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Proposal for "Analytical Techniques of Electroacoustic Music"

Introduction

The foundations of musical analysis have long been tested by the weight of music from the periods of tonal practice. There is a rich and expansive repertory of techniques from which the analyst may choose in approaching music composed in the tonal tradition of the Eighteenth and Nineteenth Centuries. The Twentieth Century saw an expansion of compositional strategies, which in turn charged theorists and musicologists with the tasks of developing and adopting new methods of analysis. Analysts met these challenges by employing a range of techniques nearly as varied as the post-tonal compositions themselves. Pitch-class set theory and twelve-tone serial techniques have been the most widely adopted analytical methods for the post-tonal repertory, representing rigorous, quasi-scientific approaches to what is often extremely complex music.

This expansion of compositional and analytical techniques coincided with the development of technology that eventually made its way into the hands of composers. Technology's influence on composition in the mid-Twentieth Century formed in the concurrent strands of *musique concrète* and *elektronische Musik*, one concerned with the use of recorded sound as a malleable medium, the other with generating sounds themselves through electronic means. The two approaches eventually converged, with varying degrees of cohesion, into what is generally referred to as electroacoustic music.[1]

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[1] Leigh Landy discusses various titles applied to strands of electronic-based music in Landy 2006. While the proposed dissertation will summarize these terminological aspects the present proposal will simply use the term "electroacoustic music" to mean any music composed with the full or partial use of electronic means.

Electroacoustic music practice is multilayered in that all of the techniques of the past are available to the composer along with the seemingly limitless sonic possibilities afforded by technology. Once technology was brought into the compositional landscape the composer was bound to adapt to technical processes typically considered to be outside of the realm of music. Many of today's academic music institutions teach electroacoustic composition techniques alongside the traditional methods.

The music theory community's response to the musical changes brought on by electronic sound technology has not been as enthusiastic as were previous responses to atonal and serial techniques. Synthesis and signal processing are integral parts of electroacoustic music, not simply being the means to make beautiful sounds but actually forming the basis of structural processes within the music. One would hardly argue that no knowledge of orchestration—or at least instrumentation—is necessary in order to analyze a Mahler symphony, and yet many of the technical aspects of electroacoustic music have long been considered as specializations that hold no interest for those not involved with creating such music. What kind of analytical techniques can be applied to music of such a diverse compositional style and whose very structure is so heavily based on highly technical processes? In this proposal I will present the basis for a document that will engage this and other important questions related to electroacoustic music analysis such as the related issues of pedagogy, and preservation, and representation.

Addressing the pedagogy of electroacoustic music is important because of its specialized technical nature, which tends to limit exposure to the students who take advanced composition courses at universities. This leaves future music theorists and musicologists without the ability to articulate technical processes in electroacoustic music to the same degree that they are trained to with regard to traditional tonal and post-tonal repertory. Part of the original contribution of the dissertation will be to find ways to make the technical aspects of electroacoustic music accessible. Preservation is another subtopic that is important because of the nature of electroacoustic music as an often “scoreless” medium, an issue that has a severe impact on analysis. Methods of preserving electroacoustic works without traditional scores is another part of the dissertation’s original contribution and a problem that has a substantial impact on the future of electroacoustic music analysis. The problem of representation is related to preservation but is a wider question addressed in the dissertation. Because so much electroacoustic music is without a traditional score and often in the form of fixed media (i.e. existing only as a recording) the issue of visual representation becomes important in the context of analysis.

These questions that relate to the overall picture of electroacoustic music analysis will be addressed through rigorous examination of the problems, existing solutions, and potential solutions moving forward. The results should be a fairly exhaustive survey of the existing analytical literature as well as investigations into the areas of representation, pedagogy, and preservation and how they have impacted analysis in the past and how they may be addressed to aid in analyzing electroacoustic music. The original contribution will focus on software-based solutions to some of these problems, taking into account what works and what doesn’t from the examination of existing analytical techniques and implementing them in an environment that facilitates analysis while also offering solutions to the related problems of representation, pedagogy, and preservation.

Proposal

The proposed dissertation will investigate the range of analytical techniques that have been previously applied to electroacoustic music, and to present techniques and ideas to further the study of electroacoustic music analysis. The methodology consists of two parts: (1) to examine existing analytical techniques applied to electroacoustic music and demonstrate these techniques through a group of sample analyses of electroacoustic works; and (2) to propose a software-based technique that draws upon the strongest elements of the previous methods and demonstrate this technique through an extended analysis of an electroacoustic piece. Each technique will be evaluated according to how much it reveals, conceals, or ignores the structural components of a work.

