chosen for this project are *Tombeau de Messiaen* (1994) for piano and digital audio tape by Jonathan Harvey (1939-2012), and *The Texture of Time* (2006) for flute and electronics by Joshua Fineberg (b. 1969). The tape component of the former is based on piano sounds tuned to twelve different harmonic series, one for each tempered pitch class, creating an interesting dialectic with the live piano that remains in equal temperament; each tuning system simultaneously questions and reinforces the other. The electronics of the latter are based on resynthesized versions of the live flute's sounds, which trail behind the live flute as morphed echoes of the past, creating a dramatic dialogue between past and present through the use of shifting inharmonic spectra. In each case, technology is not just a means to an end, but its incorporation is essential to the interpretation of each piece, as each is characterized by the interactions between live and electronic components and their semantic consequences.

Though each piece contains an internal dialectic between live and electronic components, the methodologies used for each analysis are distinct yet complementary. Harvey's piece is fairly straightforward to reverse-engineer through tracing and labeling the partials of various harmonic spectra, while Fineberg's remains quite elusive in terms of uncovering the actual compositional models used to create the various inharmonic spectra at play. The former will therefore lend itself to a more poietic (creation-oriented) analysis, while the latter will lend itself to an esthesic (reception-oriented) one (Nattiez 1990), which will ground observations in theories of psychoacoustics. As we shall discover, these methodological categorizations are not inflexible, and much overlap exists between the two. However, approaching two works from vastly different angles will allow for a larger reflection on the epistemology of analytical discourse as it pertains to mixed works: what kind of statements can be made about this type of music and how do we go about making them?

The remainder of this chapter will provide deeper context for the 'spectral mixed' subset of contemporary concert music, briefly exploring the historical background of mixed-format and spectral works, problematizing the medium of the mixed work and categorizing its many manifestations and dualistic oppositions, and examining how spectralism enables mixed works to overcome simplistic oppositions of electronic versus acoustic sounds. Following this I will present the psychoacoustic terminology that will pervade the remainder of this thesis. The second chapter will be strictly devoted to questions pertaining to methodology, and will borrow Jean-Jacques Nattiez' semiological tripartition as a model to classify the various poietic and esthesic analytical techniques that will be considered and utilized throughout my analyses. The third and fourth chapters will consist of the two analytical case studies as described above, each providing additional context as it pertains to the specific problematic of each work.

.2 The Dualism of Mixed Music – At the Intersection of Two Music Traditions

To trace the origins of mixed music we must first begin with the emergence of the electroacoustic music tradition, beginning with the impact of recording technology on composition in the1940s. One of the pioneers of this new compositional medium was French composer Pierre Schaeffer (1910-1995), who developed the concept of *musique concrète,* or music created from "concrete sounds" recorded onto record or magnetic tape and manipulated with the technologies of the time. One such work was Schaeffer's *Étude aux chemins de fer,* which was the first piece of *musique concrète* to be broadcast by Radiodiffusion Française, on October 5, 1948. Working within the collective *Groupe de Recherche Musicale*, Schaeffer was the first to coin the term "acousmatic" (*acousmatique*) in reference to *musique concrète,* and defined it as "referring to a sound that one hears without seeing the causes behind it" (1966, 91). The word itself is borrowed from Pythagoras, whose *akousmatikoi* referred to his group of disciples who listened to him speak from behind a veil, so that they would focus on the content of his lectures without the distraction of his presence. (Similarly, listeners of acousmatic music listen to the sound content itself from behind the "veil" of loudspeakers, hidden from the sound sources.) It is from this starting point that Schaeffer developed his concept of reduced listening (*écoute réduite*), where listeners learn to differentiate sounds not based on their presumed sources but on certain morphological qualities of the sounds themselves. In this way, expanded timbral palettes and modulations between different timbres create much of the musical expression and internal dialogue for this genre of music, as opposed to traditional idioms of pitch and rhythm.

As *musique concrète* was taking off in France, a similar style of music developed in Cologne, Germany at the public radio station WDR's electronic music studio. After briefly working with Schaeffer in France, German composer Karlheinz Stockhausen soon took up residence in the studio. One of the aesthetics pioneered here was *elektronische Musik,* music created entirely from electronically generated sounds, as opposed to relying on recordings of acoustic sources in the manner of *musique concrète* . A great example of this type of music is Stockhausen's *Studie II* (1954), composed entirely of manipulated sine tones, which also happens to be the first piece of electronic music accompanied by a published prescriptive score, outlining precisely how the piece can be recreated in a studio.

Building upon the pioneering efforts of Schaeffer, Stockhausen, and many others, the aesthetics of *musique concrète* and *elektronische Musik* have combined to form the more generically labeled electroacoustic or acousmatic tradition, which has largely been aided by the construction of electroacoustic studios within the composition departments of most major universities. A certain type of performance practice has developed alongside acousmatic music, in which listeners are gathered in a concert hall with loudspeakers surrounding them on all sides. The composer or another qualified technician will often "diffuse" the work live, creating spatial effects by fading the sounds between different loudspeakers. The addition of live diffusion has been seen as an attempt to reintegrate a certain level of "liveness" to the otherwise static loudspeaker concert, which nonetheless remains a projected playback of pre-composed material. Surround-sound spatialization and the creation of immersive acoustic environments could be considered the second main novel contribution of acousmatic music, following the aforementioned expanded timbral palette.

While purely acousmatic music continues to enjoy popularity within academia, it was only a matter of time before the technological breakthroughs of this genre came into contact with the more established Western tradition of live concert music, creating the ‘mixed’ work with which this project is concerned. In fact, this happened relatively soon after the innovations in Paris and Cologne. Some of the earliest known mixed works were Bruno Maderna’s *Musica su due dimensioni* for flute and tape (1952), Edgard Varèse’s *Déserts* for orchestra and tape (1954), and Karlheinz Stockhausen’s *Kontakte* for electronic sounds, piano, and percussion (1958–60). Maderna’s piece begins by alternating solo flute sections with sections of tape, but gradually the ‘two dimensions’ come into contact with one another and play simultaneously, a novel innovation at that time. Varèse’s *Déserts* was the first mixed piece for an ensemble and tape, the ensemble featuring fourteen brass and wind players, five percussionists, and a pianist. The tape portions are played alone, dividing up the ensemble parts. Lastly, *Kontakte* was Stockhausen’s first mixed work, combining piano and percussion with a tape part, whose purely electronic sounds were generated using a ring modulator, a reverberator and an impulse generator.

Coordination between live and electronic components has always been a significant obstacle in mixed works, as the temporal rigidity demanded by the playback of pre-recorded material places significant restraints on the expressive liberty of the live performers. Each of the above examples found its own solution to this problem: *Musica su due dimensioni* did not require precise coordination and thus allowed the performer to approximate their entries, while

Kontakte demanded the pianist to follow and coordinate with the pre-recorded tape to a high degree of precision. *Déserts* sidestepped this issue completely by not having the two play simultaneously whatsoever. Since the time of these early experimentations, further technological developments have seen the rise of "live electronics," which use a variety of hardware and/or software to create effects in real-time, altering the input sound of the live-instrument. Stockhausen's *Mantra* (1970) for two pianos and electronics is a good example of this, using ring-modulation to create effects in real-time.

While the simultaneous presentation of two vastly different acoustic and electronic sound worlds presents its host of logistical problems, their interactions and coexistence can also give rise to unique modes of expression and new semantic terrain. When handled gracefully, tensions between visual cues and auditory results, familiar and unexpected sounds, human and machine, and presence and absence can create incredible dramaturgic effects and sonically pleasing results for the listener. When handled poorly, however, these dualisms may draw attention to themselves (Frengel 2010, 96), pointing out the various aesthetic and logistical problems that arise when these two very different traditions are espoused within a single musical work. Within the framework of this opposition, the emergence of mixed music could be seen from one of two angles: either it is an attempt to reintegrate a sense of "liveness" and visual dramaturgy to the less visually stimulating acousmatic medium, or an attempt to extend the sounds and spaces of traditional concerts beyond the limitations of acoustic instruments played on a stage. Regardless of one's starting point, the tensions between these two music traditions unleash a vast potential of semantic consequences, along with many ways of establishing the relationship between electronics and live performers.

.3 Classifying Relationships in Mixed Works

The mixed work is far from being a homogeneous genre - there are a multitude of ways in which electronics and live instruments can be brought together, some of which yield more interesting results than others. Electroacoustic composer Michael Frengel (b. 1972) has written about these relationships in extensive detail, and his article "A Multi-dimensional Approach to Relationships between Live and Non-live Sound Sources in Mixed Works" (2010) introduces terminology that is helpful in mapping out a taxonomy for these diverse relationships. He identifies nine axes that constitute the basic framework: *segregational, proportional, temporal, timbral, behavioral, functional, discursive,* and *pragmatic*. Each one of these axes contains several nodes of possibilities for classifying any particular work. For example, the *timbral* axis has three nodes: similar, dissimilar, and equivalent, for describing the different ways in which the timbre of the electronics can be compared to the timbre of the live instrument(s). Rather than reproducing the article verbatim, I will only engage several of these axes in an attempt to highlight significant issues.

Let's first consider the more practical *pragmatic axis*, specifically the sound production format. As previously stated, electronic sounds in mixed works are generally either pre-recorded (fixed) or rendered in real-time (live). While live electronics may overcome issues of fixity and coordination, their technologies often become outdated and obsolete at an astonishingly rapid rate, rendering many pieces completely unrealizable in a matter of years. In addition, because composers do not have the ability to edit their sounds in the studio to their satisfaction (they control the process but not the outcome), the resultant sounds are often sonically inferior (Frengel 2010, 104). Two pieces that have been successful in transcending these problems are Stockhausen's *Mantra* and Pierre Boulez' *Anthèmes 2* for violin and electronics. Both use simple yet effective processes that are not tied to any one specific technology, such as ring-modulation and amplification in the case of *Mantra*, and frequency shifting, infinite reverberation, and delay in the case of *Anthèmes 2.* In addition, both scores contain extensive details prescribing exactly what should be happening in the electronics at all times, rendering it possible to reproduce the same effects with different/updated technologies, allowing them to stand the test of time in ways that other pieces for "live" electronics cannot.

Composers who resort to more technology-specific processes or do not labor over prescriptive scores find that many of their works originally conceived for live electronics eventually end up being preserved in a more fixed state. Unfortunately, for the time being it seems as though one must choose between live electronics and the potential for a work's longevity. While Boulez and Stockhausen attempted to transcend this from the angle of real-time electronics, there are also ways to liven up fixed electronics out of their temporal rigidity. Frengel differentiates between what he refers to as "single-indexed fixed" and "multi-indexed fixed," the former referring to a single playback track that plays continuously through a performance, the latter to dividing the electronic part into multiple indices, whose playback can be controlled by a performer using a trigger. Dividing the pre-recorded sounds into smaller cells "minimizes the temporal constraints associated with fixed formats" (Frengel 2010, 104), allowing the performer more flexibility between fixed sound events. Whatever sound production format is ultimately settled on by the composer, the challenge always remains the same: how to balance a rich sonic palette, temporal freedom, and the potential for longevity in a manner that calls for the least possible number of compromises.

Moving beyond pragmatic choices of technology and medium for the electronics, there are many ways in which a composer can situate the live instruments in relation to the electronics.

Several of Frengel's axes are somewhat interrelated; the segregational and timbral axes are closely linked, as are the functional and behavioral axes. All four of these contain nodes which articulate two extreme scenarios of the live/non-live confrontation: the two components can either coalesce or be in complete opposition to one another. The segregational axis describes whether the sounds of the electronics and live instrument are *monomorphological* or *polymorphological,* the former referring to a situation in which only one musical identity is perceived by the listener, the latter to when multiple musical identities are heard concurrently. Connecting to the timbral axis, when the timbre of the electronics is similar to the live instrument, we are more likely to perceive a monomorphological event, and the live/non-live dualism is somewhat diminished (98). The behavioral axis refers to how autonomous the components are in relation to one another; being independent, interdependent, or singular. Independence would refer to situations where the components have little influence on one another, interdependence where they respond or react to one another, and singular where their identities are functionally inseparable. The functional axis describes what roles components take on within this behavioral framework. An independent function would be setting up the electronics as an *environment,* taking on the role of a spatially articulated backdrop for the live performer. Interdependent functions would include *dominant/subordinate*, *coequal*, and *causal* relationships between components, while a singular function would be the established notion of the electronics being an *extension* of the instrument. Once again, singular behavior and function would allow the components to coalesce, whereas independence would place them in opposition.

Having established a taxonomic framework, we can now use Frengel's terminology to evaluate which types of relationships are more or less likely to yield meaningful results. At one extreme, pieces in which the electronic and acoustic components are too independent, too timbrally dissimilar, too functionally disparate, etc., draw attention to the dualism between electronic and acoustic elements to the point where it can become distracting and detract from a meaningful dialogue between the two. At the other extreme, if the components are completely identical (and performing identical functions), the dualism might disappear altogether to the point where one questions the incorporation of electronics in the first place. Some of the most interesting results in the mixed-work format have resulted from an attempt to transcend these binary binds. *Synchronisms No. 6* (1970) for piano and electronics by Mario Davidovsky (b. 1934), uses both piano sounds with altered morphologies (such as a crescendo rather than a diminuendo after an initial attack) and sounds of other timbral profiles that nonetheless mimic certain qualities of the piano's sound. The behavior of the electronics thus shifts at various points, moving from singularity to independence and back again in a seamless fashion, turning the dualism itself into a compositional resource to be exploited. *Synchronisms No. 6* was somewhat of a rare phenomenon at its time, which no doubt contributed to its Pulitzer Prize win in 1971. With the rise of spectralism, however, many more mixed works have been created that overcome simplistic dualistic tendencies, thanks to certain aesthetic principles of the movement, to which we will now shift our focus.

.4 Spectralism and Ambiguity

As stated earlier, in its simplest definition spectralism is concerned with "the way sound changes in time and the affects it produces in the human mind." This may seem like a self-evident and banal statement to make about musical composition, but in the context of post-serial intellectualism that dominated academic concert music in the 1970s, this simple attitude was both reactionary and revolutionary. Joshua Fineberg argues that one of the main problems with serialist/post-serialist music is that the complex, highly intellectualized pitch relationships are incomprehensible to the average listener (2006, 109). He argues that many revered serialist pieces were effective not because of their pitch relationships, but rather because of their "orchestration, motion and contrast…The pieces work *in spite* of this intellectual baggage not *because* of it" (111). Seeking to counteract this disconnect between compositional procedures and sonic results without resorting back to tonality, two of Olivier Messiaen's students, Gérard Grisey and Tristan Murail, decided to turn to the materiality of sound itself for inspiration.

An excellent example of Grisey's early work that demonstrates some tenets of spectral techniques is his 1975 work for eighteen instruments, *Partiels.* Beginning with a spectral analysis (sonogram) of the attack of an E2 on a trombone, Grisey used this data to re-construct the timbre of the trombone by having different instruments play its harmonic partials. When heard together, all of the partials played by different instruments create a lush chord that roughly approximates the sound color of the trombone. This technique is known as instrumental or orchestral synthesis, and the resultant sound objects it creates are referred to as composite timbres. The creation of global sound properties from many individual sound sources relies on the psychoacoustic phenomenon of fusion, or the ability of the human auditory system to group together different simultaneous frequencies into one perceptual object (more on this topic shortly). While the resultant orchestrated sounds in *Partiels* do not identically match their model, they offer a microscopic view into the inner sound of a trombone attack – a sound that can be stretched slowly over time to examine in detail the richness of its inner harmonic content.

One of Murail's stunning achievements that set a precedent for other spectral mixed works was *Désintégrations* (1982) for seventeen instruments and electronics. Similar to how Grisey started from the analysis of a trombone attack in *Partiels,* Murail wrote *Désintégrations* based on the analyses of various instrumental sounds, including pianos, clarinets, flutes, trombones and bells, among others. The title comes from the idea that certain instrumental timbres are gradually "disintegrated" into their component pieces allowing their interiors to slowly reveal themselves, in addition to how harmonic spectra are gradually distorted into inharmonic spectra through a technique known as stretching (Fineberg 2000, 122). Because the pitch material for both the tape and instrumental parts is based on the same instrumental models, the two components blend and fuse together unusually well. This ability to blend acoustic and electronic sounds by basing both components on similar models extends to his other mixed works, including *Bois Flotté* (1996) for five instruments and synthesized sounds, based on sounds created by water, and *L'esprit des dunes* (1993-94) for eleven instruments and synthesized sounds, based on traditional vocal and instrumental timbres from Tibet and Mongolia. Fineberg credits the possibility for composers to base both electronic and acoustic parts on the same acoustic models for the fact that mixed works have become so ubiquitous for spectral composers (Fineberg 2000, 85).

While the ability to use similar models for composing both electronic and acoustic components certainly facilitates the use of spectral techniques in mixed works, I would argue that the high quantity of mixed pieces composed by spectral composers should not be attributed solely to this phenomenon. Rather, I believe the aesthetic desire to create perceptual ambiguity in listeners underlies the marriage of convenience between spectral composers and mixed works, and the fact that many works base both components on similar models is merely a symptom of this larger aesthetic value at play. Perceptual ambiguity could be defined as any situation in which acoustic information challenges our innate and learned perceptual mechanisms, or leads us to perceive things that do not exist in the physical materiality of the sound. Stephen McAdams writes, “Of particular interest for music composition are the ways in which [perceptual] mechanisms operate with respect to ambiguous acoustic information, the ways a listener can be beckoned beyond the boundaries of established patterns of perceiving” (1982, 279). This aesthetic is at the heart of purely instrumental spectral works as well: in *Partiels,* the ambiguous transformations between an actual trombone sound and its orchestrated twin are responsible for much of the dramatic dialogue and perceptual intrigue of the piece. By incorporating electronics into the mix, composers multiply the available techniques and possibilities for orchestrating perceptual ambiguity. Sounds can be distorted, morphed or hybridized in conjunction with instrumental sounds to uncover new sonic terrain and musical signifiers at the ambiguous boundaries between harmony and timbre, as well as between the acoustic and synthetic.

A strong proponent of ambiguity, English composer Jonathan Harvey (1939-2012) has admired the spectral tradition and often incorporated its values and techniques into his compositional language. He believes that ambiguity plays an important role in all music, what he describes as a “vibrant tension” between unity and variety (1999, 28). Perceptual ambiguity plays an important role in his work *Advaya* (1994) for cello, keyboard and electronics. The piece takes its name from an old Buddhist term meaning “not two,” which Harvey further qualifies as meaning “beyond duality (without denying duality’s existence)” (1999, 82). In terms of production format, the piece combines a multi-index playback of pre-recorded samples with live electronics. The electronics are all based on cello sounds, varying in length from small gestures to several minutes of playback. This creates perceptual ambiguities in terms of discerning which sounds were produced live and which were pre-recorded; whether their source was instrumental or electronic. Harvey has written that live electronics enable a metaphysical dialectic, one in which he can convey personal transcendent experiences and dreams, and where “two worlds are brought together in a theatre of transformations" (1999, 80).

The aesthetic drive for perceptual ambiguity enables many mixed spectral works to overcome the blatant dualisms discussed in the previous section. Composers are able to construct sonically rich electronic parts from acoustic source material, and then place them in dialogue with live instruments. At any given moment, the sounds may blend and fuse together beautifully, erasing questions of multiple sources, while in the next moment they may become starkly segregated and individual. This exploits the ambiguous boundary between singularity and independence—between individual and multiple identities. These ambiguities disturb the conventional binary opposition found in mixed works of acoustic versus electronic/nature versus technology, transforming the opposition into a more fluid dialectic between "not two" voices. The acoustic and electronic sound worlds coexist and coevolve on the same plane, giving agency to technology to participate actively in a hybridized musical dialectic. While my argument hinges on the potential of spectral mixed works to create perceptual ambiguities, I have not yet provided a more technical description of the acoustic and psychoacoustic principles that lie at the heart of music perception. The following section will explore those concepts in more detail through an overview of some of the work surrounding auditory perception and its relation to spectral music, specifically the work of Stephen McAdams, Daniel Pressnitzer and Albert Bregman.

.5 "Music for Human Beings:" Psychoacoustics and Auditory Scene Analysis

In his book, "Classical Music, Why Bother?" composer Joshua Fineberg makes a strong polemic for the potential of spectral music to overcome the intellectual, social, and cultural barriers currently driving a wedge between contemporary classical music and the general listening public. Unlike serialism and other contemporary styles, whose abstract theoretical constructions are often rendered inaudible in the music itself, spectralism appeals directly to aspects that can be heard and impressions that can be created in a human listener. In short, spectralism, in using the very physical nature of sound as its source material, attempts to create a "work of sound designed to be heard by human beings" (2006, 137).

Daniel Pressnitzer and Stephen McAdams echo this sentiment in their article "Acoustics, psychoacoustics and spectral music" (2000, 34), when they write: "Though [a perfect understanding of acoustic phenomena] is necessary [for spectral composers], this comprehension is not sufficient: what counts in the end is certainly (at least in the logic of the spectral approach) what is perceived and understood by the listener. It is at this level that psychoacoustics, which extends and validates the reflection on purely physical structures, enters the picture." In this respect, it appears as though spectral music, more explicitly than other types of music, is meant to interact directly with the human auditory system, and that these interactions are more deliberately understood and contemplated from the composer's end. Though a composer's musical intention will always remain ontologically distinct from its resultant auditory impression in a listener, perhaps the gap between these two objects is somewhat reduced through a more deliberate contemplation and intimate understanding of the auditory system by the composer. How exactly does the human auditory system make sense of spectral music, and how can composers exploit these psychoacoustical mechanisms to create varied and musical results?

To better understand the human auditory system and how it analyzes complex sound environments, including those created by spectral and/or mixed music, it is imperative to consider the work of Albert Bregman on auditory scene analysis (1990). The term "scene analysis" derives its name from a query in robo-optics called the "scene analysis problem," in which a machine has to determine which regions within a visual field should be allocated to which objects based on the information (colors, lines, etc.) it is presented with (1990, 4). Scene analysis is thus the appropriate partitioning of physical evidence obtained by the sensory organs to make meaningful and accurate perceptual representations of our physical environment. For the sense of vision, a simple scene analysis problem can be described in terms of the correct grouping of regions (1990, 6). For hearing, scene analysis becomes the correct allocation of frequency components within a group of sounds to their individual sources. Auditory scene analysis is what allows us to answer questions such as "How many people are talking? Which one is louder or closer? Is there a machine humming in the background?" (1990, 6) rather than hearing an indiscernible mass of sound.

Considering that the only input information available to our ears is a "collection of interleaved sinusoids, with frequencies and amplitudes varying over time," (Pressnitzer and McAdams 2000, 49) it is quite remarkable that we are able to "structure the acoustic world in terms of coherent entities that we can generally detect, separate, localize, and identify." It is this natural and automatic ability to structure our auditory environment that allows musical experience to be something greater than a "simple succession of percepts" (49). This structuring is made possible via two principal mechanisms for grouping sounds into coherent psychological entities (also known as auditory images), the first being the grouping of successive events into auditory streams, and the second being the perceptual fusion of simultaneous sounds.

The first mechanism groups a sequence of events from the same source into a coherent auditory image distributed over time, and allows us to hear musical melodies and to follow the voices of different individuals speaking or singing. While this "horizontal" grouping mechanism is fascinating, and has been exploited musically in the past (most notably with compound melody: multiple melodic streams can be separated via rapid arpeggiation, creating virtual polyphony on a monophonic instrument), it is the second grouping mechanism, that of simultaneous or "vertical" fusion, which is especially pertinent to spectral composers and listeners.

At its simplest level, the grouping mechanism for vertical fusion is what allows us to hear a single note instead of a collection of partials. In this way, the primary objective of this grouping mechanism is to group together all partials that likely come from the same acoustic source, and separate them from other acoustic sources. In music, however, there are many ways in which a composer can play with the various competing acoustic cues that might lead us to group or segregate certain sounds into one or many audio images, leading to new perceptions of sound qualities that become something other than the simple acoustical sum of their component physical sources. Bregman writes, "Normally, in perception, emergent properties are accurate portrayals of the properties of the objects in our environment. However, if scene analysis processes fail, the emergent perceived shapes will not correspond to any environmental shapes. They will be entirely chimerical" (1990, 5). Deceiving natural processes of vertical organization to create emergent audio images is thus an essential part of musical orchestration.

What exactly are the acoustic cues that might make our auditory system fuse or segregate certain sound events? Bregman identifies several heuristics that aid the auditory system in performing scene analysis on a complex group of simultaneous sounds. The first is called the "old-plus-new" heuristic, in which a sound event is joined by a new sound event, with a large enough lapse in time that it is rather easy to distinguish the two sounds as coming from separate sources. The second is the intensity of certain partials at various places along the sound spectrum, and whether these fall into typical patterns of sounds found in nature, including lower intensities for higher partials. The next heuristic is harmonicity; whether or not certain groups of partials fall into a harmonic series. Bregman suggests that when confronted with a mixture of sounds, "we listen for one or more harmonic series. We determine its fundamental, assign a pitch, then remove this set of partials from all partials being considered. The remainder is then subjected to further analysis" (1990, 240). Another heuristic is called the "common fate" principle, which includes onset and offset times, amplitude and frequency modulation, and any other time-varying behavior. This heuristic works on the principle that "if different parts of the spectrum change in the same way at the same time, they probably belong to the same environmental sound. It is unlikely that unrelated elements in a scene subset will undergo parallel changes by accident" (1990, 249). The final heuristic identified by Bregman is that of spatial factors. Spatiality seems to have a strong multiplier effect in the segregation of sounds - when a spatial difference is added to some other difference, it greatly increases the amount of segregation between the sound events (1990, 294).

Bregman argues that the different "cues for spectral grouping compete and cooperate until scene-analysis systems converge on the best estimate of how many sounds there are, where they are, and what their global properties are" (1990, 394). As an example of how competing cues may alter our perception of sound events, Bregman cites an experiment performed at IRCAM with a synthesized oboe sound. The even and odd partials of an oboe were synthesized and sent to different channels, one on the left and the other on the right of a listener. Frequency modulation was performed synchronously on both channels, and because of the common fate heuristic, the sound was perceived as merged and located between the two speakers. When the frequency modulation was not synchronized, the sounds were split, had individual sound qualities, and could be localized by the listener as emanating from two separate speakers (1990, 256-7, 296). In this case, the common fate heuristic overrode the spatial cues separating the sounds, creating an audio image that was fused and chimeric in terms of its spatial origin. Not only is this an interesting example of how different acoustic cues compete in the scene analysis process, it is also an intriguing display of the potential for synthesized music projected on loudspeakers to trick natural processes of auditory organization, which unleashes a host of possibilities for composers of electronic and mixed music.

From this perspective it could be argued that if a composer properly understood how to create sound environments in which natural scene analysis processes could be manipulated, then they would be able to precisely understand and control how their music was perceived. This presumes that the human auditory system works independently from other cognitive activities and that every person interprets incoming raw data in precisely the same way. In reality, however, we know that subjective high-level cognitive processes such as focused attention to certain details, pre-learned listening schemas, and memory also affect how individuals interpret the music they perceive. Bregman refers to these latter processes as “top-down,” while the innate human auditory interpretations of raw data are understood as “bottom-up” or “primitive” processes. While distinct from each other, these two processes work together in the construction of auditory representations (1990, 397).

Returning to Fineberg’s polemic for the place of spectralism in contemporary music today, it becomes evident that spectralism allows for these bottom-up, innate processes to take prominence and be theorized on a grander scale, bridging the gap between auditory representations and the theories that are imposed on them. This is in stark contrast to traditional serialism, which uses intellectualized, learned schemas far removed from one’s actual experience of the music as a psychoacoustic object. Of course, not all spectral music is quite so literal—

some composers prefer a more metaphorical approach, drawing inspiration from certain acoustic models but not trying to prescribe any one type of spectral fusion or segregation. However, even these more metaphorical approaches bring bottom-up and top-down processes of auditory image construction into a closer dialogue than other compositional traditions.

Chapter 2 - Mapping out Methodologies

.1 Geography of Analysis

Music theory in general, and analysis in particular, have long grappled with issues of identity and legitimacy within the framework of academia. Once seen as "myopic" (Kerman 1985, 63) in its dual emphasis on Schenkerian analysis and pitch-class set theory in the 1970s, we have since witnessed a shift in the field to a more pluralistic environment in which new analytic strategies are being applied to new and old repertoires. While the field has diversified in terms of content, some of its central defining attributes have remained intact: the music itself as a starting point rather than external factors, and a concern for music's internal structures and relationships (Agawu 2004, 270). In advocating for the value of music analysis, Kofi Agawu argues that analysis aids perception and gets to the 'truth content,' or the compositional surplus of the work. He believes that "each analysis must produce a result unique to the work, it must bring out […] the unique problematic of each work" (272).

With such a proliferation of analytical possibilities, in an environment where each work may require a unique toolset to shed light on its particular characteristics, awareness and clarification in defining one's methodology becomes of the utmost importance. One model that has been extremely helpful in systematizing the various ways in which analysts approach musical objects is Jean-Jacques Nattiez's semiological tripartition, explicated in his seminal work, *Music and Discourse: Towards a Semiology of Music* (1990). From the tripartition, Nattiez creates six major *situations of musical analysis,* which for him "sketch what might be called a *geography* of analysis—one that allows us to define the real import of a given analysis, or a potential analysis, among the totality of musical processes" (143).

It is from this geography that I will attempt to map out the specific strategies I will be employing in my analyses of *Tombeau de Messiaen* and *The Texture of Time.* This chapter will problematize the various objects I will be analyzing and how they can be combined under various methods, from a tripartional vantage point. To the extent that my specific queries may exceed the confinements of Nattiez' theory, I will adapt the theory flexibly and critically. I will begin with an overview of Nattiez' tripartition and situations of musical analysis, followed by a discussion of analytical strategies available for spectral music and mixed music in general, along with the strategies I will use in my analyses.

.2 The Semiological Tripartition and Situations of Musical Analysis

In his application of the field of semiotics for generating a theory for musical meaning, Nattiez rejects the dual view of the sign (signifier and signified) as proposed by Saussure on the basis that it is too static (5). He uses the example of the signifier "happiness," which could never correspond to just one specific meaning (one signified), given the proliferation of situations and associations that English-speakers might use for that one word. Instead he prefers Charles Peirce's more complex model of the sign (in which an object and its sign are linked by a series of interpretants—other signs that are created in the mind of the receiver to stand in for the object [6]), because the process of referring from a sign to an interpretant is infinite—it allows for multiple signs that vary from one receiver to the next, according to their own personal experiences. From here he extracts a working definition of the sign: "*a sign, or a collection of signs, to which an infinite complex of interpretants is linked, can be called* A SYMBOLIC FORM" (8).

Each symbolic form can be understood in terms of three dimensions, each corresponding to an object in Nattiez' tripartition: the poietic, the esthesic, and the trace. Nattiez defines the poietic dimension as "the *process of creation* that may be described or reconstituted" (12), which need not include the intended meaning of the creator. The esthesic dimension refers to the process of receivers "construct[ing a] meaning, in the course of an active perceptual process" (12). The trace refers to the physical embodiment or material reality of the symbolic form that can be perceived by the five senses, and is also called the neutral or immanent level. In the specific context where the symbolic form is a musical work, the poietic and esthesic dimensions are processes—the process of producing the work by the composer and that of listening/interpreting/understanding the work by an audience, whereas the trace is a physical structure—the sound waves created by the work's live production, its material score, its recording, etc.

In terms of analysis, each object of the tripartition yields its own type of musical analysis, yielding poietic and esthesic analyses, and analyses of the neutral level.[1] The first two, being analyses of processes rather than structures, are quite distinct from analyses of the neutral level both epistemologically and methodologically (16). Nattiez argues that historically, analyses of one type have often been asserted as paramount at the expense of the others, but that there are ways in which all three dimensions can be brought together within a single piece. He vehemently argues for the methodological necessity of analyzing the neutral level, believing that poietic and esthesic analysis on their own are only partial approaches, and that we need a description of the neutral level "to show how poietic and esthesic interpretants are linked with the work's material presence" (139). This necessary inclusion of the neutral level becomes apparent in his description of the six analytical situations, which he outlines as follows:

[1] In his review of *Music and Discourse* (1992, 93), Robert Hatten criticizes Nattiez on attempting to justify a purely objective analysis at the neutral level. Because the analyst's conjectures are always tainted by his or her own poietic or esthesic hypotheses, "the neutral level is a theoretical fantasy."

1. Immanent analysis (immanent structure)
2. Inductive poietics (immanent structure → poietic processes)
3. External poietics (poietic processes → immanent structures)
4. Inductive esthesics (immanent structure → esthesic processes)
5. External esthesics (esthesic processes → immanent structures)
6. Communication between all three levels

   (poietic processes = immanent structure = esthesic processes)

The first situation, analysis of the immanent level, deals exclusively with the structural configurations of a work, of which Allen Forte's set theory is a good example. The second situation, called *inductive poietics*, is an analysis in which "one can proceed from an analysis of the neutral level to drawing conclusions about the poietic." (140) The reverse of this is called *external poietics,* in which an analyst takes sketches or writings by the composer and analyzes the work in light of this information. On the esthesic side of the diagram we have a similar set of cases, the first being *inductive esthesics*, in which an analyst makes a "statement on an analysis of the work, then describes what he or she thinks is the listener's perception of the passage." Nattiez believes this to be the most common case, as many analyses try to appeal to perception. The reverse of this is external esthesics, which "begin[s] with information collected from listeners […] to understand how the work has been perceived" (141), and is more commonly found in the domain of experimental psychologists.

The sixth and final situation is a case where the immanent analysis is "equally relevant to the poietic as to the esthesic." He cites Schenker's theory as an example, as it is rooted in Beethoven's sketches yet attempts to outline how we perceive different levels of tonal music, combining external poietics with inductive esthesics. In a slight critique of Nattiez' model, I would argue that this sixth category need not exist on its own - it would suffice to state that the first five analytical situations can come together in different combinations within one analysis.[2] The emphasis on equality is also questionable, as an analysis could be both poietically and esthesically relevant, but may lean more strongly to one side or the other. Even his example of Schenkerian analysis, I would argue, is much more relevant to esthesics than poietics. If a sixth category must be created, I would suggest categorizing it as "a mixture of any of the previous five analytical situations." This flexible adaptation of Nattiez' model is crucial for my purposes, as my analyses in this project will combine Nattiez' first five analytical situations in different (and not necessarily equal) combinations.

.3 Methodologies for Analyzing Harmonic Spectra

When confronted with any spectral work, barring any *a priori* poietic knowledge, one of the first things an analyst might intuitively begin to search for are harmonic spectra and harmonic relationships (just intervals) contained within the work. This starting point can be justified from both esthesic and poietic perspectives. In terms of perception, "the [human] auditory system is biased toward the processing of harmonic, as opposed to non-harmonic sounds" (McAdams 1982, 281). Many of the pitched sounds we encounter frequently in our everyday environments come from harmonic complexes, forming a basic mental template that processes incoming data (Hasegawa 2009, 355). Non-harmonic (inharmonic) spectra can yield several pitch sensations, i.e., they do not fuse together into one perceptual object (one pitch) as

[2] Hatten (1992, 94) argues for a similar multiplicity when critiquing Nattiez' methodology of segmentation at the neutral level before considering the esthesic or poietic: "To avoid confusing the poietic and esthesic we need only recognize a varying degree of overlap between the two."

well as harmonic ones do. From a poietic standpoint, it is much easier for an analyst to locate and identify harmonic spectra within a score or recording with a certain degree of certainty than non-harmonic ones, whose complex relationships often prove to be much more difficult to reverse engineer.

Even though harmonic relationships may be easier to identify than non-harmonic ones, the task is not always quite so simple as finding a fundamental with all of its harmonic partials conveniently stacked directly above it in any given score. Many composers use filtered harmonic spectra, taking either a slice of partials from somewhere within the spectrum or eliminating specific partials, either according to a pattern or seemingly at random. There are often cases where one may encounter competing interpretations for a set of partials and for this reason there needs to be a way of determining what qualifies as a better fit.

Theorist Robert Hasegawa has worked on developing a flexible theory of tone representation based on three preference rules for the interpretation of spectral harmonies. To briefly summarize, the first rule is to prefer interpretations of "tone representations which require the least retuning from the heard intervals to the referential just intervals" (2009, 357). This is especially relevant for instruments playing in equal temperaments, where any spectral harmony will be only an approximation of a true harmonic relationship and will require the ear to tolerate a certain amount of tuning discrepancy. The second rule is to prefer the interpretation with the simplest possible just intervals between its members, i.e. preferring lower partial numbers and higher fundamentals. Thirdly, interpretations that "use the smallest possible number of fundamentals" (359) are preferred.

These preference rules are helpful in delineating boundaries for when harmonic/just intonation interpretations are useful or not for the analyst. Beyond the 32nd partial in the harmonic series, the intervals between subsequent partials become so minuscule that they become increasingly difficult to approximate by tempered instruments to a high degree of precision. The analytical implication of this is that you can *always* find a harmonic relationship that approximates any given set of tones if you climb high enough up the harmonic series. However, this creates an abundance of interpretations that dilute their significance. Hasegawa writes, “The complex intervals created by higher integers are difficult to comprehend in most musical contexts” (357). This is not to say that a composer never employs intervals that use partials beyond the thirty-second, but that it becomes increasingly difficult for an analyst to assert harmonic relationships as either poietically or esthesically relevant the higher up one goes on the harmonic series.

Returning to Nattiez’s tripartition, the type of analysis which finds and labels harmonic relationships in a musical score has claims to both the poietic and esthesic sides of the tripartition. There is obviously a component of inductive poietics at work here. Starting from the score, one finds evidence of harmonic spectra and makes conclusions about how the composer may have organized the work. However, I would argue that this type of analysis also contains a certain element of inductive esthesics. By grouping certain pitches together as belonging to one harmonic series, are we not suggesting that a listener’s auditory system might also perceive them as such?

I would argue that finding harmonic spectra in the immanent level of a work does suggest ways in which listeners perceive and interpret the piece. However, there is an epistemological distinction to be made here, between speculation on perception and actual perception. By analyzing a score or recording of a work, we cannot make claims on exactly what is heard in a piece, i.e. claim to know the exact auditory image created in the mind of a listener. Pressnitzer and McAdams write, "All we can hear in a sound is not obvious in any of its physical representations" (2000, 47). They believe it to be an extremely complex undertaking to try to accurately predict percepts induced by a physical stimulus, because of the need to account for a large number of phenomena that interact in complex way. We can, however, posit how we think certain physical signals may interact with the auditory system, based on theories of psychoacoustics such as Bregman's, and speculate on the aural effects of certain structures found in the music. This speculation can be an enriching and rewarding activity for both the analyst and listener/reader, heightening their awareness of both the musical and psychoacoustical processes at work.