An overarching motivation behind these investigations is what I have observed as a general lack of attention paid by the music theory community to the electroacoustic repertory. Indeed a large gap exists in the analytical literature for this music and I seek to provide a clear presentation of analytical tools with which music theorists may engage this repertory. In doing so I hope to take at least a preliminary step towards lifting the veil of specialization that seems to shroud so much of this music. In order to take this step a preemptive chapter outlining techniques and compositional norms will be required. This chapter will contain a summary of the most frequently used techniques including elements of synthesis and signal processing. The goal of this section is to introduce relevant compositional processes in electroacoustic music and to provide a range of analytical terminology to aid with analyzing such music.

This preliminary discussion will also have implications that point to the very important questions of pedagogy and preservation of electroacoustic music as I trace some of the technical aspects that underlie much of the repertory and engage the techniques of representation that have been employed owing to the unique, and often "scoreless" nature of the music. Thus the manner in which representation and compositional technique inform and affect the process of analysis will be a constant touchstone throughout the dissertation.

The following paragraphs outline the major points of the dissertation in the form of a review of the relevant literature related to each point. First is a brief discussion of the nature of electroacoustic music, its differences from traditional instrumental music, and how these differences impact analysis. The second point concerns the problem of representation of electroacoustic music and how the lack of a traditional score affects analysis. The third section discusses some existing analytical techniques with some preliminary remarks on the section of the dissertation that will represent its original contribution to the field of music analysis, namely that of an analytical technique based on recreation of a part or whole of an electroacoustic work in an interactive software environment. This final section will summarize the research tasks involved in accomplishing this original work as well as present some thoughts on possible conclusions that may be reached through this study.

The Nature of Electroacoustic Music

Electroacoustic music represents a wide range of styles and techniques. Often the compositional techniques are devised for each individual work, making the task of defining generally applicable analytical methods sometimes difficult. Even so, there are some general trends that can be traced through the more than sixty years of electroacoustic compositional practice. Below is a summary of the most defining characteristics that differentiate electroacoustic music from other types with a review of relevant literature on the technical and aesthetic aspects of electroacoustic music.

In his theoretical treatise *On Sonic Art* Trevor Wishart confronts the dominance of music that is "lattice-based," a term he uses to define music that resides within the constraints of fixed pitch and duration inherent to the traditional system of western music notation (Wishart 1996, 23–30). With both older (tape) and newer (computers) technologies used to create electroacoustic music, pitch and duration do not have to be fixed as if upon a two-dimensional lattice but instead may be continuously variable. In electroacoustic music pitch is often measured in frequency (Hz) instead of the traditional western note names, and duration is usually measured in terms of time-based units such as seconds and milliseconds. The concept of a "note" as it is conceived of in western music is not always applicable to electroacoustic music and various terms such as "sound object" and "sound event" have been created to describe sounds and processes that stretch beyond the typical conception of a musical note. The analytical problem then is one of segmentation and the dissertation will explore methods of segmenting sound objects in great detail using computer visualizations.

Besides the differences in how pitch and rhythm are conceived, the role of timbre is much greater in electroacoustic music than it has been in other music. In instrumental music timbre has traditionally been engaged through orchestration and extended techniques but in the electroacoustic medium composers are able to specify timbres with much greater precision. It has been known at least since the time of Mersenne that natural sounds are composed of multiple simple sine waves existing within a spectrum of frequencies (Green and Butler 2002, 250). The structural components of this spectrum (i.e. number of sine waves and their individual frequencies and amplitudes) are understood to be the primary elements that contribute to a sound's timbre. Electronic technology—and computer synthesis in particular—has afforded an unparalleled level of control over the spectral content of sounds. The timbre of a sound can now be made to evolve over time in very precisely prescribed ways and different sounds, either synthesized or recorded, may even be made to morph into one another. Such a level of control over timbre introduces new analytical questions that are still being answered. Studies on the subject of timbre have not been limited to electroacoustic music with important work spanning traditional instrumental and electronic styles (Erickson 1975; Slawson 1985). With the increasing control over timbre via technology several writers have also engaged timbre as a structural element inherent to electroacoustic music (Wessel 1979; Smalley 1994; McAdams 1999).

Much electroacoustic music is sound-based, meaning it is composed using sounds recorded from the air by a microphone. The types of sounds used are limited only by the composer's imagination and by what can reasonably be captured by recording technology. This process can be traced back to Pierre Schaeffer's *musique concrète* movement wherein any sounds may be used as musical material. This aspect of electroacoustic music poses an analytical challenge, as the conceptual leap from note-based music to sound-based music is considerable in terms of its impact on segmentation and identification of structural components. Several sources exist detailing the principles and techniques of sound-based music, many focusing on the process of manipulating tape (Wells 1981; Naumann 1985) with other sources dedicated to similar techniques using newer technologies (Pellman 1994).