In fact, this epistemological distinction is not unique for the analysis of spectral music. Any inductive esthesic analysis is necessarily speculative. We can never claim to know exactly what people hear, but we can suggest interpretations that may approximate different ways of hearing any given piece. The only difference with spectral music is that these interpretations refer to perception on a more subconscious level, appealing to the innate processes of the human auditory system, as opposed to higher level cognitive activities or learned schemas such as tonality. As such, any attempt to "hear" the analysis, or to let the analysis "aid perception" is different in this context than for other analyses, including Schenkerian, set-class, or transformational analyses. To the extent that spectral analyses might illuminate new ways of hearing a piece, I would argue that they might help to develop a consciousness of what would otherwise remain pre-conscious processing mechanisms; an awareness of how our auditory system might interact with specific sections of any given work.

.4 Analyzing Inharmonic Spectra:

The analysis of spectral works would be relatively simple if it was solely the act of finding and labeling harmonic spectra, but in practice harmonic spectra just scratch the surface of the harmonic language of spectral music. While most pitched acoustic instruments have spectra that are very close to harmonic, there are many ways of producing inharmonic sounds with the very same instruments via extended techniques. There are also a host of instruments, such as gongs, bells, etc., which are naturally inharmonic, not to mention the limitless possibilities for artificial non-harmonic spectra enabled by synthesis techniques. All of these non-harmonic sounds resist spectral fusion, allowing different components of the spectra to be heard individually, and giving conflicting pitch and timbral cues to a listener (Fineberg 2000, 91). Because harmonic spectra can easily be distorted to become inharmonic, there is an extremely intriguing threshold between the harmonic and inharmonic that has been exploited by spectral composers. An analogy to tonality has often been made that harmonic spectra are “consonant” and have less tension, and inharmonic spectra are “dissonant” or have more tension (Harvey 2001, 13). However, whereas most intervals and chords in tonal contexts fall into an either/or category, there are far more nuanced gradations between harmonic and inharmonic within spectral harmony, which will be discussed in further detail in chapter four.

Because of the limitless possibilities when it comes to composing with inharmonic spectra, from an analytical standpoint it becomes nearly impossible to conduct a meaningful inductive poietic analysis of a spectral work. There are a plethora of distortion and synthesis techniques, as well as acoustical models for a composer to draw from, and if one has no *a priori* knowledge of the composer’s models or techniques, it becomes a very difficult task to draw conclusions on the compositional process just by analyzing the neutral level. For spectra that are close to harmonic, a few things could be attempted, such as finding out whether a group of notes belongs to a stretched or compressed harmonic spectrum. However, this involves finding values that fit the equation freq = $(\text{rank}*\text{fundamental})^n$, where both the fundamental and the value of n (the distortion coefficient) are unknowns, leading to a lot of tedious trial and error work. Because of this difficulty, it seems that many existing analyses in the academic literature on spectral music are rooted firmly in external poietics. If not written by the composer him- or herself, the analyst likely had access to a multitude of materials and information from which to write an analysis that lays out plainly the composer's compositional processes, models, and often their intentions and goals as well. Examples of this type of analysis are Rozalie Hirs' work on Tristan Murail (2009), and Philippe Lalitte's analysis of *Metallics* by Yan Maresz on IRCAM's website.

Are analyses firmly rooted in external poietics the only plausible type of analysis for spectral works that make extensive use of inharmonic spectra? It appears as though this assumption has led to a large epistemological gap in theoretical literature regarding these works in terms of their hermeneutics, where we might benefit from analyses of the inductive esthesic genre. Because a niche has yet to be carved in academia for this type of analysis on spectral repertoire, it is difficult to know exactly what analytical techniques may best serve this purpose. My hypothesis is that for spectral music, keeping observations grounded in terms of acoustic data and psychoacoustic theories and speculating how we might hear passages in light of such knowledge is one way to avoid subjective superficiality in this type of analysis. For mixed spectral works, I believe this type of knowledge to be of high value when contemplating how the electronic sounds interact with the acoustic instruments and how we might perceive those interactions. However, there are some methodological issues that need to be sorted out when introducing another object of analysis, the electronics, to the analytical agenda.

.5 Mixed Works: Locating the Neutral Level

Up until this point we have yet to problematize the neutral level of the piece. For works that are solely acoustic, the score is by far the most utilized neutral level for conducting an analysis. However, it's crucial to remember that these scores are prescriptive: they provide a set of directives, or an idealized state of a piece, from which a performer must mediate the composer's wishes to an audience, using their bodies and instruments to transform the notes on the page into physical sounds. Electronic sounds, however, are mediated directly from the composer to the audience through technology and are often pre-recorded or pre-programmed, evaporating both the role of a human performer and the need for a prescriptive score. The neutral level thus becomes either a pre-recorded electronic part to be played back during a performance (for works with fixed media) or a pre-programmed software patch that responds to incoming sound data from a live instrument in a predetermined way (for works with live media). If the electronics are included on the score, they are usually in a symbolic, descriptive form that exists solely as an aid for the performer to correctly coordinate his or her performance with the electronics. How can one analyze this type of neutral level and how does that fit in conjunction with an analysis of the instrumental score?

Taking a step back from mixed works, the analysis of purely electroacoustic works is in of itself a relatively new territory for analysts, although two streams have recently emerged. First of all there are the listening-based analyses of Dennis Smalley (1986), Stéphane Roy (2003), and Lasse Thoresen (2007), which transcribe sound recordings using either formalized or idiosyncratic notation systems. These are types of inductive esthesic analyses, and the descriptive scores they generate are not equivalent to the work itself, but are second order symbolic traces that are mediated through the analyst's own esthesic activity (Nattiez 1990, 135). While perhaps useful in providing new terminology with which to discuss complex sound phenomena such as timbre, this second layer of symbolism often complicates more than it elucidates. It requires readers to become fluent in a brand new meta-language, one that is awkwardly self-conscious of its own limitations, and it often flattens the nuances of sound by forcing them into an oversimplified system. The second popular stream of analysis of electronic music is of the external poietics variety, the technological exegeses of programs and patches that provide content for publications such as *Computer Music Journal.* These also require readers to be fluent in other languages—in this case programming languages such as Java—along with possessing intimate knowledge of software such as OpenMusic or MaxMSP. While speaking to a very specific audience located at the intersection of music and technology, these analyses do not speak to the wider theoretical or musicological community, most of whom are not proficient in deciphering matters of computer science.

One of the fortunate things about spectralism is that although it is largely concerned with timbre, many of the complex sounds are still derived through frequency calculations. This means that quite often the electronic component of mixed spectral works (at least those with fixed media) can be broken down into frequency components that can be transcribed using traditional music notation, though this notation often needs to be supplemented with cent deviations or precise hertz values. To achieve this transcription, all that is needed is a software program that can track partials over time within a graphic interface. I prefer to use SPEAR (Sinusoidal Partial Editing Analysis and Resynthesis), which analyzes data using peak interpolation and partial tracking, and resynthesizes it with sinusoidal modeling. Other software available for these purposes include AudioSculpt, Lemur, and MetaSynth. Once transcribed, the score of the electronics can be brought together with the instrumental score to highlight any moments of musical or perceptual interest. Though they appear to be on the same level, it is important to remember that they are ontologically quite distinct: the instrumental score remains an idealized prescription of which frequencies should be played, void of timbral nuances, while the transcription of the spectral data is a reduction of a sound to its primary frequency components, and not a representation of the sound images created by our auditory systems. Both, however, are representations of acoustic data that are meant to interact within the context of the piece, even if one has yet to come into being and the other is a reading of what has already been created.

In order for the electronic and acoustic elements to truly meet as equal analytical objects, one has to resort to the level of the live performance or a recording thereof to find a physical trace that fully incorporates the two dimensions on the same terms. This appeals to the type of subjective listening analysis performed by analysts of electroacoustic music or performance analysts, and is esthesic in nature. In my preliminary work on *The Texture of Time*, I discovered that transcribing the recording using Thoresen's typography did not yield very useful results, most likely because Thoresen's notation is better suited to works with highly contrasted timbres. The transcription of the instrumental part did not show any information that wasn't already in the prescriptive score, and the transcription of the electronics did not differentiate between the qualities of inharmonic sonorities, due to the limitations of the notation system. While there were a few moments of ambiguity as to whether or not a certain sound belonged to the flute or electronics, these few moments did not validate the translation of the piece into a completely new symbolic language. While I personally have not found second-order esthesic notations to be of any significant help for analyzing mixed works, I do think that listening remains an integral part of esthesic analysis: any claims made based on the acoustic data need to be confirmed, or at the very least not contradicted, by the act of listening to that passage. To that effect I will occasionally interject my analyses with subjective observations based on my personal experiences of listening to certain passages.

.6 Two Analytical Case Studies: Engaging Both Sides of the Tripartition

Having outlined and problematized several analytical techniques for spectral music and how they are situated within Nattiez' tripartition, let us now turn our attention toward how these techniques will be applied in two analytical case studies. The pieces selected for this project, Jonathan Harvey's *Tombeau de Messaien* and Joshua Fineberg's *The Texture of Time,* share the feature of allowing the electronics and instrument to coexist on the same plane, to work together as equal components, and both expand the palette of sounds beyond what is normally available to the instrumentalist. The spectral language used for both is however quite different; the former being an exploration of how harmonic spectra interact with twelve-tone equal temperament, the latter consisting largely of inharmonic chords that fuse together to different degrees.

For this reason, the methodologies for each analysis will also be quite different, as I attempt to "bring out the unique problematic of each work." My analysis of *Tombeau de Messiaen* will concern itself mainly with the poietic side of the tripartition. First of all there will be some use of external poietics, as Harvey has published some insights as to his intentions and compositional procedures for this piece. I will also make use of inductive poietics: by analyzing the DAT part in SPEAR, I'll be able to find out exactly which harmonic spectra are used where (appealing to Hasegawa's preference rules) and can thus speculate on the piece's formal construction. Though the analysis will lean heavily to the poietic side, there will still be esthesic implications, as demarcating different spectra may elucidate how certain moments may fuse or segregate from a perceptual standpoint.

Following the more poietic exploration of *Tombeau de Messiaen*, I will embark into the area of inductive esthesics for my analysis of *The Texture of Time.* Once again I will analyze the electronics in SPEAR, but will this time use the observed frequency data to speculate on how varying degrees of harmonic tension can be created through the interactions between electronic and acoustic components. I will be appealing to Bregman's theory of scene analysis to make conjectures about the aural effects of raw acoustic data that I obtain. While this engages the esthesic side of the tripartition, my work will also contain an external poietic component, in that I will be connecting observations about various passages to ideas from the literary work that inspired the piece. In addition, several observations could have inductive poietic implications as well, as they might point to how certain passages were conceived by the composer.

As you can see, both analyses will incorporate two of Nattiez' analytical situations prominently, in addition to a more implicative third situation, and each will balance a unique relationship between the three while engaging both the poietic and esthesic sides of the tripartition. While it may seem like I will be juggling too many concurrent streams of activity, methodological diversity in this case is neither a personal polemic nor a reflection of some inherent weakness of this genre of music. As Nattiez argues, "*it is…the inevitable result of the symbolic nature of musical and analytical facts*; that is, it results from the fact that we are presented with a very large latitude of choice between all possible interpretants released by the corpus being studied" (1990, 134). By weaving several methodologies together in order to make claims about two specific pieces within a larger genre of works, it is my hope that the diversity and flexibility of my analyses is strengthened by the intention to reflect the works that drive them: just like a mixed work itself, my analyses will attempt to fuse multiple objects to create a gripping and cohesive dialogue that is greater than the sum of its parts.

Chapter 3: "Spectral Fusion" and "Microtonal Polyphony" in Jonathan Harvey's *Tombeau de Messiaen*

.1 Spectralism and Jonathan Harvey

Following an invitation from Pierre Boulez to work at IRCAM in the early 1980s, Jonathan Harvey (1939-2012) gained access to cutting-edge music technologies, enabling him to delve deeper into ideas he had adopted from the spectral school of composers. For Harvey, "Spectral music is allied to electronic music: together they have achieved a rebirth of perception. The one would scarcely have developed without the other. Electronic music is a well-documented technological breakthrough, spectralism in its simplest form as color-thinking, is a spiritual breakthrough" (Harvey 2001, 11). This spiritual breakthrough is attributed to the way in which spectral harmony lies outside of linear time, unlike the goal-oriented conventions of tonality, and how this transcendence enables an engagement with philosopher Julia Kristeva's "semiotic world" of the pre-symbolic; "a world prior to the dictates of the constitution of the speaking subject" (Harvey 1999, 39). Yet Harvey's goal was not to leave the symbolic world completely behind, seeking rather to overcome simplistic dualisms through the exploitation of ambiguities between different modes of perception. In Harvey's spectral pieces, harmony can give way to timbre, and melodic intervallicism can give rise to vertical spectra; "the symbolic world [is] seen in the larger perspective of the semiotic one" (Harvey 2001, 14). The precision required to exploit these boundaries is difficult to attain without technological intervention, and it is here that the alliance between electronic and spectral music is forged.

One of Harvey's earliest creations, both spectral and electronic, is his first composition completed at IRCAM, *Mortuos Plango, Vivos Voco* (1980). Comprised of different slices of the inharmonic spectrum of a church bell and the voice of his son, Dominic, *Mortuos Plango* features modulatory shifts between different bell spectra, using prominent partials as pivots and sine tone glissandi to shift from one spectrum to the next. “The aim of this piece,” Harvey writes, “might be described as coaxing us to hear abnormally, to hear a spectrum as de-fused individualities. Or rather, the aim is to hear it *both* that way, and the normal way, simultaneously” (Harvey 1987, 181). This description exemplifies Harvey’s taste for ambiguity and multiple modes of perception, encouraging listeners to simultaneously embrace and deconstruct the unified nature of sound through two interdependent modes of listening.

Following *Mortuos Plango* and his second composition at IRCAM, *Bhakti* (1982), Harvey’s later works were “concerned with completely recognizable sounds and the paradox of their interchangeability” (Harvey 1987, 185). Of particular interest are his mixed works, where “ambiguity is constantly present in that the ear is often unsure whether it is hearing tape or live player” (184). Harvey completed two such works in 1994, the previously discussed *Advaya,* for cello, electronic keyboard, and electronics, and the piece with which this analysis is concerned, *Tombeau de Messiaen,* for piano and digital audio tape (DAT). *Advaya* features only cello-derived sounds while *Tombeau de Messiaen* consists of mostly piano-derived sounds, in addition to some bell sounds. Mixed works composed in this fashion collapse blatant distinctions between the acoustic and electronic components, by “[allowing] two worlds to be brought together in a theatre of transformations” (Harvey 1999, 80).

As the title suggests, *Tombeau de Messiaen* is an homage to the renowned French composer Olivier Messiaen, who died in 1992. Besides some obvious stylistic quotations of Messiaen’s compositional practice in this piece, including homophonic chordal passages in even-note values, chords built from augmented and perfect fourths, and chromatic aggregate sets, what Harvey pays tribute to most in this piece is Messiaen’s consideration of resonance in his harmonic thought, which has led Harvey to refer to Messiaen as a "proto-spectralist" (Harvey 2001, 14). While Messiaen was limited by equal tempered tuning in his piano compositions, Harvey expands Messiaen's harmonic thought through the addition of a digital audio tape which features recorded piano sounds tuned to twelve natural harmonic series, one for each pitch class. The live solo piano remains tuned in equal temperament, and thus "has the role of providing the grit, the resistance to the spectra without seeming to be altogether outside them, partly because it plays the same, or nearly the same, spectral pitches." In this way a dialectic is created between two similar versions of the same material, each tuning system simultaneously questioning and reinforcing one another (Whitall 1999, 58). This is another example of Harvey's love for ambiguity and concurrent modes of listening, as the live piano and DAT flow "in and out of fusion" (Whitall 1999, 28).

Harvey has referred to the dialectic between live and recorded piano sounds as "[changing] constantly from spectral fusion to microtonal polyphony and back." The term "spectral fusion" was adopted by Harvey as a result of his encounters with Stephen McAdams at IRCAM in the early 1980s, and thus can be interpreted here in the psychoacoustic sense, as a grouping mechanism of our auditory system that allows us to hear a single sound event instead of a collection of simultaneous partials. This was covered in detail in section 1.5, but let us quickly recapitulate the heuristics that contribute to the degree to which a vertical sonority will fuse into a single perceptual object: an old event joined by a new one, spatiality, onset/offset times, frequency modulation and other time-varying behaviors, intensities of partials and harmonicity. This last heuristic, referring to whether partials fall into harmonic series with one another or not, is particularly relevant to our current investigation. Throughout *Tombeau de Messiaen,* there will be many instances where piano pitches will be good approximations of certain partials within a certain harmonic series in the DAT. These are instances where if the pitches are sustained together, there is a high likelihood that some level of spectral fusion might take place for a listener.[3] Throughout the piece there are also many instances where the tempered piano is in conflict with the DAT; where frequencies do not line up and fusion would be unlikely. In psychoacoustic terms this would be understood as "segregation," where the individual identities of each partial resist fusion and are easily perceptible. In terms of vertical sonorities, this is what allows the piano and DAT to go 'in and out of fusion.' Harvey relishes the ambiguity: "The fact of partly not fitting makes the discourse interesting for me" (2000, 14).

'Microtonal polyphony' is not a psychoacoustic term but its musical definition would imply two or more simultaneous independent melodies playing in microtonal intervals. Psychoacoustically speaking this would refer to the horizontal grouping mechanism of auditory stream creation, which allows us to group a sequence of events from the same source into a coherent auditory image distributed over time, i.e. allows for the perception of melody and speech. In keeping with his fascination for boundaries and ambiguities, Harvey aims to bridge the gap between vertical and horizontal sound images: "The fascination of spectral thinking is that it can easily turn into melodic thinking: there is a large borderland of ambiguity to exploit... Intervallicism can come in and out of spectralism" (Harvey 2001, 13-14).

The dialectic between live and recorded piano sounds, which gives rise to various degrees of spectral fusion and segregation, as well as more linear polyphonic passages, is the primary concern of this analysis. Though the score for *Tombeau de Messiaen* indicates the approximate

[3] Even if the pitches lie in harmonic relationships with one another, the variables of each live performance would also have an effect on whether groups of pitches would fuse together or not. If onset times are not synchronized, or the balance between electronic and live piano sounds is not correct, other competing heuristics might prevent harmonic elements from fusing as well as they would in performances where these elements were better aligned.

pitches of the DAT piano sounds as much as possible, this serves more as a reference for the pianist to know when to play rather than providing any clear information about the harmonic spectra that the live piano is both blending with and resisting. Analyzing the DAT component of this piece using the software *Sinusoidal Partial Editing Analysis and Resynthesis* (SPEAR), I was able to identify a large portion of the spectra used and the specific partials employed for different sections of the piece. Through a series of analytical examples, I hope to shed light on the ways in which spectral fusion and microtonal polyphony define this piece, while remaining attentive to larger-scale questions of thematic development and overall form. Before diving into the analysis, however, I would like to further investigate Messiaen's consideration of resonance in his harmonic practice, addressing the issue of approximating partials of the harmonic series with a piano in equal temperament.

.2 Messiaen and Resonance:

Messiaen was deeply influenced by color in his harmonic practice, both literally, in the form of his synesthetic hearing which allowed him to perceive his modes of limited transposition and special chords as specific colors,[4] and figuratively in terms of harmonic resonance. Though he began studying the twelve-tone system of the Second Viennese School in 1938, he criticized it for lacking both color and for "[doing] away with the phenomenon of resonance" (Samuel 1994, 241-242). In a recent article, James Mittelstadt argues that both natural acoustic resonance (*résonance supérieure)* and the hypothetical (but not naturally occurring) lower resonance of subharmonics (*résonance inférieure*) are "key to the structure and the unifying foundation for all

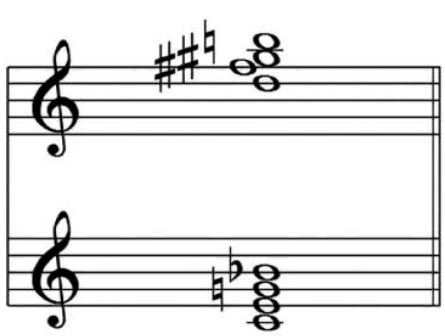
[4] For a detailed view of how this affected Messiaen's music, consider Jonathan Bernard, "Messiaen's Synaesthesia: The Correspondance between Color and Structure in His Music," in *Music Perception,* 4/1 (Fall 1986): 41-68.

his *accords spéciaux* as well as his use of the total chromatic" (2009, 30). In his findings, he remarks that in all of Messiaen's chords most partials appear in their appropriate register, with the occasional octave transposition, and that the use of subharmonics in most chords allowed Messiaen to complete the chromatic scale without resorting to very high partials (2009, 59-60). One of these chords in particular, the *accord de la résonance* (chord of resonance) is unique in that it contains only natural acoustic resonance (no subharmonics) and features all partials in their correct registral placement. This chord is based on Messiaen's perception of the upper partials of a piano note, which he described in detail at the *Conférence de Notre-Dame*, December 4th, 1977:

> If I play very loudly a low C on the piano, after a few seconds I will hear, successively and very distinctly layered, the first sounds that are called the "natural resonance of sounding objects." If I possess a normal ear, I will hear another C, higher than the first (at the octave), then a G (the fifth). If I have a sharp ear I hear beyond that an E (the third); finally, a very musical ear hears B♭ and D (the seventh and the ninth). Personally, I hear additionally an F# (augmented fourth), quite strongly, and an A♭ (minor sixth), very weak. Then come a multitude of higher harmonics, inaudible to the unaided ear, but of which we may get some idea when we hear the complex resonance of a tam-tam or a great cathedral bell.

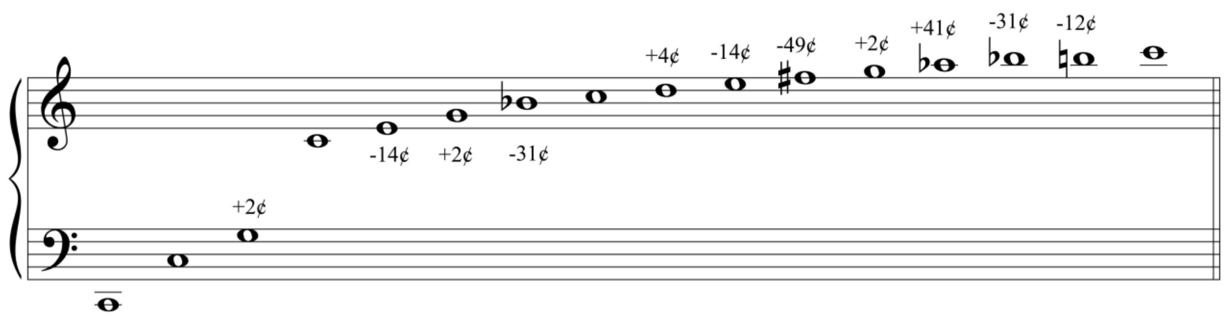
These pitches represent partials 1, 2, 3, 5, 7, 9, 11, and 13, respectively. Transferring partials 2 and 3 up to the same octave as partials 5 and 7, and including partial 15 (B♮), these pitches are stacked vertically as shown in figure 1.

Figure 1: Messiaen's Chord of Resonance (Messiaen 1956, 37 Ex. 208).



In Messiaen's *Technique de mon langage musical,* he concedes that these notes are tempered (1956, 37) and he adopts the assignments of partials to the chromatic scale that were agreed upon at the time in France (Mittelstadt 2009, 32). As we can see from a chart of the first sixteen partials and their cent deviations from equal temperament (figure 2), the seventh, eleventh, and thirteenth partials are significantly altered when represented by equal temperament. Especially the eleventh partial, which lies almost exactly halfway between F and F# in this case, could be approximated equally well (or poorly) by either pitch class. Having clearly established the significance of resonance in Messiaen's harmonic practice, and having noted the large discrepancies between certain partials and their equal-tempered assignments, let us now turn our attention to how equal-tempered approximations of different harmonic series are at play within *Tombeau de Messiaen.*

Figure 2: First sixteen partials of the harmonic series on C2 with cent differences from equal temperament



Partial: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

.3 *Tombeau de Messiaen*

In Arnold Whittall's brief description of *Tombeau de Messiaen* he writes, "the work proceeds through a sequence of clearly patterned stages to a fierce climax and a rapid, stark, descent, as if acknowledging the inescapable reality of death" (Whitall 1999, 74). These "patterned stages" take the form of reinterpreting similar thematic materials within different spectral contexts, with a general motion towards increasing density and spectral ambiguity as the piece progresses. This analysis will focus mainly on tracing these development stages, and highlighting the dialectic between the live piano and the DAT throughout this development process. A key component of the formal design of these stages is the shifts between four specific textures: a gradual unfolding of a harmonic spectrum, contrapuntal melodic passages, homophonic chordal descents, and sporadic rapid-fire spectral glissandi. Through the following examples, I hope to demonstrate how Harvey uses these different textures to bring out elements of spectral fusion and microtonal polyphony as the piece travels toward its "fierce climax."

Let's first consider the opening passage of the piece (figure 3), which begins with the lowest note on the piano, A0, played at a dynamic marking of *forte* with the damper pedal depressed, allowing the full natural resonance of that note to manifest itself just as Messiaen described. What follows is a gradual ascent spanning three octaves and completing a chromatic aggregate set, while the DAT shadows with similar material, though sometimes moving in contrary motion, filling out various partials (mostly multiples of odd partials) of a harmonic series built on A0. The pitches in the DAT are sustained after being played, allowing the spectrum to emerge gradually.

Figure 3: Tombeau de Messiaen, Page 1, first system

Partial:	6, 14, 10, 18, 8, 22, 14, 30, 26,	44,	60,
		42,	56,
Fundamental: A0 = 27.5 Hz		32,	42,
			28,

What's interesting about this opening theme is that the live piano features notes that both belong to and fall completely outside of the spectrum built on A0. While E3 (partial 6), G4 (14), C♯5 (20), B5 (36), and the highest notes G♯6 (60), and A6 (64), are clear approximations of the series, how can we make sense of the other pitches? After taking a closer look, beyond Messiaen's approximations up to the 15th partial (and multiples thereof), we can add to this spectrum the pitches C6, which is only 2 cents sharp of partial 38, and F♯5, which is 6 cents flat of partial 27.[5] In addition to our spectrum on A0, there seems to be a competing tempered spectrum built on D♯2, including the notes A♯3 (partial 3), G4 (5), E♭5 (8), F5 (9), and D♯6 (16).

[5] This is assuming the piano is tuned exactly in equal temperament. Another thing to consider in performances of this piece is that slight mistunings of notes in the live piano may result in slightly different blends with various harmonic series.

This competing spectrum, a tritone away from A in terms of pitch class, will prove to be significant as we progress through the piece. The two remaining pitches, F♯4 and D2, do not fit into either spectrum and could be understood as providing "grit" to the fused nature of both series.

The opening theme is already a perfect example of the ambiguity between spectral fusion and microtonal polyphony that Harvey was aiming for in this piece. The gradual unfolding of the incomplete spectrum on A0 in the DAT is complemented by additional partials in the piano part that are not found in the DAT, such as the 27th, 38th, and 64th, suggesting a blend at the moment where the pianist is instructed to let the strings vibrate. This potential for total fusion, however, is disrupted by the beating caused by the close microtonal intervals between (multiples of) odd partials in the DAT against a series of tempered major and minor seconds, tritones, and minor sixths in the live piano. This beating adds sensory dissonance to this passage, giving it a unique spectrotemporal texture.

This theme is repeated almost identically following a ghostly sine-tone bell sound in the DAT and chromatic flourishes in the piano. The second time, however, the F# octave dyad is raised by a semitone to pitch-class G, and the partials in the DAT on the last chord are all sharpened slightly to become the 20th, 33rd, 40th, and 43rd partials of a D# spectrum (figure 4). This octave dyad now blends fairly well with the new spectrum as the 10th and 20th partials, both 14 cents sharp. D♯6 is partial 32 exactly, while G♯6 and A6 are twelve cents flat and ten cents sharp of partials 43 and 45, respectively. This abrupt shift plays on the ambiguity of the upper partials, as the upper two piano pitches were easily reinterpreted as belonging to a D#1 spectrum rather than an A spectrum. Without the F♯4 to clash with the spectrum, this grouping would theoretically blend better than before, but Harvey evades any chance to let this blend sink in by quickly bending the spectrum in the DAT up and down, activating the pitch space between the partials of a D♯ spectrum. This is significant in that it shows how the electronic portion is extending beyond the limitations of the piano's discrete pitch space, and incorporating sonic elements that would not be possible had he used thirteen differently tuned acoustic pianos in one room rather than twelve recorded pianos and one live piano.

Figure 4: Page 1, end of second system and beginning of third system

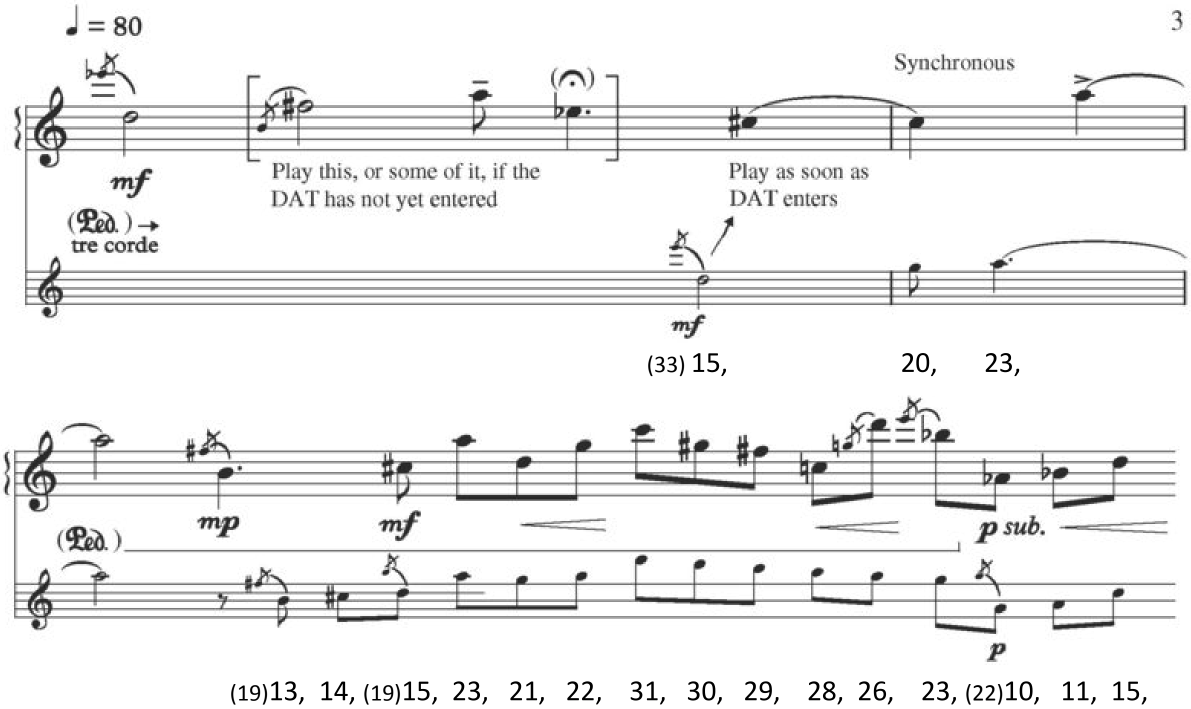
6, 14, 10, 18, 8, 22, 14, 30, 26, 44, [43,]
42, [40,]
32, [33,]
[20,]

Fundamental: A0 = 27.5 Hz

[Fundamental: D#1 = 38.8909 Hz]

Following a transitional passage consisting of a series of descending chords in the piano over the fluctuating spectrum in the DAT, we arrive at a contrapuntal section where both the live piano and the DAT are playing individual melodic lines, a demonstration of the more horizontal intervallic play of microtonal polyphony (figure 5). The unique melodic intervals of the harmonic series are juxtaposed by their tempered counterparts in this passage, as the DAT bounces between various partials of the same D♯ spectrum we arrived on at the end of the first page, while the live piano plays similar material.

Figure 5: Page 3, First two systems



Fundamental: D#1 = 38.8909 Hz

The unique elastic quality of this passage arises from discrepancies between the two different tuning systems. These discrepancies are much more exposed in contrapuntal textures such as this, where partials sounded individually without being sustained cannot hide behind the mass of an entire spectrum. The C♯5 in the piano that follows the DAT entry is 31 cents sharp of partial 14, creating a significant clash with partial 15 in the DAT. Similarly, the A5 is 28 cents flat of partial 23, and the B4 at dynamic marking *mezzo piano* highlights the 41 cent compromise of partial 13 that Messiaen used in his tempered chords. Beginning at the *piano subito* dynamic marking, the notes in the DAT are sustained briefly for about four seconds, allowing a portion of the spectrum to be heard together as a unified structure, before breaking back into individual unsustained notes. This interplay between vertical and horizontal iterations of different sections of spectra continues until the end of the section (page 4, first system), where all the notes in the DAT are sustained, gradually descending through the partials and filling in the D♯ spectrum, eventually going down to partial 5. As more and more partials are sustained, a low D♯ eventually becomes audible, giving us the fundamental of this spectrum for the first time.[6] In this way, the D♯ stage is a reversal and expansion of the opening theme on A. While the opening began with the low fundamental and gradually ascended to a chord of upper partials, the D♯ section began with this chord and later descended until a fundamental was audible. In addition, while the opening theme featured both harmonic and melodic thinking—spectral fusion and microtonal polyphony simultaneously—this section features a more gradual shifting between the two, featuring moments where one or the other becomes more prominent.

A transitional passage of homophonic descending chords follows, after which the DAT eventually finds rest on a C spectrum while the final chord of the piano implies an E spectrum (figure 6). This chord in the piano is very similar to Messiaen's chord of resonance built on an E, consisting of approximations of partials 5, 7, 9, 11, 13, and 17. Besides partials 4 and 6 missing, the 13th is curiously represented by D♭ rather than C, which is a slightly worse approximation at 59 cents sharp rather than 41 cents flat. This is an instance where the DAT part and the piano are not in fusion, though as the pianist releases various notes individually, we

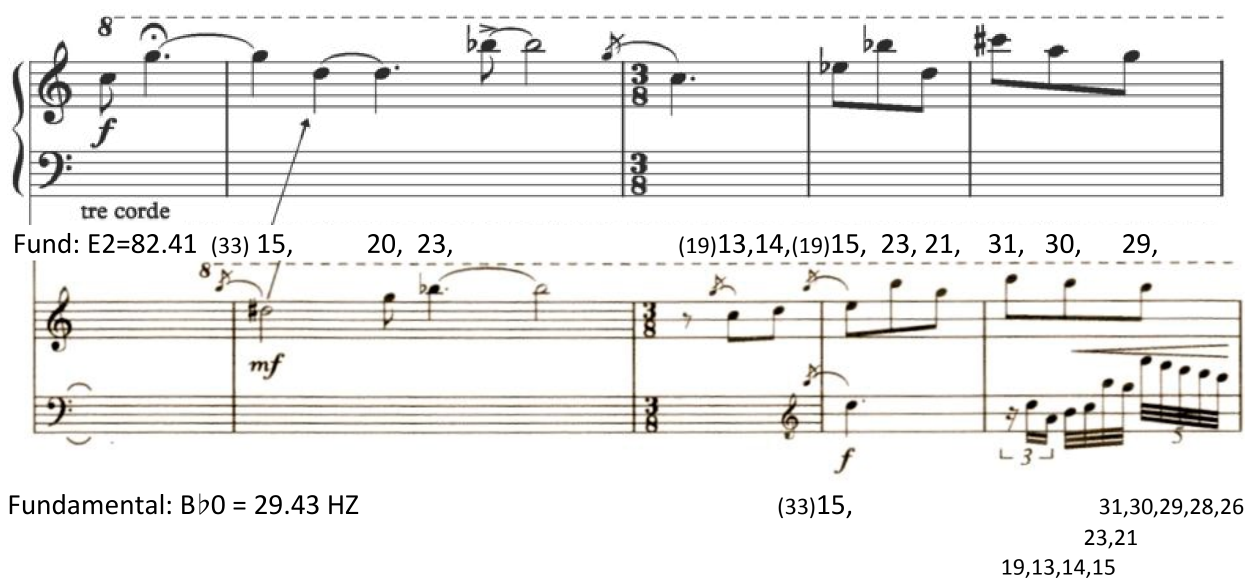
[6] This is one of the few instances in this piece where a collection of upper partials actually contribute to the psychoacoustic perception of a fundamental pitch that is not physically present in the acoustic signal, known as a virtual fundamental or residue pitch. It should be clarified that the fundamentals indicated in my spectral analyses are not representing this type of literal psychoacoustic phenomenon, but should rather be understood as a way of organizing the upper partials and their harmonic relations, thus representing a more theoretical notion of a "chordal root." Even if multiple upper partials of a certain spectrum appear simultaneously, if the spectral spacing of the partials are too close together (indicating a low virtual fundamental), and the lowest component is too high in frequency, they may lie outside what is known as the "existence region of the tonal residue" (Ritsma, 1962, 1227). For example, a set of harmonics 50 Hz apart will only produce a virtual fundamental at 50 Hz if the lowest component is less than 1000 Hz, corresponding to the 20th partial (Zwicker and Fastl, 2007, 120). In addition, Ritsma discovered a "principle of dominance," which indicates that the 3rd to 5th partials were most important for determining a fundamental pitch in the lower frequency range (Moore, 2013, 226).

Figure 6: Page 4, Third system

eventually hear the B♭ and D as fusing with the spectrum on C in the DAT, as the 7th and 9th partials. This juxtaposition of two spectra a perfect third apart contrasts with the opening passage, having more partials in common than the A and D♯ spectra did being a tritone apart. However, both of these moments foreshadow the simultaneous juxtaposing of different spectra that will become even more prominent as the piece progresses.