Technology has played a part in the creation of electroacoustic music since its inception. Besides the aforementioned use of tape manipulation techniques two primary uses of electronics are found in even the earliest electroacoustic compositions: *signal processing* which involves the modification of existing sounds and *synthesis* which is the electronic creation of new sounds. Examples of signal processing include filtering, reverberation, delay and echo effects, and modulation effects such as chorus, flanging, and phasing. Several types of synthesis have been created such as additive synthesis where complex tones are realized by summing simple sine waves related by particular frequencies, and frequency modulation synthesis in which even more complex sounds can be created by modulating one sound with another (Chowning 1973). While early pieces used analog equipment found only in dedicated studios, advances in computer technology and processing power have made these processes more affordable and thus accessible to composers. Several guides to signal processing and synthesis with computers exist, some presenting general concepts (Mathews 1969; Roads 1996; Dodge 1997) and others that convey processes in the context of particular software environments such as Csound (Boulanger 2000; Bianchini, Cipriani, and Scipio 2011; Aikin 2013), PureData (Puckette 2007a; Farnell 2010), and Max (Cipriani and Giri 2010; Manzo 2011). Signal processing and synthesis are integral parts of electroacoustic music that often form structural components of a work rather than simply being effects for the sake of effects. The analytical problem with these processes is a question of how to adequately describe their role as structural determinants. This is where the aforementioned pedagogical aspects of the dissertation will come into play because understanding the basic premise of certain signal processing and synthesis techniques is a necessary prerequisite for obtaining a complete analytical picture of a piece. The analyst of electroacoustic music should be able to aurally identify certain technical processes as well as be able to articulate the fundamental aspects of those processes in technology-agnostic language.

The nature of electroacoustic music is such that new concepts of what music is and can be and new processes behind the creation of the music must be engaged. Familiarity with the technical processes, while certainly not a prerequisite when using some of the analytical techniques this dissertation will deal examine, is an added benefit to anyone analyzing this music much in the same way that knowledge of particular instrumental practice or compositional techniques can be of aid in analyzing traditional instrumental music. It is in the analyst's interest to be able to identify relevant processes in a piece, since, as we will see, electroacoustic music analysis does not always benefit from the existence of a traditional score.

Representation of Electroacoustic Music

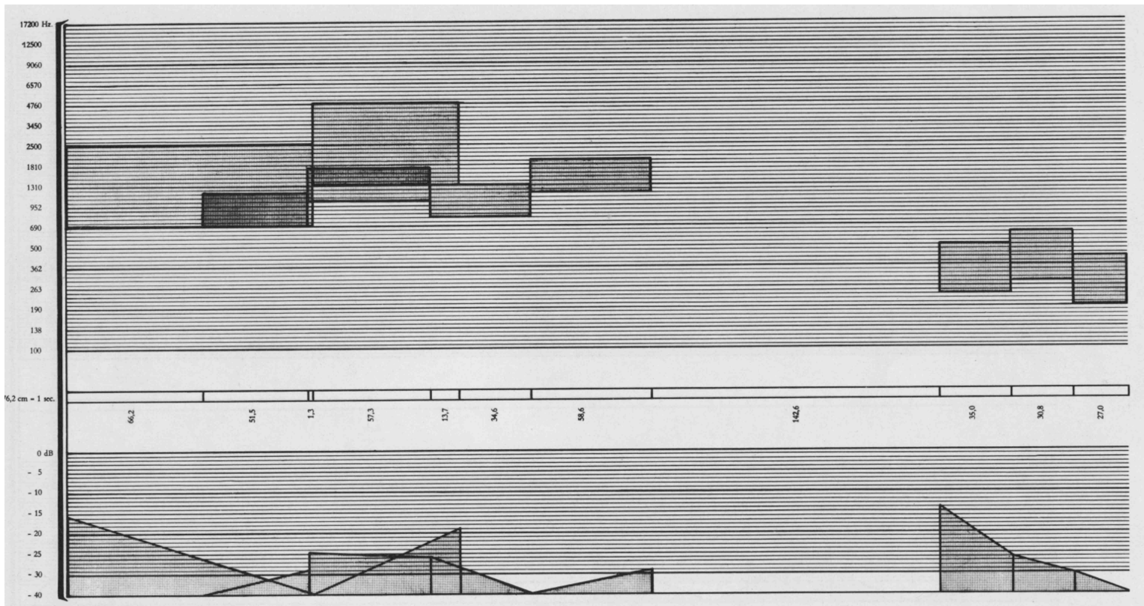
Throughout history various means of visually representing music have been developed. Transmission and preservation were the primary reasons for creating methods of visual representation of music but an additional benefit of visual representation is in the realm of analysis. As music is a temporal art a musical representation allows one to examine musical ideas outside of a temporal context (Stroppa 1984, 180). This ability to abstract musical ideas outside of a real time performance has made an easier task of analyzing music and the score has become an indispensable tool of the analyst.