The contrapuntal texture reemerges afterwards, with the same theme appearing in the DAT transposed up a minor ninth to belong to a spectrum on E2 (figure 7). Shortly after the entry of the theme, however, a third voice enters in the DAT on a B♭ spectrum, beginning with the same interval of partial 33 to partial 15 but then veering off into a rapid arpeggiation of a portion of the spectrum, our first encounter with this figure. This is a compressed version of the earlier version of this theme, utilizing the same partials in a similar order but in a rolled chord harp-like form, collapsing the melodic line into a more vertical sonority. The addition of another spectrum, once again a tritone away from the first, furthers the effect of microtonal polyphony in this passage. Curiously, while the rest of the harmonic series in this piece line up with fundamentals based on the equal tempered frequencies of the lowest twelve notes of the piano, the B♭0 used in this series is not 29.1352 Hz. as we would expect, but rather it is a 9/5 minor seventh above an equal tempered C, resulting in a slightly sharper B♭ at 29.43 Hz. Perhaps this was done deliberately to create even less fusion than we would expect with the piano, but this is only speculative, as a 0.3 Hz difference would most likely not be very distinguishable in that pitch range.

Figure 7: Page 4, Fourth system



The live piano begins this section in a similar fashion to before by playing pitches close to the partials in the DAT, with D6 (14), B♭6 (23), G6 (19), C6 (13), and E♭6 (15), but when the third voice on the B♭ spectrum enters, the two notes that follow, B♭6 and D6, could be approximating either the 23rd and 14th partials of E2's spectrum, or the 64th and 40th partials of B♭0's spectrum. Similarly, C♯7, A6, and G6 could represent partials 27, 21, and 19 of E2 or partials 76, 60, and 54 of B♭0. One could continue to analyze in this fashion but the point here is that Harvey is once again exploiting the ambiguous identities of higher partials. Immediately after the rapid arpeggiation in the DAT the piano mimics with a similar figure, showing an exchange of motivic materials between the DAT and the live piano. This is further reflected at the end of this section, which concludes with the piano filling out certain lower partials of the E spectrum with the damper pedal depressed, eventually going down to the fundamental E2, a role that the DAT provided at the end of the D♯ section.

The next stage of development features a retrograde version of the opening theme over a B♭ spectrum, which comes to the forefront after competing with the E spectrum of the preceding section (figure 8). The piano material remains untransposed, which is significant in that pitches that were not in fusion with the spectra in the opening statement, such as the D3 and F♯4, find a home in the B♭ spectrum as partials 5 and 13. Others, such as the B♭3 and F5, which were accounted for as belonging to the competing D♯ spectrum (which remains present here, a perfect fourth away rather than a tritone), also blend in with the new B♭ spectrum as partials 8 and 24. The B5 and C6 now closely approximate partials 34, and 36, while the E♭5, C♯5 and F♯6 approximate partials 21, 19, and 26. In fact, most of the pitches of the original aggregate set are reinterpreted nicely here, with the exception of E3 and D♯2.

As a transition before the next main theme, the E3 is depressed silently in the piano along with D3 and B♭3 after the pedal is released. When the upper melody in the live piano is played shortly afterward (figure 9, mm. 2-3), certain upper partials of the three depressed keys resonate sympathetically – the 16th, 12th and 15th partials of E3, the 18th, 12th, 17th and 14th of D3, and the 9th of B♭3. This transition is interesting in that it employs a technique for playing natural harmonics on a piano – connecting it further to Messiaen's concern for natural resonance in his *accords spéciaux.* In addition, the presence of simultaneous harmonics of multiple fundamentals foreshadows the more chaotic passages yet to come.

Figure 8: Page 5, Beginning of third system

Fundamental:	36,	31,	29,	24,	15,	7,	11,	5,	8,	3,
B♭0 = 29.43 Hz	35,	25,	26,	23,						
	34,									
	33,									

Figure 9: Page 6, first system

Partial: 32, 31, 33, 30, 27, 29, 29,
3, 7, 9, 4, 11, 7, 15, 13, 22, 30, 32, 36,
5, 21, 28,
16, 23,
Fundamental: C#2 = 69.2957 Hz 14,

The next recontextualization of the opening theme follows this transition, and is played over a C♯ spectrum in the DAT and in the regular ascending form in the live piano (figure 9). This time, however, none of the lower piano pitches match the harmonic series of C♯2, creating a moment of definite microtonal polyphony that evades vertical fusion. It is not until we reach the upper pitches where we could understand them as fusing in any way with the C♯ spectrum, starting with E♭5 (9), followed by F5 (10), G5 (11), B5 (14), C6 (15), D♯6 (18), G♯6 (24), and A6 (25). Immediately after this the DAT starts playing the upper partials of a G spectrum, the fundamental being once again a tritone away from the previous one in terms of pitch class. The piano plays a brief fragment of the opening theme, while the DAT rapidly arpeggiates a portion of the G spectrum. The piano imitates this motive once again with some rapid chromatic figurations before attacking and holding a G4-G5 octave dyad. This dyad is for the first time reinterpreted as multiples of the fundamental pitch—as exactly in tune with the spectrum in the DAT, rather than approximating an upper partial or clashing completely.

We begin to see a slow densification of texture as the following polyphonic passage gradually morphs into Messiaen-like homophonic chords: the piano begins with two chromatic voices and eventually expands this into six voices by the end of page 7 (figure 10). The DAT plays a descending line consisting of the upper partials of the C♯ spectrum, leading to a rapid arpeggiation of the C♯ spectrum that overlaps with a descending G spectrum, as if each spectrum is competing with the other. Eventually, the DAT plays the lower partials of the G spectrum down to the fundamental G2, while sustaining the pitches, allowing the individuality of the melodic line to be lost in the unity of the spectrum, an example of polyphony giving way to fusion. Meanwhile, the piano softly plays chromatically dense material in the upper voices, shifting in and out of the spectrum's upper partials.

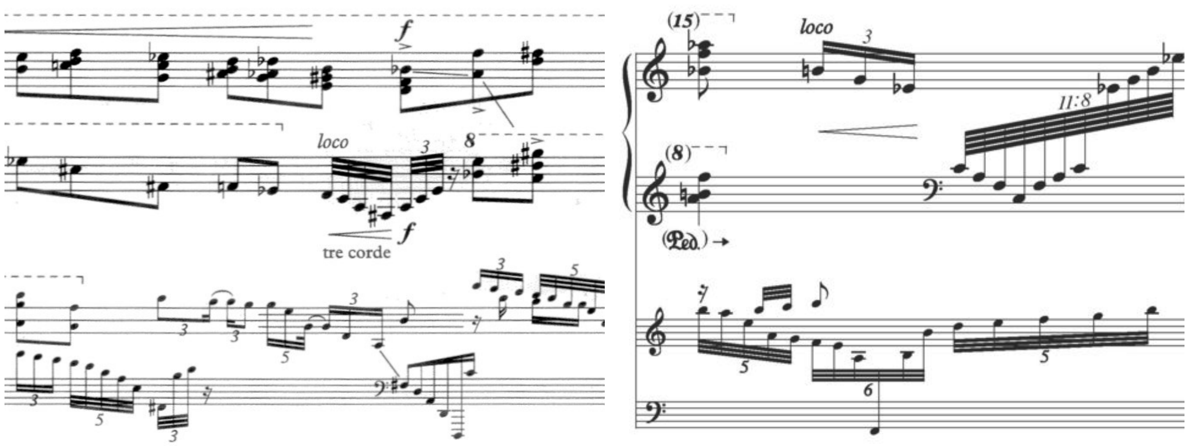
Figure 10: Page 7, Third system

21, 20, 19, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 2, 3, 5, 7,

Fundamental: G1 = 48.9994 Hz.

This G spectrum then ascends back into an upper register where it is overlapped with another descending C♯ spectrum as the passage continues. What's interesting in the music that follows is that in a similar evolutionary manner to the densification of the piano part, the DAT brings other spectra into play beyond the C♯-G dialectic, rapidly arpeggiating portions of spectra D, B, and F in succession, following the last arpeggiation of the C♯ spectrum (figure 11). The piano compliments the arpeggiation for two of the chords, playing partials 8-7-6-5-6-7-9 (at the *tre corde* marking) of the D spectrum and 6-5-4-3-4-5-6-7-9-11-14 of the F spectrum, which is almost a complete chord of resonance. In addition, the DAT descends to the fundamental D1 and to the 2nd partial of F, providing further lower support. These two moments bring intense spectral clarity to an otherwise chromatically dense passage, while contracting the overall process of morphing between spectra.

Figure 11: Page 8, End of third system and Page 9, Beginning of First system



(C#) (D) (B) (F)

Intriguingly, this arpeggiation lies at almost the exact halfway point of the piece and this is exactly where the developmental process we have traced thus far begins to unravel. Up to this point, the most prominent spectra of each section have occurred in the following progression:

A - D♯ - C - E - B♭ - C♯ -G - C♯ - D - B - F

What happens from pages 9-12 is a near exact retrograde of this progression, moving back towards an A spectrum, though the spectra become progressively more clouded by the presence of portions of other overlapping spectra. The D-B-F progression is the first to be reversed, but this time instead of full arpeggiations of each spectrum we encounter shifts within a melodic high-pitched contrapuntal line, replacing the spectral fusion of the previous progression with polyphony (figure 12).

Figure 12: Page 9, End of third system, and Page 10, Beginning of first system.

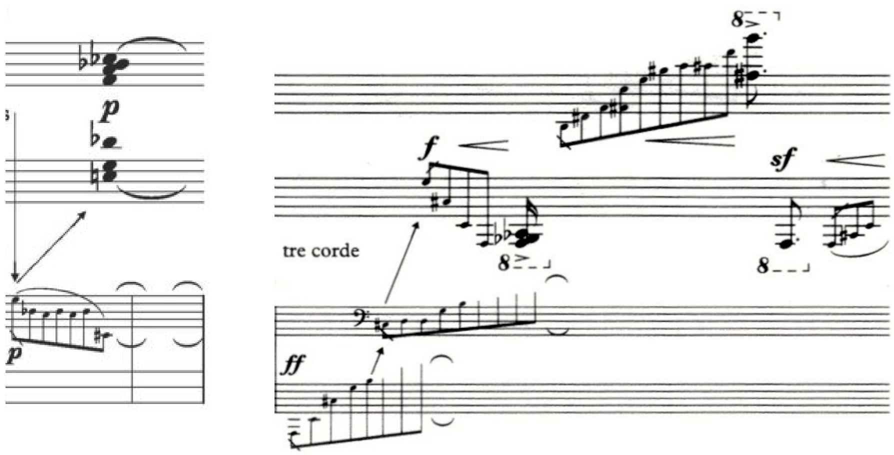
F1: 25,23,16, 20, B1: 25, 24, 19, D1: 38, 35,12,22, 36,26,23, 7, The rest of this section further develops the fragmentary nature of these motives, eventually leading to sporadic glissandi of extreme chromatic density, each representing one spectrum most prominently, with other pitches clouding the clarity of each. They progress as follows:

C♯ - B - G - C♯ - B♭ - E - C - D♯ - A

With the exception of the second glissandi on mostly a B spectrum, the rest complete the retrograde of the progression outlined in first half of the piece. To give an example of the obscurity and density of the spectral content of this progression, let's examine the G spectrum at the end of page 10. Just considering the partials below 1400 Hz, I discovered partials 9, 13, 17, 18, 19, 22, 23, 24, and 27 of a G1 spectrum, partials 11, 17, 19, 22, 27, 35 of a D1 spectrum, partials 8, 17, 19, 34, and 36 of a C♯1 spectrum, partials 11, 18, 19, 34, 36, of a D♯1 spectrum, and partials 11 and 13 of a G♯1 spectrum, which is the only instance of a G♯ spectrum that I could find in this piece. This is highly different from the first section with a spectrum on G, where the full harmonic series was given down to the fundamental and sustained. This intense vertical stacking of partials from various spectra represents an extreme form of non-fusion that takes place in these figurations.

At the end of page twelve (figure 13), the piano settles on a chord, which approximates partials 5, 7, 10, 13, 16, 17, and 18 of a spectrum on A0, functioning once again as a variation of Messiaen's chord of resonance. After a series of rapid arpeggiations of the lower partials, the piano plays the lowest three notes on the piano at the dynamic of *forte*, densifying the natural resonance of the piano with three competing spectra. Following this there is a rapid ascent to a minor ninth dyad of F♯6 and G7, the first time these two pitches appear simultaneously in this manner rather than octave sets of either pitch-classes F♯ or G. Immediately following is the single note A0 played at the marking *sforzando*, which effectively concludes this retrograde process by bookending the section with the same note that began this piece.

Figure 13: Page 12, End of second system and middle of third system



The remainder of the piece is the "fierce climax" and its conclusion, which begins with homophonic chordal descents in the piano against various bell sounds in the DAT. The DAT part eventually plays individual chords as well, and both the piano and the DAT accelerate gradually while the chords become increasingly chromatically dense. Eventually the sound is so dense that it becomes a mass of sound; there are no perceivable individual spectra because there are so many spectra simultaneously superimposed onto one another. However, eventually the mass begins to thin out and an F♯ spectrum comes into focus, the first time we have encountered this spectrum on its own. The climax ends with bell sounds on an F♯-C tritone and a triple *forte* F♯ major triadic sonority in the piano (figure 14). The piano then alternates between F♯ major and C major triads, emphasizing the equal division of the octave that is unique to equal-tempered tuning, while re-emphasizing the juxtaposition of spectra a tritone apart that Harvey exploited throughout the work. Gradually these chords are morphed and the piano descends without the DAT down to the lowest range of the piano, eventually thinning the chordal texture to tritones or perfect fourths in each hand (figure 15). The last three chords together create another total chromatic set consisting of the lowest 12 notes on the piano, effectively evoking the natural resonance of all twelve pitch classes simultaneously, the final breath of audible sounds as this piece meets its final rest.

Figure 14: Page 17, third system

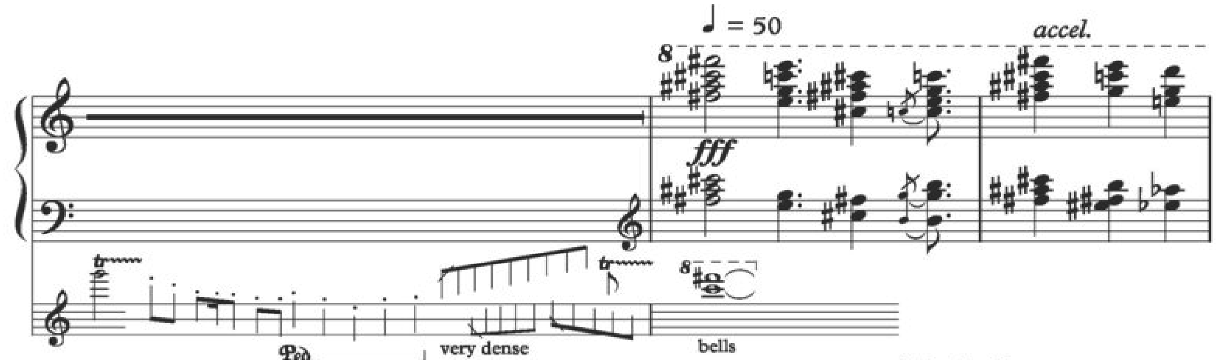


Figure 15: Page 17, sixth system

This analysis has consisted largely of reconstructing the developmental stages of this piece, in order to understand the various ways in which the equal tempered piano interacts with the twelve different spectra that manifest themselves to different degrees of clarity. While this analysis serves more of a poietic function in retracing the harmonic spectra and partials that Harvey used in the DAT, I hope that my insight into how some piano pitches may be interpreted as well as my findings on the progression of spectra and transformation of thematic materials throughout the piece might enable listeners to be drawn into various moments with new considerations. Through analyzing various sections in terms of their degree of spectral fusion, while simultaneously progressing through the development stages of the piece, I was able to identify the large-scale spectral progression which defines the overall form.

Through these examples, I have drawn attention to the ways in which Messiaen's consideration of resonance in his harmonic practice comes into dialogue with contemporary spectralism and electronic music in Jonathan Harvey's *Tombeau de Messiaen.* While the approximation of spectral pitches on a piano in equal temperament provides an interesting source for pitch material as well as nice timbral blends, the addition of piano sounds which are tuned exactly to harmonic series allow these two tuning systems to confront each other in ways that both blur and reinforce the distinction between spectral fusion and microtonal polyphony. This dialectic with, rather than rejection of equal temperament is emblematic of the openness of Harvey, who by embracing ambiguity, simultaneity, and multiplicity is able to negotiate boundaries between different musical traditions as well as between nature and technology.

.4 Interlude:

This piece provided an excellent case study for an analysis in which the retracing of a compositional process provided an in-depth look at the complex interactions between an acoustic piano and its re-tuned electronic counterpart. While serving mainly a poietic function, there were also esthesic implications to the analysis, as the discovery of harmonic series within the piece was also a way of describing the potential groupings of frequencies by a listener's auditory system. *Tombeau de Messiaen* lent itself well to this type of analysis because it was clearly organized according to a model that was explicitly described in literature by the composer, providing ample external poietic information from which to begin my search. What happens, however, when the composer's methods are not clearly known beforehand, and cannot be easily deduced through inductive poietics? When the only external poietic information we have is the origin of the work's title and some of the composer's techniques used in other pieces?

As previously argued, an epistemological gap lies in literature surrounding the interpretation of contemporary works as experienced by listeners. It is here where the analyst can contribute in a more creative fashion to the discourse surrounding a work, by offering insights into how a work may be perceived and received by an audience. What follows is a foray into this territory, through a case study of Joshua Fineberg's *The Texture of Time* for flute and electronics. In a similar fashion to *Tombeau*, Fineberg's piece is a mixed work for a solo instrument and electronics and makes use of spectral ideas and techniques. This surface-level similarity only illuminates the diverse range of this body of repertoire, as Fineberg's piece will actually provide quite an analytical contrast to Harvey's. First of all, it makes extensive use of inharmonic spectra as opposed to the mainly harmonic spectra of Harvey's piece. Secondly, its name is derived from classic literature rather than as homage to an influential composer. Most importantly, its harmonic vocabulary and varying textures lend themselves well to an esthesic analysis, one which seeks to explicate the perceptual effects of various harmonic textures and their semantic implications. While my case study of *Tombeau de Messiaen* was mainly poietic with esthesic undertones, the impending analysis will weave together external poietics with inductive esthesics.

CHAPTER 4: "The Colored Contents of the Past" – Temporal Implications of Harmonic Tension in Joshua Fineberg's *The Texture of Time*

.1 Context and Background

The main difficulty in composing a work for acoustic instruments and electronics is that too often the juxtaposition between live and pre-recorded or pre-programmed components detracts from a meaningful dialogue between the two. After the novelty of the incorporation of technology wears off, we are often left with a performance featuring a live instrumentalist or ensemble accompanied by an electroacoustic soundtrack. In his 2006 composition *The Texture of Time* for flute and electronics, American composer Joshua Fineberg transcends such blatant oppositions by basing the electronics on resynthesized flute sounds and ensuring that all electronic sounds are projected from a single speaker located in front of the flutist's feet. The similar sounds emanating from the same monophonic source allow the electronics to blend maximally with those played by the flutist, creating ambiguities for the audience as to which sounds come from which source. The potential for such blends and ambiguities allows for a productive dialogue between electronic and live components in which new sonic and semantic terrain can be fervently explored.

Fineberg considers himself to be a part of the spectral tradition of composers, having turned toward spectralism early in his composition career after studying with one of its founders, Tristan Murail (Fineberg 2006, 135). In its simplest definition, spectral composers employ knowledge gained from the fields of acoustics and psychoacoustics in their compositional practice, shifting the focus away from abstract pitch systems (i.e. serialism) to "the way sound changes in time and the affects it produces in the human mind" (Fineberg 2006, 113).

Psychoacoustician Albert Bregman speaks of "emergent" and "global" properties for the ways in which the human auditory system can sometimes create phenomena that are not actually present in the acoustic waveform (Bregman 1990, 327). Examples of such phenomena include difference tones, masking, the perception of beats and roughness, and virtual fundamentals. In addition, the brain innately fuses or segregates simultaneous sound components when analyzing any given set of incoming acoustic data, through a process known as scene analysis. One of the goals of the spectral composer then, is to create acoustic conditions that lend themselves to the possibility of emergent properties or fooling certain scene analysis processes when interpreted by a human listener. In *The Texture of Time*, interactions between the flute and electronics create acoustic conditions in which roughness and varying degrees of spectral fusion, both contributors to the musical concept of "harmonic tension," may emerge in the mind of any human listener.

The Texture of Time takes its title from a fictional philosophical treatise on the nature of time by the character Van Veen in Vladimir Nabokov's *Ada.* While the novel uses its central love affair and narration techniques to enact dramatic temporal conflicts between the past and present, I believe Fineberg's musical adaptation achieves similar results through its exploitation of harmonic tension between the live flute and electronics. Through a series of analytical examples, I will show ways in which acoustic evidence from the score and electronics can be used to suggest resultant psychoacoustic phenomena, and the semantic implications of these phenomena as they relate to philosophical notions of time in the novel *Ada.* The first part of the project, analyzing acoustic evidence for speculations on psychoacoustic properties, is necessarily of the inductive esthesic variety (i.e. analyzing the neutral level to draw conclusions about how the piece is perceived). My concern is less how or why certain frequencies were derived by the composer, but on the resultant sound qualia that are experienced by listeners when perceiving certain passages of piece. In addition, while I can certainly vaguely verify my personal perception of roughness or fusion for any given passage, my insights regarding possible emergent psychoacoustic phenomena remain speculative in that human auditory images cannot be reduced to simple models and graphs in the way that acoustic data can. Along with this inductive esthesic methodology, the interpretation of these passages utilizes external poietic information, mainly the philosophy of time as outlined in *Ada* and its incorporation in the novel. My overall goal is to fuse these two methodological approaches together to present a strong case for how this piece may be both perceived and interpreted. I will preface my analytical examples with a more detailed examination of the philosophy of time as outlined and used in *Ada,* along with a more technical digression into the psychoacoustic concepts employed throughout this analysis.

.2 Perceptual Time in Nabokov's *Ada*

The writing of Nabokov has been a frequent source of inspiration for Fineberg throughout his compositional career, beginning with his quintet "…a ripple-ringed pool…" (1990), which takes its name from a passage in Nabokov's *Lolita* (1955). Further inspired by *Lolita*, Fineberg composed the homonymous opera from 2003 to 2008, the year of its European premiere, making *The Texture of Time* his third work inspired by Nabokovian prose. When considering the level of craftsmanship involved in Nabokov's virtuosic wordplay, coupled with his ability to push the boundaries of the medium through meta-commentary and ethical dilemmas, it seems only fitting that a composer who also displays a virtuosic attention to detail would therein find such a rich inspirational resource.

While *Lolita* is quite dark in its themes, *Ada* is quite a playful parody of the traditional Tolstoyan novel. It chronicles the life-long incestuous love affair between two presumed cousins, the eponymous protagonist and Van Veen, a professor of philosophy who narrates the majority of the story. The setting is an alternate universe of sorts, a planet called Antiterra where the historic and geopolitical details resemble altered versions of Earth's history and geography in the 19th and 20th centuries; a few examples include the nations of Amerussia and Scoto-Scandinavia, or the leader Abraham Milton. The residents of Antiterra question and debate the existence of another world called Terra, a "distortive glass of our distorted glebe" (1969, 18), where Russia and America are separate nations with individual histories (i.e., a world identical to our Earth).

The fourth section of *Ada* consists largely of "The Texture of Time," the rough draft of a treatise on the nature of time by Van Veen. Its influence can largely be traced back to the seminal French philosopher on time, Henri-Louis Bergson (1859-1941), most notably his work on *la durée* (duration) in his doctoral thesis, *Time and Free Will: An Essay on the Immediate Data of Consciousness* (1889). Bergson argued against the Kantian notion that free will exists only outside of time and space, believing that Kant had a limited view of time that reduced it to its spatial dimensions. He believed that this reduction demanded a translation of time from a heterogeneous state to a homogeneous one, in which our present and past selves are converted into a deterministic succession of distinct moments. Bergson's *durée* is defined as "pure mobility," which can't be reduced to any particular static moment: it is a continual transition and no one particular moment can be thought of having caused the next, thus avoiding determinism and establishing free will. He writes, "Pure duration is the form which the succession of our conscious states assumes when our ego lets itself *live,* when it refrains from separating its present state from its former states" (1910, 100).

Nabokov situates Van clearly in accord with Bergson's divorce of time from space. The treatise begins with the declaration that one can be "an amateur of Time, an epicure of duration" (537), as opposed to a lover of Space, and outright rejects any space-tainted time, including the concept of space-time in Einstein's (fictionalized in Ada as "Engelwein") relativity theory. He believes it is extremely difficult to conceive of time without inferring concepts of space - the very act of measuring time requires movement in space, a sundial, an hourglass, etc. Van's time is "pure time, perceptual time, tangible time, time free of content, context, and running commentary […] All the rest is numerical symbol or some aspect of Space" (539).

Also in keeping with Bergson's view of duration but perhaps pushing it even further is Van's rejection of the traditional triptych of past, present, and future, instead advocating for only two panels, the past and the present. "If we make a third compartment of fulfilled expectation, the foreseen, the foreordained, the faculty of prevision, perfect forecast, we are still applying our mind to the Present" (560). The core of Van's philosophy is that "time is but memory in the making" (559), and since we have no memories of the future, nor lived percepts of it, it does not have a place in the concept of pure time.

Along with the obvious correlation to Bergson's *durée*, one can also detect an acknowledgement of French author Marcel Proust (1871-1922) and his seminal seven-part work *À la recherche du temps perdu* (1913-1927) in Van's discussion of the past. As renowned literary critic Georges Poulet wrote in regards to Proust, "The Proustian world is a world anachronistic in itself without a home, wandering in duration as well as extent…" (Poulet 1959, 259). This anachronistic approach to time and memory is similar to Van's, for whom the past is considered an accumulation of images, rather than a dissolution implied by metaphors of transition. These memories are colored and shaded, filtered through our emotions and attention to detail; some of them retained by the mind less clearly than others. Events spanning large intervals of time can be recalled in a flash, and events can be recalled out of order. “Reviewing…the immediate past involves less physical time than was needed for the clock’s mechanisms to exhaust its strokes…The ‘less’ indicates that the Past is in no need of clocks and the succession of its events is not clock time, but something more in keeping with the authentic rhythm of time” (547-48).

Van Veen’s notion of perceptual, pure time provides one of the core themes of *Ada,* and its ideas permeate the novel on multiple levels. In his book, *Dying for Time: Proust, Woolf, Nabokov* (2012), Martin Hägglund argues that the relationship between Van and Ada weaves its own texture of time, as it “stretches across long periods of absence and is torn by interruptions” (80). He continues: “In order to counteract this loss of time, Van and Ada persistently trace patterns of repetition. In narrating their story they emphasize reflections of the past that not only yield an experiential texture, but also display apparently perfect symmetries.” An example of one such symmetry is how Van calls Ada on the telephone in 1922, from the hotel where they parted in 1905. This reminds Van of calling Ada in 1886 to meet at the place where they had parted in 1884. “That telephone voice, by resurrecting the past and linking it with the present…formed the centerpiece in his deepest perception of tangible time, the glittering ‘now’ that is the only reality of time’s texture” (Nabokov 1969, 465).

In addition to the actual narrative of the plot embodying Van’s ideas on time, the same ideas are reflected at the level of narration. *Ada* is not just a chronicle about two lovers; it also documents the process of writing such a chronicle. Nabokov parallels the period of writing the memoir (1957-1967) with the narration of Ada and Van’s encounters between 1884 and 1922. Through parenthetic comments inserted throughout the text, we witness the process of editing and filtering one’s own past. Häagglund writes, “Van is the main signatory of the text, but Ada takes over from time to time, both of them interrupt the narrative of the past to refer to circumstances at the time of writing, comment on certain details, admit lapses in memory, or demand that certain passages be eliminated or rephrased" (2012, 91). This meta-commentary inserted within the text is another way in which past and present are linked, influencing one another and embodying variations of one continuous state of consciousness. While the word "chronicle" usually connotes a factual, objective record of events written in chronological order, *Ada* is anything but. Instead, it parodies the genre by providing a glimpse into two intertwined subjective accounts of events littered with self-conscious anachronistic commentary, reflecting how our own consciousness concurrently interweaves memories of the past with perceptions of the present.

Having seen how Nabokov cleverly incorporated these philosophies of time into *Ada,* both in the narrative of the central relationship as well as through the process of narration itself, one can begin to appreciate how these heterogeneous states of consciousness in which the present and past intersect lend themselves well to representation via a temporal artistic medium such as music. In Fineberg's adaptation, the flute and electronics weave together their own texture of time, in which filtered versions of flute sounds embody the notion of a colored past, which is brought into dialogue with the presence of the live flute. In the program notes to the piece, Fineberg writes, "The piece takes the image of a sort of viscous time in which the live flute leaves trails behind as it moves from note to note in its long line. The thickness of the trail varies as does the longevity of the traces, but the ultimate effect is a dialogue across time between present, past and through anticipation future." I am convinced that this dialogue is intensely dramatized through the exploitation of emergent psychoacoustic properties, such as roughness and spectral fusion, both of which are connected to the concept of harmonic tension.

Let us now explore these concepts in a more detailed manner, before proceeding to link these attributes to specific temporal conflicts within *The Texture of Time.*

.3 Harmonic Tension:

Harmonic tension is a well understood concept within the construct of Western tonality – in a simple tonal cadence, the tension created by an unstable dominant seventh chord, which includes a dissonant tritone interval, is released upon resolving to the stable tonic chord, which contains only consonant intervals. The schema of tension and release, with tension being associated with dissonance and instability, underlies tonality's hierarchical system of chordal relationships and their resultant harmonic syntax. In spectral music, the harmonic vocabulary is much less clearly defined. Chords can be based on highly diverse acoustic models and personal calculations, yet the concept of harmonic tension can be retained in the concept of harmonicity. Jonathan Harvey has suggested that a type of hierarchy can be understood in spectral music in which harmonic spectra are akin to the stability of a tonic in tonality, while altered and inharmonic spectra are "less stable and more complex" (Harvey 2001, 13). While this analogy is compelling, it doesn't capture the more nuanced gradations of harmonic tension in spectral music as compared to tonality. Harmonic spectra can gradually morph into inharmonic ones through stretching, compression, and other mathematical processes in a continuous frequency-space, whereas the chords of tonality are contained within the discrete points of a fixed pitch-space.

While harmonic tension relies on a sliding scale of harmonicity in spectral music and on the interplay of consonance and dissonance in tonality, in both instances harmonic tension is also linked to the perceptual phenomenon of roughness. Roughness is produced by simultaneous frequencies that fall very close together within what is known as a critical band. The two frequencies interfere with each other and a parasitic amplitude modulation called "beating" occurs (Fineberg 2006, 81). German physicist Hermann von Helmholtz famously attested that dissonant intervals were perceived as such because of the beating created between the upper partials of two tones (1877/1954). This hypothesis, however, only works with complex (instrumental) tones with many partials. Tests using pure sine tones have shown that both experienced and inexperienced listeners will perceive roughness if two tones fall within a critical band, but that beyond the critical band the inexperienced listeners will consider all intervals to be consonant, even major sevenths, which were still considered dissonant by experienced listeners. Fineberg writes, "This suggests that we can all perceive roughness and learn to associate that roughness with musical structures, even if the roughness is later removed" (2006, 81).

Though the phenomenon of roughness occurs between two or more tones within a critical band, there are varying degrees of roughness and different sizes of critical bands. Psychoacoustic experiments have confirmed the following pattern of events as one pure frequency is gradually shifted away from another. When the two frequencies are identical, one fused pitch is heard. As one of those frequencies is either increased or decreased slightly, up to 10 Hz or so (this amount varies depending on register) we begin to hear audible beats but still one pitch. If the same frequency is shifted further, to about 15 Hz, the audible beats give way to an unpleasant sensation of roughness. Shifting the frequency beyond this zone, it will pass the *limit of frequency discrimination*, and two separate tones with separate pitches will be heard. At this point, roughness still persists, especially in low regions, until another limit is reached, that of the critical band, beyond which the two tones will be separate and smooth. The size of the critical band is larger in lower register, around 10.8 semitones at C1, and smaller in the upper registers, around 1.9 semitones at C8. Figure 1 below illustrates the perceptual differences within the critical band while figure 2 illustrates their sizes in terms of frequency and musical interval.

Figure 1: The perceptual changes that occur when a pure tone fixed at frequency F_1 is heard combined with a pure tone of variable frequency F_2 (Howard and Angus, 75, Figure 2.6, reprinted with permission)

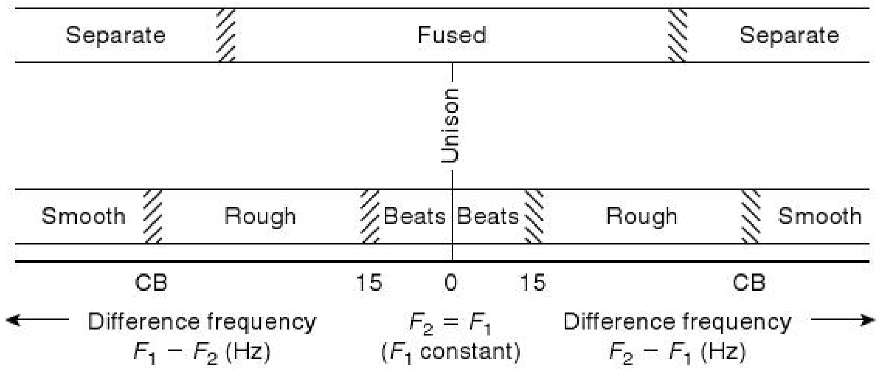


Figure 2: Critical bandwidth sizes between two pure tones measured in semitones at different center frequencies. Data is extracted from Figure 3.5 in *An Introduction to the Psychology of Hearing* (Moore, 2013, 77) and is approximate.

C1 – 10.8 semitones
C2—6.8 semitones
C3—4.5 semitones
C4—3.2 semitones
C5—2.5 semitones

C8—1.9 semitones

As we can see in figure 1, there are actually two separate psychoacoustic phenomena at play when frequencies lie within the same critical band, roughness as well as fusion. Fusion is the ability of our auditory system to group a collection of simultaneous frequencies together into one perceptual auditory image, or the inability to segregate each component frequency into separate sound identities, with many sound events falling on a continuum between fully fused and fully segregated. As previously discussed, one of several factors that affect the degree to which we hear a collection of frequencies as fused or segregated is harmonicity—in fact, McAdams argues that along with coordinated modulation and relative familiarity of the spectral envelope, harmonicity is one of “the most efficacious cues” (1982, 281). Besides having direct implications for spectral music, fusion may be a factor in the perception of chords in tonal music as well. Bregman believes that chords made up of traditionally consonant intervals, such as major triads, fuse together (though incompletely) into one perceptual sound object because our ear does not find multiple distinct sets of harmonics, owing to the close mathematical relationships among the partials (1990, 507). Dissonant combinations of tones, on the other hand, "are less likely to fool the scene-analysis process into assigning them to the same perceptual object." While both fusion and roughness are obvious contributors to notions of harmonic tension in both tonal and spectral music, it is important to distinguish between the two: "heard as one" is not synonymous with "heard as smooth" (508).

Fineberg has been known to use harmonic tension as an organizing principle in works that pre-date *The Texture of Time.* In his 1994 work *Streamlines* for nine instruments, he derived chords from the upper spectrum of a pitch played on a double bass with a rapidly fluctuating vibrato and bow pressure, then placing them on a scale of harmonicity based on an algorithm for finding the virtual fundamental for each pitch (virtual fundamental: the emergent psychoacoustic property whereby the human auditory system calculates a fundamental pitch that may be perceptible even when there is no physical fundamental frequency present in the sound). Higher virtual fundamentals were associated with a greater degree of harmonicity and less harmonic tension, as they indicate that the frequencies in consideration fall into harmonic relationships relatively low in the harmonic series (i.e., they correspond to low-integer ratios). Interestingly, Fineberg was able to verify that the intended differences of harmonic tension in the harmony of *Streamlines* were perceptible when he collaborated with Daniel Pressnitzer, Stephen McAdams and Suzanne Winsberg on a psychological experiment at IRCAM on musical tension and roughness (2000). Isolating several chords from the piece so that other musical factors such as dynamics and rhythm were negated, a group of subjects were presented with every possible combination of two different chords and asked to determine which one was more rough and tense. The conclusion of the experiment was that tension-release schemas could be conveyed through orchestral timbres without any basis in functional tonality, and that the perception of roughness was “highly correlated with the musical notion of tension” (2000, 79).

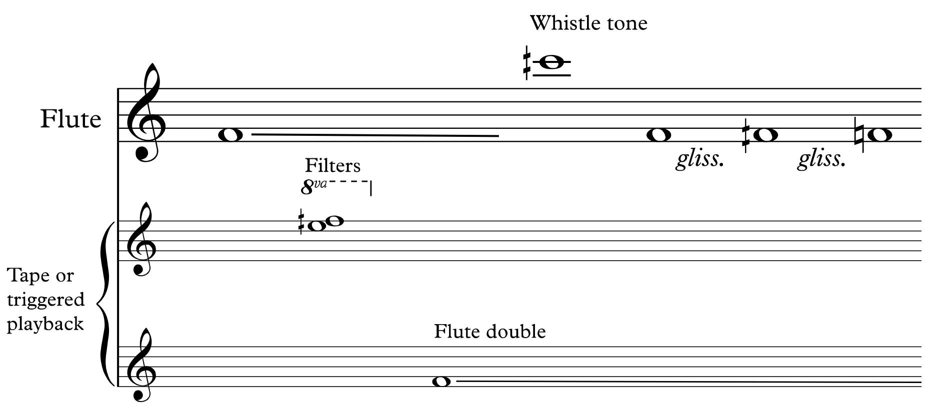
What’s interesting about the example of *Streamlines* is that there is existing literature in terms of both its external poietics (specifications on how the composer derived and organized the harmonies), and external esthesics (a psychological experiment verifying the perception of harmonic tension in listeners). While neither of these exists in published form for *The Texture of Time*, the example of *Streamlines* provides valuable insights for our current project. First is the knowledge that Fineberg has explicitly used harmonicity/harmonic tension as an organizing principle in the past, making it a known part of his compositional process. While my present concern is with the perceptual results of harmonic tension rather than its derivation, there is a certain validation in the knowledge that the composer has explicitly exploited this phenomenon in the past. Secondly, the results of the psychological experiment verify that listeners are indeed able to perceive roughness and associate it with musical tension-release schemas in non-tonal contexts, providing evidence of some of the ideas suggested throughout this chapter. My analysis will take these conclusions as a starting point, and offer examples of the passages most likely to exploit the phenomena of roughness and fusion in *The Texture of Time*. Having unpacked the concept of harmonic tension into its acoustic and psychoacoustic components, let us now begin our analysis to discover how these phenomena are used in *The Texture of Time* to convey information about the philosophy of time.