The analysis of electroacoustic music revitalizes the problem of musical representation. Electronics and especially computers offer the ability to more flexibly manipulate the four musical parameters of pitch, duration, intensity, and timbre. Traditional scores typically contain visual representations describing incremental values of most of these parameters, with only approximations of timbral content through instrumentation and orchestration. With electroacoustic music these parameters can be manipulated in more finely tuned gradations allowing musical parameters to be continuously variable (Bossis 2006, 107-8). This increased precision and variability leads to the problem of adequately representing the music in a visual format that is capable of rendering the type of clarity found within the traditional music score.

Several models of representation have been applied to electroacoustic music, each with varying degrees of usefulness to analysis. Realization scores, parametric graphs, spectrographic analysis, graphic interpretations, and software realizations are all means of representing electroacoustic music. Each of these models has advantages and disadvantages, which is why recent scholarly work in the area of electroacoustic music analysis has tended to use a blend of techniques (Simoni 2006b, 8).

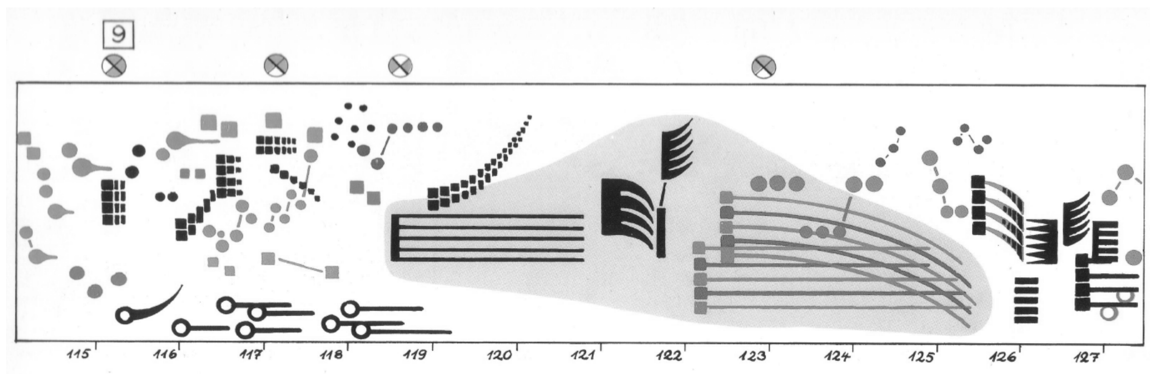
The first technique of representing electroacoustic music is known as a *realization score* or a *technical score*. These documents are usually some form of schematic or list of operational data that guides the reader through the steps of creating the piece (Stroppa 1984, 177). If the work is a mixture of electronic and acoustic sources there may be a combination of standard notation for the acoustic instruments and an instruction manual for executing the electronic portions. Examples include the scores of Karlheinz Stockhausen's *Studie II* and Gottfried Michael König's *Essay*, both examples of early *elektronische musik* composed at the WDR studio in Cologne during the 1950s.

Parametric graphs are visual representations that usually consist of a timeline with shapes or lines that define values for parameters within whatever electronic system is used to realize the electroacoustic work. Examples include the scores to Joji Yuasa's *Projection Esemplastic for White Noise* and Stockhausen's *Studie II* (Ex. 1). The Stockhausen piece, which also contains realization instructions, is perhaps the best-known example of this technique. The score's parameters are duration, amplitude, and frequency. Duration is represented in tape lengths, while geometrical shapes represent amplitude and frequency. The lengths of the shapes depict the duration of events and the heights depict the values of amplitude or frequency of the events.



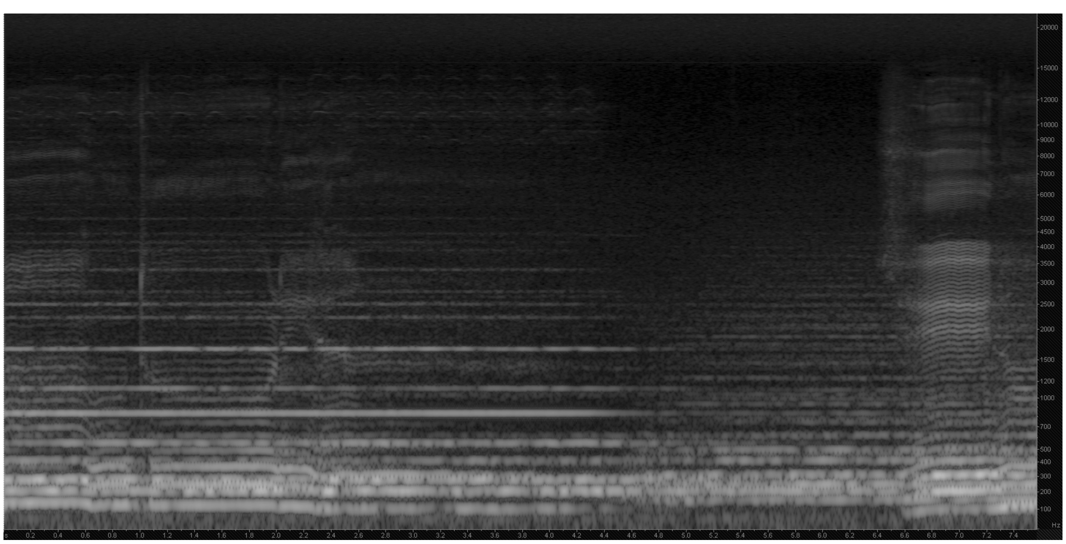
Example 1. Parametric Graphic Score of Stockhausen's *Studie II*.