.4 *The Texture of Time*

The Texture of Time is roughly six minutes and forty seconds long, largely consisting of long flute lines and their filtered electronic trails that linger behind. The piece is quite rhythmically free and has no clearly defined teleological form, leaving the impression of a more improvisatory approach to its performance. Though the flute part contains mainly long sustained notes, virtuosity is demanded of the performer in terms of a wide array of multiphonics and extended techniques, extreme dynamic detail, precise quarter note tuning (24-TET), as well as occasional rapid flourishes. The electronic component is composed largely of sustained chord-like sonorities, often containing several frequencies in close proximity to one another. Besides these sustained chords, there are also several passages where clusters of partials move more rapidly. Within the score, the former are notated as horizontal black lines, while zigzag squiggles represent the latter. While such notation provides enough information for a performer, this analytical investigation will require a closer reading of specific frequencies within certain chords and clusters. To obtain this data, I ran the sound-files from the version for fixed media through the software program SPEAR, and took readings of the most prominent partials in each chord/cluster. The reason for analyzing the version for fixed media was pragmatic; the resultant sound is not variable from performance to performance, making it possible to more accurately make predictions on potential interactions with the live flute. The following musical examples will either be of the score as written (or a reduction thereof), or include my own transcriptions of the electronic component.

Let us begin our close analysis by taking a look at the opening system of the piece (figure 3A), which immediately introduces the harmonic tension and interplay between electronic and live components that will prove to be so pivotal throughout this piece. Right after the flute plays its first note F4, the electronics (labeled in the score as “filters”) play an E6 and F¼♯6. These surround F6, the fourth partial of F4, on either side; one note a semitone lower and the other a quarter tone higher, both within its critical band. The limit of frequency discrimination for pure tones in this frequency range is between a semitone and a whole tone, suggesting the possibility of some level of fusion between the fourth partial of the flute and the prominent partials in the electronics, while still creating conditions viable for roughness. This roughness introduces a high level of harmonic tension within the first few seconds of the piece.

Figure 3A: Score reduction



Interestingly, the live and fixed components reverse roles for the following part of this opening gesture; the electronics double the sustained F4 flute sound, while the live flute plays a C¼♯6 whistle-tone (whistle tones have a very few upper partials, and thus have a sine-tone like quality to them). This whistle-tone is now a quarter tone sharp of the third partial of F4, creating similar tension within a different region of the flute’s spectrum. The opposition established within this opening passage is not so much between live and fixed components, but rather between a sustained harmonic spectrum and the tension induced by other sound events, with the live and electronic components contributing to both aspects of this sound. Figure 3B illustrates the proximity of the electronics and live whistle-tone to the harmonic spectrum of F4.

Figure 3B: First four partials of fundamental F4 with nearby conflicting frequencies

Partial No.	Ideal Pitch	Ideal Freq. (Hz)	Conflicting Pitch and Freq.	Interval from Nearest Partial
			F¼♯6 1438	50¢ above 4th
4th	F6	1397		
			E6 1318	100¢ below 4th
			C¼♯6 1077	48¢ above 3rd
3rd	C6+2¢	1048		
2nd	F5	698		
1st	F4	349		

At the end of the system the flute plays a gesture that will be utilized throughout the piece, a slow glissando to and from a note a quarter tone higher. This slow slide between F4 and F¼♯4 activates the frequency region between these notes, as well as the frequency regions between their upper partials, and can be seen as a playing out of the concept of gradual gradations between fusion and non-fusion. Retroactively, the F¼♯ and C¼♯ from the beginning could be thought of as foreshadowing the activity around each partial as the F slides to the F¼♯. Within the first twenty seconds of the piece we begin to establish a dialogue between present and past: the notes introduced in the beginning as providing roughness to the partials of the F4 spectrum are now included as part of the spectrum on F¼♯4.

The beginning of the next system employs a similar type of harmonic tension, though perhaps with a nuanced difference in quality. Here the electronic part continues to play the F4 from earlier, but it is now joined by a set of four prominent partials, filtered and resynthesized from previous flute material, which are transcribed in figure 4A. The chord continues to play on the critical bands of F4 and its partials, with frequencies lying near the second through sixth partials of F4 (figure 4B). Along with the four frequencies from the electronics, a whistle-tone in the live part on G6 also conflicts with the fourth partial of F4. When listening to this passage in comparison to the previous one, my immediate reaction was that I could detect roughness in both sounds, but that more pitches stood out from the mass in the electronics at 25".

Figure 4A: Score reduction with transcribed electronics (middle staff)

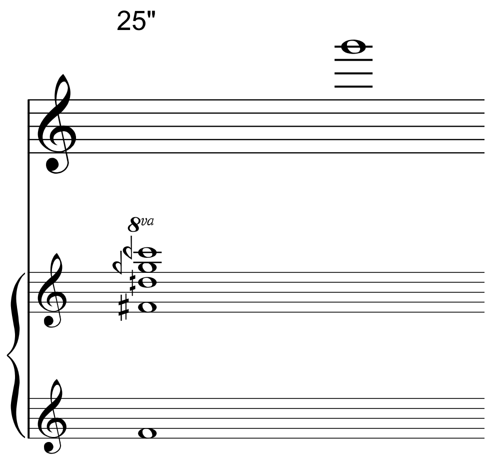


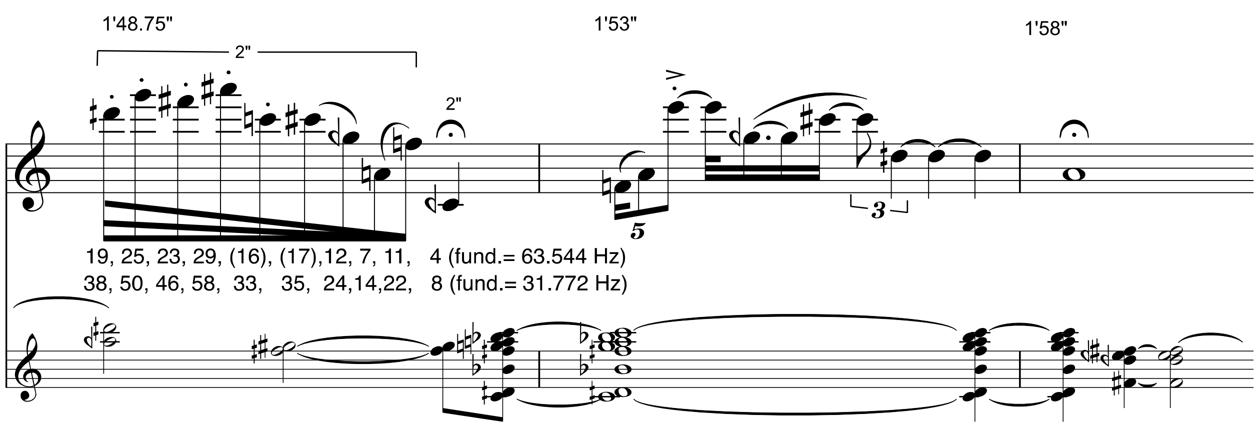
Figure 4B: First six partials of fundamental F4 with nearby conflicting frequencies

Partial No.	Ideal Pitch	Ideal Freq. (Hz)	Conflicting Pitch and Freq.		Interval from Nearest Partial
6th	C7	2095			
			C¼♭7	2036	50¢ below 6th
5th	A6-14¢	1746			
			G6 (flute)	1568	186¢ below 5th, 200¢ above 4th
			G¼♭6	1527	154¢ above 4th
4th	F6	1397			
			D¼♯6	1219	236¢ below 4th, 262¢ above 3rd
3rd	C6+2¢	1048			
			F♯5	731	80¢ above 2nd
2nd	F5	698			
1st	F4	349			

What's interesting here is that different portions of the critical band are being activated for different partials simultaneously: the intervals between partials and nearby frequencies vary considerably in size, spanning from a quarter tone (50¢), to larger than a whole tone (>200¢). The larger intervals lie just on the edge of the critical band in this frequency range, so would thus lie beyond the band of frequency discrimination (meaning their individual pitch identities could be discerned) while still creating a small amount of roughness. This chord introduces several new gradations of harmonic tension in which the tones could be heard both fused and separately (to different degrees), while simultaneously providing varying amounts of roughness to the sound. The F4 that continues to linger in the background would be perceived quite differently in this context, showing another instance of how varying degrees of harmonic tension can color or shade our perception of an event. Here the lingering F4 seems to embody a continued presence of the past, while the filters and live flute provide a lens through which the past is perceived differently. We bear witness to the process of coloration of past events by present circumstances, the moment in which the present gives way to "the colored content of the past" (547). What's fascinating about the previous two examples is that conditions are created in which the electronics and flute interact with one another at the level of their individual spectra; the presence of one changes our perception of the other, creating an overall perceptual object that is greater than the sum of its parts.

Another section that appeals to the notion of a colored past comes at 1'48", where the flute breaks out if its slow-moving line in a rapid flourish of notes. This is immediately followed by a more familiar motif, while the electronics play a dense chord cluster. Upon initial inspection of the flourish, I suspected that this might be a melodic composing-out of a vertical harmony, a tactic that is common not only in spectral music, but also in tonal and atonal works. To see if this passage might be indicative of fusion, I looked for any harmonic relationships in the pitch material and found that one must evoke fairly high partial numbers to approximate all of the pitches into one harmonic spectrum, inferring a low virtual fundamental (C¼♭1, 31.772 Hz). However, most of the harmonic relationships could be maintained by inferring a virtual fundamental one octave higher at C¼♭2 (63.544 Hz). This would allow all of the pitches to have lower-integer harmonic relationships (especially the lowest four, 4:7:11:12) and present a stronger case for harmonicity. The only outliers would be the C6 and C♯6, which would now poorly approximate the 16th and 17th partials (figure 5A).

Figure 5A: Score excerpt with transcribed electronics, including potential partial numbers



These notes could easily be passed off as providing resistance to a passage of otherwise harmonic intervals, but they find added significance in the chord cluster that follows in the electronics. The cluster is largely a verticalization of the melody that preceded it in the flute part, with a few alterations. The basic harmonic relationship of 4:7:11:12 is preserved, though raised a quarter tone so that the new virtual fundamental would be C2 (65.5 Hz) instead of C¼♭2 (63.554 Hz). The C6 that was previously out of place appears unaltered in the new chord, blending in nicely as the 16th partial of C2, while the previous C#6 is not found in this chord, but closely approximates the 17th partial of this new spectrum. While accounting for two previous pitches in its spectrum, the new chord also contains two new frequencies that resist its own harmonic fusion: a D¼♯4 and A5, which only poorly approximate the 5th and 13th partials. These latter notes seem to blend better with the D¼♯5 and A4 that arrive in the flute part in the same bar, while the rest of the concurrent flute part remains distinct. Figure 5B illustrates in a more detailed manner how various flute and electronic pitches approximate partials within the two hypothetical harmonic series.

Figure 5B: Similar harmonic relationships between a melodic flute line and its following chord

Flute line at 1’48.75”					Electronics at 1’53”			
Partial No.	Ideal Partial Freq. (Hz)		Actual Freq. (Hz) and Pitch		Partial No.	Ideal Partial Freq. (Hz)		Actual Freq. (Hz) and Approx. Pitch
29th	1842.8	⟷	1864.7 (A♯6)					
25th	1588.6	⟷	1568.0 (G6)					
23rd	1461.5	⟷	1480.0 (F♯6)					
19th	1207.3	⟷	1209.1 (B¼♯6)					
17th	1080.2		1108.7 (C♯6)	⟷	17th	1113.5		
16th	1016.7		1046 (C6)	⟷	16th	1048	⟷	1053 (C6)
					14th	917	⟷	920 (≈B♭5)
					13th	851.5	⥲	881 (≈A5)
12th	762.5	⟷	761.7 (G¼♭5)		12th	786	⟷	790 (≈G5)
11th	699.0	⟷	698.5 (F5)		11th	720.5	⟷	712 (≈F¼♯5)
7th	444.8	⟷	440 (A4)		7th	458.5	⟷	463 (≈B♭4)
					5th	327.5	⥲	302 (≈D¼♯4)
4th	254.2	⟷	254.2 (C¼♭4)		4th	262	⟷	262 (C4)
1st	63.544				1st	65.5		

From a perceptual standpoint it seems as though enough of the frequencies in the electronic chord lie in harmonic relationships that our ear would want to fuse them, though the mistuned 5th and 13th partials could possibly interfere with the fusion process. From listening to the passage, I found that this chord tended to blend into one sound mass, and that it was rather difficult to hear its individual pitches, suggesting a high degree of fusion despite some mistuned partials. This near-harmonic vertical sonority echoes the nearly harmonic intervallic relationships of the melodic line that it collapses, and provides an interesting illustration of how harmonic tension can be created through degrees of harmonic fusion rather than through roughness. From an interpretive standpoint, this passage has several implications. First of all, there is the fact that a chronologically ordered melody is collapsed into one simultaneous chord when it is recalled in the electronics – a concrete example of Van's notion that the past is outside of measured clock time, a succession of events being recalled in one instant. Then there is the question of why the chord is retuned up a quarter step when it returns in the electronics. One possible explanation is that it adjusts itself to the mistuned 16th and 17th partials of the previous flourish. This seems to imply a certain deliberate re-imagining/re-shading of past events to correct any inconsistencies that were previously present. In addition, we are confronted with new flute material while the electronics play this colored version of a past event, reminding us of the heterogeneity of the present moment.

Following this high-energy passage, the flute returns to its familiar slow pace, playing a succession of four sustained pitches in a descending melodic line (figure 6A). Halfway through this descent, the electronics play a cluster of four prominent partials, each one within three quarter tones of one of the four pitches in the flute. This chord only overlaps with the second and third flute tones in the line, and provides harmonic tension with both as it contains partials that lie within their critical bands (figure 6B). What's interesting about this chord is that its frequency content is seemingly derived from the descending flute line, but is presented in a fully realized state before the flute even completes its descent. Like the preceding passage, it flattens any sense of chronology into one present moment; however, it does not wait for the flute line to finish before presenting itself as a re-shaded memory. It's as if a future memory has already manifested itself in the present moment, looking both forward and backward simultaneously. Following this cluster, there are three further clusters of partials, each one containing frequencies within the critical bands of one of the previous four flute tones, along with some new ones. This continues the flow of energy into familiar frequency bands, while rearranging the chronology: first there is activity around F4 and D¼♯5 simultaneously, then A4, followed by D¼♯5 again. These final chords reclaim the role for the electronics as a memory of past events, here recalled out of order and once again recolored.

Figure 6A: Score reduction with transcribed electronics, 2'04" – 2'25"

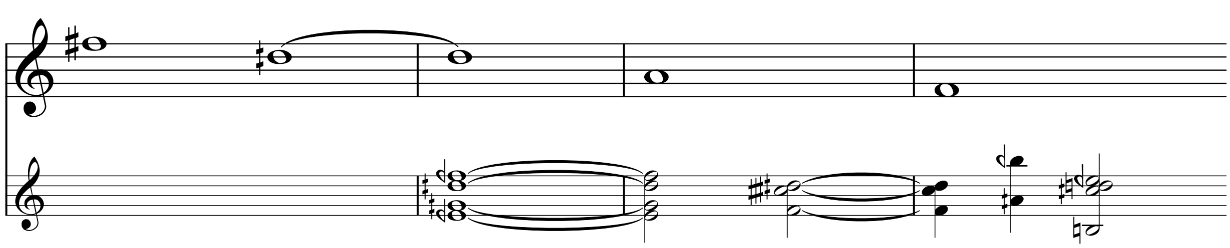
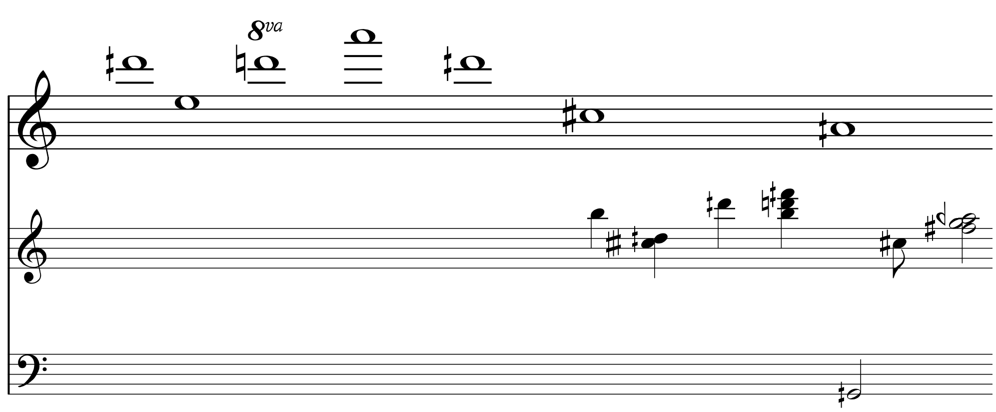


Figure 6B: Chord at 2'15" and its relation to the flute melody from 2'04" – 2'25"

Flute pitches	Flute (Hz)	Electronics (Hz)	Interval
F♯5	740	681	144¢
D¼♯5	604.5	600	13¢
A4	440	426	56¢
F4	349	322	139¢

In contrast to the more dense chord clusters of the two previous examples, the passage from 3’11” to 3’44.5” has a relatively sparse texture, and is significantly less harmonically tense, sounding as though it is arriving at a resting point or relieving tension, in a similar fashion to a cadential progression in a tonal composition. The flute begins with a series of very high-pitched whistle tones, which are similar to sine-tones in their spectral make-up, giving the impression that they’re meant to contribute as partials to a larger sound complex. After a series of descents in the flute part, the electronics eventually come in and further fill out the sound, descending all the way down to a low G¼♯2, at exactly 100 Hz (figure 7A). This is one of only two tones in the whole piece in this low frequency range, with most of the frequency material remaining above middle C.

Figure 7A: Score reduction with transcribed electronics, partial no. and frequency readings added



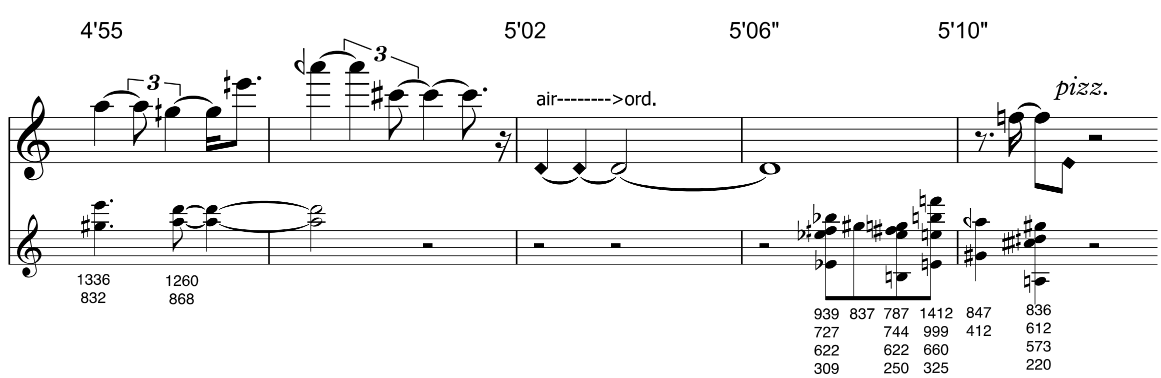
When the rest of the pitch material of this passage (in both the flute and electronic parts) is looked at in light of this low bass tone at 100 Hz, we notice that almost every pitch approximates a multiple of 50 Hz, or one octave below the bass tone (figure 7B). In this way, many of these pitches have the potential to fuse together harmonically, with a virtual fundamental at 50 Hz and a strong second partial present at 100 Hz. Beginning in the upper register and slowly filling in harmonic context is reminiscent of the previously discussed passage at 1'48", but here it goes down an octave further, leaving a stronger impression that these frequencies belong to a single harmonic series and are meant to be heard together. Additionally, there are no frequencies that are far off from a multiple of 50 Hz, unlike the passage in figure 5 that featured several fusion-resisting outliers. In this passage the electronics work with the flute part to gradually enrich what was formerly a naive present—providing context and harmonic depth to the sequence of whistle tones. Here there is less of a conflict between past and present—the electronics are not re-shading past events but working together with the live flute, in a gradual unfurling of the present moment.