Other representation techniques consist of drawn or digitally rendered *graphic transcriptions*. This technique is distinct from the parametric graphic in that it does not depict representations of precise values corresponding to musical parameters. Instead it represents general sound events as abstract shapes that roughly correspond to dimensions of duration, frequency, and intensity but may also depict other processes or even combinations of process. Probably the most famous example of this technique applied to electroacoustic music is Rainer Wehinger's listening score of György Ligeti's *Artikulation* (Ex. 2). The score is a highly abstract collage of colored shapes that correspond to gestures using sine tones, impulses, and filtered noise. The use of shapes and colors to define particular parameters or sound objects offers a helpful guide for exploring larger connections within a music work.



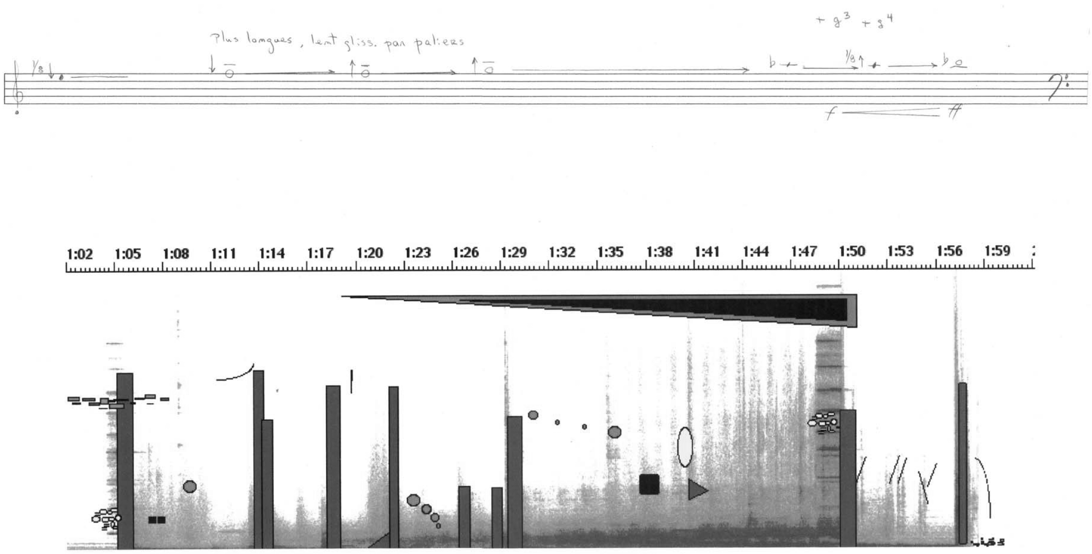
Example 2. Listening Score to Ligeti's *Artikulation* by Rainer Wehinger.

A fourth representation technique employs *audio signal visualization*. This term actually encompasses a range of techniques that have become highly accessible through the development of computer technology. *Time-frequency visualization*, also known as a sonogram, is the most widely used type of audio signal visualization for analysis (Ex. 3). In a sonogram the horizontal axis represents time, the vertical axis is frequency, and amplitude is represented by intensity of displayed brightness. With this scheme the analyst can perceive a timescale and trace events throughout it with ease.



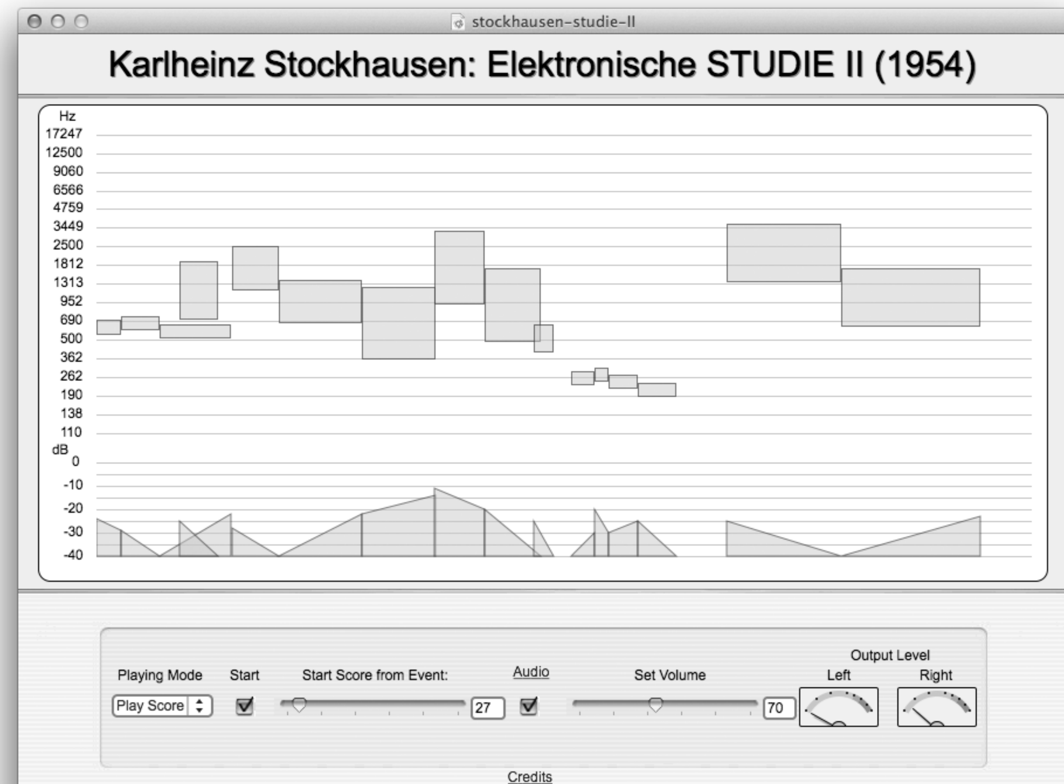
Example 3. Time-Frequency Audio Signal Visualization.

One downside is that because the sonogram depicts spectral components of sounds as separate visual entities it can be difficult to perceive the fundamental events of which they are constituent parts. Having a visualization of spectral content is invaluable for analyzing the kind of timbre-based transformations that are often intrinsic to styles and genres under the umbrella of electroacoustic music. The time-frequency visualization technique has been used extensively for analysis with notable early contributions by Robert Cogan (Cogan 1984), but has also been used in electroacoustic scores. The score to Gilles Gobeil's *La Perle et l'Oubli* (2001) for Ondes Martenot and tape makes extensive use of sonogram visualization alongside both standard music notation and graphic transcription (Ex. 4). Here the notated part for Ondes Martenot is written above a sonogram image of the previously rendered tape music. Graphic annotations are then made on the sonogram presumably to highlight important events.



Example 4. Score to Gobeil's *La Perle et l'Oubli* for Ondes Martenot and Tape.

A final technique is the use of software realizations of electroacoustic music. A more recent approach than the previous techniques, software realizations aim to reproduce previously composed electroacoustic works using modern computer technology. The nature of software development makes this a particularly amorphous category. Depending on the chosen platform and the expertise of the developer a software realization can take on any imaginable form. The choice of programming environment has a great impact on how successful the realization is in terms of being an analytical aid. An example of a software realization of an existing electroacoustic work is Georg Hajdu's rendition of Stockhausen's Studie II using the Max programming language (Ex. 5).



Example 5. Georg Hajdu's Max patch realization of Stockhausen's *Studie II*.

Max is a visual programming language created to enable musicians to create their own software for electroacoustic music and multimedia art. Included as an example in the official Max software installation, Hajdu's patch displays an animated version of the original parametric graphic score that proceeds along with the sonic realization of it. This comes closer to an ideal mode of representation than any other technique previously mentioned. The user can play the score from the beginning or skip to different sections out of time. Using a user interface slider the score can be stepped through either forward or backward or one can jump directly to any event. This amount of control over the timeline makes this realization highly interactive. Software realization, in combination with other techniques such as graphic transcription and sonogram analysis, presents an ideal opportunity for continuing endeavors in electroacoustic music analysis.

Analytical Techniques of Electroacoustic Music

Marc Battier identifies two primary camps of analytical approaches to electroacoustic music: the *esthesic* camp and the *poietic* camp (Battier 2003, 249). The esthesic camp engages in analysis from a perceptual basis while the poietic camp uses the processes that go into making the music as the basis of analysis. The majority of existing analytical methods fall under the esthesic camp as models for describing sounds have been a preferred recourse for analytical discourse on electroacoustic music. Examples include Pierre Schaeffer's typo-morphological classification of sound objects (*objet sonore*) using descriptive terminology (Schaeffer 1977; Chion 1983) and Denis Smalley's concept of *spectromorphology*, which builds upon Schaeffer's ideas by classifying types of sounds based on their perceived spectral content (Smalley 1986; Smalley 1997; Smalley 2010). These techniques start with the act of listening and proceed according to a set of descriptive tools for identifying structural relationships between different types of sounds. Some classification techniques supplement terminology with a range of symbols such as in R. Murray Schafer's classification system for types of natural and artificial sounds (Schafer 1994). Classification symbols are often used in conjunction with some type of visual representation system, usually the aforementioned time-frequency visualization or sonogram, where they are placed on the representation to identify certain sound events and structural relationships. Perception-based analytical techniques can be very helpful for describing sounds and events that fall outside of note-based conceptions, but they mostly leave aside the compositional processes that make electroacoustic music unique.