Figure 7B: Approximations of flute and electronic pitches to partials of a harmonic series

Partial No.	Ideal Partial Freq. (Hz)	Actual Freq. of Electronics (Hz)	Actual Freq. of Flute (Hz)
47th	2350		2349
42nd	2100		2109
35th	1750		1760
29th	1450	1439	
24th	1200	1209, 1181	
20th	1000	1001	
17th	850	856	
16th	800	795	
15th	750	750	
13th	650		659
12th	600	604	
11th	550	565, 552	554
9th	450		453
2nd	100	100	
1st	50		

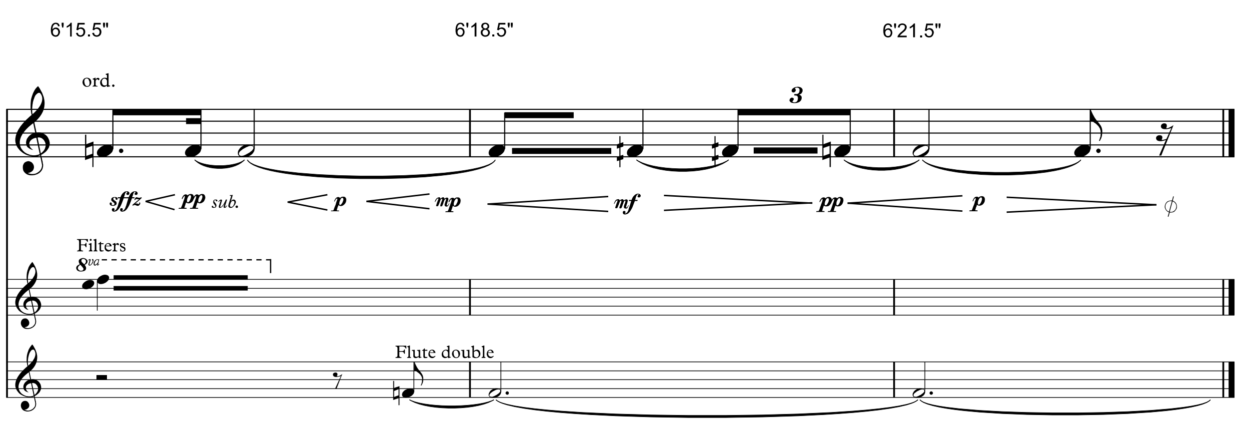
After looking at several passages with moments of vertical fusion and the collapsing of horizontal lines into vertical events, let's explore a passage where the chords in the electronics take on a more melodic profile. Looking at the passage from 4'55" to 5'16" (figure 8), the flute plays a version of the basic motif that recurs throughout the piece, which is followed by a series of six clusters in the electronics while the flute sustains a D4. These clusters, when listened to closely, are quasi-fused identities that take on a melodic profile due to their rapid succession. This “melody” follows the exact contour of the preceding flute line, though the pitch values and intervals are distorted. From my transcription of the passage, you can see that the lowest frequencies follow the same basic shape of the flute line from 4’55” - 5’02”: an initial descent, followed by two ascending steps, completed by a final decent. While previous examples showed instances where the chronology of past events was either flattened or reordered while intervallic relationships remained fairly intact, this example shows a somewhat maintained chronology with new intervallic identities. In terms of critical bands, it’s worth noting that all of the chords contain a partial that is close to A5, the 3rd partial of the sustained D4 in the live flute. These partials all lie between a quarter tone and a whole tone away from A5, but none of them match it exactly. This activation in the region of the third partial brings a more harmonically rich sound to the moment, one of many instances where the present is colored by the past, our recent memories altering our perception of the present moment.

Figure 8: Score excerpt with transcribed electronics, frequency readings added



The piece eventually folds in on itself in a cyclical manner, as the final passage mirrors the opening (figure 9). At 5’50” there is a whistle tone and a tongue-ram, a reversal of the events at 25”. This is followed by a B5 in the flute at 6’02.5” with the electronics providing clashes within the critical bands of the 4th and 5th partials (B6 and D♯6). Finally the flute returns to an F4, identically mirroring the opening of the piece with the exact filters in the electronics adding roughness around the 4th partial. The piece ends with a quartertone pitch bend like the one at 14”. The overall sequence of events is neither an exact chronological match of the opening sequence nor a perfect retrograde, but mixes elements of both, while also adding a bit of new, yet clearly derived material. Though this essay has largely looked at harmonicity as the principal vehicle for providing varying textures of time, I believe the ending is one instance in which the temporal dialogue is echoed on a deeper formal level. The return of the opening passage in a different chronological order reflects the way that various harmonic tensions throughout the piece have colored and re-shaded the past, allowing it to appear in new ways when brought back into present consciousness. This extension of the temporal dialogue to the level of the formal boundaries of the work is reminiscent of how Nabokov reflected the temporal themes from *Ada*’s narrative into his method of narration.

Figure 9: Score excerpt



While this analysis is by no means exhaustive, I believe that the selected passages above provide illuminating examples of the ways in which harmonic tension, created by both roughness and degrees of spectral fusion, dramatizes the relationship between the present moment and recollections of the past in *The Texture of Time.* Roughness was found to contribute to several instances of harmonic tension through the playing of electronic frequencies and/or whistle-tones within the critical bands of the lower partials of sustained flute pitches. Varying degrees of roughness were hypothesized, evidenced by the different sizes of intervals between conflicting frequencies. Similarly, harmonic tension (or lack thereof) was created using degrees of spectral fusion. Two instances were found in which many frequencies fell into harmonic relationships with one another allowing a more globally fused sound event to emerge. The first of these included many harmonic relationships but also contained outlying pitches that did not fit into my harmonic interpretations, suggesting quasi-fusion. The second instance presented a stronger case for fusion with almost all of the frequencies falling into harmonic relationships above a very prominent second partial.

All of these techniques for creating varying degrees or "shades" of harmonic tension allowed for a strong metaphorical link to be made between these speculative psychoacoustic phenomena and the way in which our subjective consciousness filters events into colored memories, what Van Veen refers to as "the colored contents of the past." Many of the examples showed cases in which motives or harmonic relationships reappeared in newly shaded forms, influencing the way the present moment was perceived. In addition, these recollections toyed with notions of chronology, either flattening horizontal motives into vertical harmonies or reordering events, strongly evoking Van's view that the past is outside of clock time. This dialogue between past and present allowed for a dynamic "texture of time" to be woven between live and electronic components, similar to the one created by Nabokov through Ada and Van's relationship.

This analysis itself has woven together two methodologies, the speculation of how events could be perceived belongs to Nattiez' category of inductive esthesic analysis, while the search for evidence pertaining to the source of the work's title would fall under external poietic analysis. The former is admittedly somewhat experimental for spectral music analysis, though I chose to ground my analysis on observable acoustic conditions for possible emergent or global psychoacoustic phenomena, most notably that of roughness and fusion, observations which also often correlated with my subjective listening experiences. The next step for this type of research would be to set up a psychological experiment similar to the one performed for *Streamlines,* where some of my speculations on possible percepts throughout this piece could be tested by a group of subjects. Regardless of the outcome of this experiment, I believe my chosen methodology adds a piece of the puzzle for the interpretation of this work, and probably would for many other works as well. If spectral composers are deliberately concerned with "the way sound changes in time and the affects it has on the human mind," then analysts of this repertoire should be equally concerned with engaging literature on acoustics and psychoacoustics in their quest for demystifying even a small kernel of this music's elusive symbolic power.

Chapter 5: Postlude

.1 Evaluating Technological Engagements

After having explored in detail two spectral mixed works that rely on different spectral techniques to communicate unique dialectics between their acoustic and electronic components, let us consider the broader implications of these discoveries in terms of the intersections between music and technology. Through my analysis of Jonathan Harvey's *Tombeau de Messiaen,* it became apparent that the electronic component was ambiguously situated neither in complete unity nor in complete opposition with the pianist, as sometimes the piano's pitches fused well with the various harmonic series in the DAT, while at other times they were in stark contrast to them. This ambiguous positioning allowed the tension between live and electronic components to provide much of the sonic and semantic intrigue for this piece. Listeners are confronted with situations in which it may be easy or difficult to distinguish component sound-sources, in addition to situations where sections may or may not sound "in-tune" according to culturally acquired expectations, and much of the piece lies in a grey area between those two extremes.

What I find most fascinating about *Tombeau de Messiaen* is that it poses such a compelling challenge to the tired dualistic trope of technology being opposed to an idealized concept of nature, one that is untainted by human activity. On the surface level, one often equates acoustic instruments with symbolizing something natural, and electronic components being exclusively technological. Because they demand human virtuosity (and don't require electricity), we often forget that acoustic instruments are extreme technological innovations in and of themselves, especially an instrument as complex as the modern piano. In addition, equal temperament is a human-made construction that provides a compromise between more "natural" justly-tuned intervals and the ability to modulate between different key areas in tonal works. Paradoxically, the electronic component in *Tombeau de Messiaen* reinserts these natural intervals back into the conversation, even though the piano sounds were retuned and played back using technological means. What can be considered more natural or technological in this context? The dualism collapses completely, leaving us with a complex hybrid human-machine interactive process that paves a new path in terms of music's potential relationships with technology.

In a similar yet distinct manner, Fineberg's *The Texture of Time* engages technology to create a variety of intriguing perceptual and musical effects. Varying degrees of roughness are created between the electronic and acoustic components, as each often contains pitches that lie within the critical bands of the other's spectral content. In addition, there are moments where melodic lines are collapsed into more vertical sonorities, allowing multiple partials in both electronic and acoustic components to fuse together to varying degrees. In this way, the presence of each component may actually alter the way we perceive the other component, and together may change how we perceive the entire sound output. While these perceptual implications are fascinating on their own accord, Fineberg takes things a step further by allowing these potential perceptual ambiguities to illustrate a larger reflection on the philosophy of time. Flute spectra are filtered and elongated in the electronic part, offering a zoomed-in perspective of the nature of the flute sound, as if allowing time to stand still. These thick trails then come into contact with the more immediate presence of the live flute, allowing both present and past to occupy concurrent space in our immediate consciousness.

A good litmus test for determining whether or not a mixed work is successful in meaningfully engaging technology on a musical level is to ask whether the same message could be communicated if the electronics were removed from the piece and their parts rewritten for a purely instrumental setting. For *Tombeau de Messiaen*, this would prove to be a tremendous logistical challenge, as re-tuning twelve pianos to twelve different harmonic series and placing thirteen pianists on stage would require an enormous amount of labor and coordination, not to mention that in higher octaves it would become impossible to represent all of the pitches of the harmonic series on a piano keyboard (e.g. in the octave between the 16^{th} and 32^{nd} partial, there are 16 partials for only 12 available piano keys). In addition, the electronic piano sounds sometimes slide between certain pitches in the electronic part, which calls into question the discrete fixity of a piano's pitch content, and is not possible to reproduce on a physical piano. For *The Texture of Time*, perhaps some of the effects of harmonic tension could be reproduced by several flutes playing various partials, but this would just sound like a flute ensemble playing spectral harmonies rather than a zoomed-in exploration of the inner sound of a flute. In addition, the tension between past and present would be completely lost, as there would be no filtering or processing of the live flute lines to represent distorted versions of past content. For both situations, any ambiguities in terms of the identities of various sound sources also rely on the visual presence of the live performer's actions being contrasted with an absence of such activity in the visual domain for the electronics. If live instruments recreated the electronic parts, the audience would always be able to decipher who was playing which part, dissolving the intrigue of ambiguity that permeates mixed works.

I have presented analytical cases for why both *Tombeau de Messiaen* and *The Texture of Time* engage technology in profound and innovative ways, and would argue that the pieces would neither sound the same nor embody the same meaning if the electronic component was removed from the equation. Does this mean that we could expect all mixed works in the genre of spectralism to engage technology in a similar manner? Obviously there will be pieces within every sub-genre of art music that utilize the restraints of their medium to communicate messages to varying degrees of success. For this project I initially selected the beautiful sounding *Metallics* (1995) for trumpet and electronics by Yan Maresz, but after spending a significant amount of time analyzing and listening to it, I came to the conclusion that the electronics served more of a harmonic background role than participating in any interesting dialectic with the live trumpet. In fact, Maresz has gone on to write a version of this piece for trumpet and orchestra called *Metal Extensions* (2001), failing the litmus test for technological ingenuity as proposed above.

At the same time, it is no coincidence that *Tombeau de Messiaen* and *The Texture of Time* both belong to the spectralist genre of concert music, while embodying intriguing interrelationships between electronic and acoustic components. As was discovered in chapter two, one aesthetic of spectral music is the desire to create perceptual ambiguities in listeners—to create conditions in which the individual identities of sound sources may be lost and found again. This has been done using entirely acoustic ensembles, but the incorporation of technology into spectral compositional practice offers new and different tools and techniques for these types of ambiguities to be exploited. The conscious exploitation of ambiguous perceptual identities of sound objects allows spectral mixed works to overcome some of the blatant dualisms that exist in mixed works in general—rather than situating the electronics in opposition to the acoustic instruments, the two work together to create sound percepts that would not be the same without the interaction of both components. Put another way, the dualism itself can become a compositional resource in spectral mixed works, as the expectations of opposition and contrast are both contradicted and reinforced. This allows for the creation of dialectics which are much more nuanced than the average mixed work, which at its worst is often viewed as nothing more than a live instrument with an electronic backing track. However, I do not wish to make the claim that all spectral mixed works engage technology in equally intriguing ways, or that other mixed works outside of the spectral tradition are incapable of transcending the dualism of mixed music. Counterexamples to each of the above claims have already been discussed and many others could be found if one were to go searching for them. Rather, my aim was to demonstrate that the aesthetic values of spectralism open up a vast potential for new and interesting dialects to be made between electronic and acoustic components in mixed works, a feat which was accomplished by both *Tombeau de Messiaen* and *The Texture of Time.*

.2 Methodological Diversity and Implications for Theoretical Discourse

Besides demonstrating how technology can permeate works in meaningful ways, one of the goals for this project was to provide insight on the implications of such investigations for the wider theoretical community. One of the first things I noticed when working with this body of repertoire was that the analysis of spectral mixed music necessitates an openness to methodological diversity, as one must be able to adapt analytical techniques to the specific constraints of each piece. This is reflective of the repertoire itself, which is unified more by its aesthetic values or compositional attitude rather than a specific set of pre-established techniques. As a result, rather than beginning with a rigid analytical methodology, I approached each piece with a question: What is the unique message that is communicated through this work? From there, I was able to interweave various theories, including preference values for tone-representation, along with psychoacoustic theories of harmonic tension, roughness and fusion.

Approaching analysis in this *ad hoc* manor required a keen awareness of what types of statements I was making about each musical work. Using an adapted version of Jean-Jacques Nattiez' tripartional model, I identified three concurrent analytical activities taking place in each of my analyses. *Tombeau de Messaien* made use of external poietic information to find harmonic series throughout the electronic part, and inductive poietics to comment on the larger harmonic progression and overall form. Inductive esthesics was also at play in terms of suggesting various moments that might be prone to or resist perceptual fusion. In my analysis of *The Texture of Time,* I took this inductive esthesic approach further, pointing out moments of potential perceptual roughness and tension in addition to moments that suggested fusion. I also incorporated external poietic information regarding the work's title, and to a lesser extent, my work also had inductive poietic implications.

While inductive esthesic approaches are common to tonal analysis, they remain marginalized in literature involving contemporary mixed works. Most academic articles on this repertoire have been of the external poietic variety, explaining software patches or compositional techniques. While this kind of knowledge is extremely helpful in terms of deepening our perspective and appreciation of the work, in addition to providing invaluable archival information, it does not discuss how listeners actually experience the music—the actual aural effects of all of the compositional processes at play, and what those effects might imply in terms of what the piece successfully communicates to a listener. While writing about music in esthesic terms cannot replace the activity of actually listening to the music, it can enhance our listening experience by deepening our appreciation for the nuances at play, drawing our attention to details we may have never noticed otherwise. While prose has its limitations, the abundance of meaning created by music ensures that the activity of analysis is never closed—there are always new things to discover in the music and to share with others.

As I see it, the only difference between an esthesic analysis performed on a tonal work and the variety I performed on *The Texture of Time* is that the former is based on learned schemas of tonality while the latter relies on more innate mechanisms of human audition. Both, however, rely on findings in the material score (or electronics) to make conjectures about possible perceptions of the piece. Just as a Schenkerian analysis might argue that a specific pitch could be heard as belonging to a certain underlying harmony, I have argued that certain groups of pitches might lend themselves to fusion or harmonic roughness. Neither is making the epistemological claim that one can actually know what is going on inside another's brain—both are necessarily speculative, yet they both can provide insight into how the music is functioning as it comes into contact with a human listener.

One of Nattiez's analytical situations which has not played a major part in this thesis nor in music theory in general until recently, is that of external esthesics, the type of analysis that begins with psychological studies to collect data on how listeners have understood a piece. As previously stated at the end of my analysis of *The Texture of Time,* it would be very fascinating to see how an inductive esthesic analysis of a mixed or spectral work would line up with an external esthesic one. This could possibly help ground some of the speculative aspects of an inductive esthesic analysis without dismissing their interpretive merits. Conversely, an inductive esthesic analysis of a work could be a good way of pinpointing moments of potential perceptual ambiguity or interest that could be further investigated by means of a psychological experiment. It is my hope that esthesic analysis (of both the inductive and external varieties) may come to be more highly pursued and valued in the theoretical literature surrounding spectral mixed music, as necessary complementary knowledge to the more widely accepted available poietic information.

When I first began this project I was so intrigued with the consequences of interactions between acoustic and electronic components in mixed music that I overlooked the role of human perception and cognition in the whole process. Of course, music does not exist and thus cannot be theorized about in a vacuum, but never before have my theoretical investigations led me so directly to the ways in which the human auditory system perceives sound and how the human brain understands music. Though the spectral movement has developed in conjunction with sound analysis and synthesis technology, perhaps its greatest innovation was the intentional desire to surprise and confuse the very perceptual mechanisms that turn sound waves into audio images for us to comprehend. As more composers begin to adopt this mindset and new technologies continue to be developed, who knows what the future holds in terms of musical engagements with both technology *and* the complex processes of auditory perception.

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