The poietic camp is considerably smaller with mostly recent efforts aimed at involving compositional processes in the act of analysis. Battier 2003, Roy 2003, and Bossis 2006 are recent examples of analytical work that make compositional processes the starting point for analysis. In these methods the materials of construction are taken into consideration and technical processes are engaged to reveal their structural significance. Because technology is so intertwined with the nature of electroacoustic music the problem arises that technology is not always a stable resource as hardware and software may become obsolete over time. This problem calls for the identification of what Bruno Bossis calls *compositional invariants*: techniques and principles that are universal to electroacoustic practice and not tethered to any one technological system (Bossis 2006). Bossis posits that finding invariants among compositions is important because many contemporary compositions have unique compositional strategies (Bossis 2006, 102). The dissertation will explore the idea of compositional invariants as well as ways of communicating technical processes without engaging specific technologies in order to facilitate this type of poietic analysis.

A third stream of analytical techniques has arisen in the form of hybrid methods that borrow from both the esthesic and poietic camps. Stéphane Roy insists that the esthesic and poietic approaches both have value and enable a comparison of the listener and composer's points of view (Roy 2003). Other techniques are concerned with both perception and procedure and often involve some type of software to facilitate listening and analysis. Pierre Couprie's *EAnalysis* is a software application that allows the user to load a recording of a piece and view a sonogram of it (Couprie 2012). EAnalysis also has graphic tools to allow the user to mark the sonogram for analytical purposes. Michael Clarke has worked extensively with what he calls *interactive aural analysis*, a method of using software to allow the analyst to explore structural aspects of a piece interactively while listening (Clarke 2005 and 2012). Clarke uses the visual programming language Max to create software environments that can either play recordings of electroacoustic works—similar to Couprie's EAnalysis—or that recreate parts of a composition to let the user investigate the processes behind it. These approaches are the most interactive of any yet presented and offer a very attractive solution to the problem of electroacoustic music analysis.

Interactive Realization

Clarke's interactive aural analysis is similar to the author's own independently conceived analytical technique called an *interactive realization* (Huff 2013), which is a software environment where all or part of an electroacoustic composition is recreated. An explanation of the technique as well as the actual implementation of it using the Max programming language will form the bulk of original work in the dissertation. The software realization is made to give the analyst a visual representation of parameters within the piece as well as control over the parameters themselves so that they may "play" the piece or even improvise within the framework of its technical materials. The software environment is also conceived as a pedagogical tool with documentation explaining the technical aspects of the composition. Larger processes such as formal organization can be viewed on the surface of the environment while lower level processes such as synthesis and signal processing are encapsulated so that the user may investigate them if they choose. Since much electroacoustic music has no score and often nothing more than a recording of its realization the interactive realization has implications for preservation as well. As Simon Emmerson has pointed out, the scoreless condition of electroacoustic music calls for a real examination of how it may be preserved for future generations in some form other than recordings (Emmerson 2006). The documentary aspect of an interactive realization can facilitate the preservation of an electroacoustic piece by making the technical aspects of its realization available in addition to providing a performable version of the piece itself. This analytical, pedagogical, and preservation tool will be my original contribution to the field of electroacoustic musicology through the proposed dissertation.

Research Tasks

The preparation for this dissertation will consist primarily of ongoing investigations of the analytical and theoretical literature as well as further research into the computer programming processes for the purpose of creating interactive realizations. Due to the origins of this type of music a substantial amount of written work in the area of electroacoustic music analysis is written in French, with some other texts in German. These sources will need to be read and in some cases translations will have to be done for the purpose of quotation.

In addition to the standard musicological research there will need to be further work in the area of software design for the creation of the interactive realization analysis. This will involve two steps: the research into methods of realizing electroacoustic works in a software environment and the actual implementation of these methods for the purpose of the dissertation's extended analysis. The chosen software environment is the visual programming language Max, with which the author already has a certain amount of fluency. The interactive software realization will be thoroughly explained in the prose of the dissertation but will also be available as a free, multiplatform download for readers to use alongside the document. Pending the acceptance of this proposal the projected completion date for the dissertation is Spring 2015.

Possible Conclusions

The effectiveness of each analytical technique under scrutiny will be tested through their application in the analysis of electroacoustic works. The pros and cons derived from these evaluations will then contribute to the larger analysis section with the best practices being integrated into the interactive realization. It is my view that interactive realization may be a helpful analytical tool that allows the analyst to have a more hands on approach with electroacoustic music similar to the way one might play through parts of a score on a piano. The pedagogical possibilities are also very attractive as the realization may contain the instructions for how the piece works even down to the smallest technical detail and as more realizations of pieces are developed it may be possible to create a repository of works whose techniques and materials are preserved through software. In this way a software realization can be used as a tool to teach students and future analysts the processes inherent to an electroacoustic work at the same time as conveying an analytical interpretation of the piece. The use of software to create interactive realizations of electroacoustic music poses some questions for how scholarly work is communicated and published. Because the analysis is tied to the experience of using the software environment it can be difficult to convey in the form of prose. This is a challenge that the academic community will have to engage as more scholarly work that crosses media boundaries is done. It will be an underlying goal of the original portion of the dissertation to successfully convey the particulars of the software realization through prose.

Electroacoustic music analysis is a very young practice and composers themselves have produced much of the analytical literature. This dissertation is meant to fill a void in the music theory literature that provides a comprehensive guide to analytical techniques based on both the listening experience and the process of composition. It is my hope that this guide may aid and encourage analysts to engage this music in greater numbers, which in turn may lead to the development of even more effective methods for analyzing electroacoustic music.

Appendix A: Outline

Analytical Techniques of Electroacoustic Music

I. Introduction
    A. Brief Discussion of Music Analysis
        1. Analysis in the Twentieth Century
        2. The Purpose of Analysis
        3. Etymology of the Word
        4. Bent's Definition
    B. Unique Aspects of Electroacoustic Music
        1. Timbre
        2. Sampling
        3. Synthesis/Signal Processing
        4. Spectral Morphing
    C. Problem of Analysis of Electroacoustic Music
        1. Summarize Inherent Problems
            a) Representation
            b) Analysis of Sound Alone
            c) Variety of Compositional Techniques
        2. Lack of Analyses
            a) Aesthetic Differences
            b) Materials and Techniques
            c) Specialization
    D. Thesis
        1. Examine Existing Analytical Techniques
            a) Discuss Theory of Electroacoustic Music
            b) Explore the Problem and Techniques of Representation
            c) Examine Existing Analytical Techniques
            d) Demonstrate Existing Analytical Techniques
        2. Propose Interactive Realization Analysis
            a) Importance of Interaction
            b) Software as Interactive Environment
            c) Portability and Preservation
II. The Theory and Nature of Electroacoustic Music
    A. Understanding the Elements of Electroacoustic Music
        1. Terminology
            a) What is Electroacoustic Music?
            b) Analysis is Not Always Analysis
                (1) Analysis of Sounds vs. Musical Analysis
        2. The Problem of Specialization
            a) Signal Processing
            b) Synthesis
        3. The Importance of Timbre
        4. Beyond "Lattice-Based" Music

B. Compositional Norms in Electroacoustic Music
    1. The Use of Sampling
        a) Roots in *musique concrète*
            (1) Pierre Schaeffer
            (2) GRM
        b) Audio Manipulation
            (1) Recording
            (2) Sampling & Editing
            (3) Time and Pitch Manipulation
    2. Synthesis
        a) Roots in *elektronische musik*
            (1) WDR
        b) Types of Synthesis
            (1) Additive Synthesis
            (2) Subtractive Synthesis
            (3) Frequency Modulation Synthesis
            (4) Granular Synthesis
            (5) Physical Modeling
    3. Signal Processing
        a) Filtering
            (1) Types of Filters
                (a) Low-Pass
                (b) High-Pass
                (c) Band-Pass
                (d) Band-Reject
                (e) All-Pass
        b) Modulation
            (1) Types of Modulation Effects
                (a) Tremolo
                (b) Vibrato
                (c) Chorus
                (d) Flange
                (e) Phaser
        c) Reverberation
            (1) Filter-Based
            (2) Impulse Response-Based
        d) Spectral Morphing
            (1) Cross-Synthesis
    4. Data Processing
        a) Timing/Sequencing
        b) Parameter Handling
        c) Routing
        d) Algorithms
        e) Generative Processes
C. Reframing Parameters in Musical Terms

        1. Analytical Terminology
        2. Parameter Naming in Reconstructive Analysis
        3. Imperative Technical Terms
III. Analysis of Electroacoustic Music
    A. Applications of Traditional Music Theory
        1. Pitch/Frequency
        2. Rhythm/Duration
        3. Dynamic/Amplitude
        4. Analytical Problems of Timbre
    B. Representation
        1. The Problem of Representation
            a) Relation to Analysis
            b) Three Modes of Representation
                (1) Prescriptive
                    (a) Created with performance or realization in mind
                (2) Descriptive
                    (a) Created to precisely describe a particular performance
                (3) Analytical
                    (a) Created to reveal elements of structure
        2. Types of Representation
            a) Realization Score/Technical Score
                (1) Set of instructions designed to aid the "performer" in realizing the piece
                    (a) Examples
                        (i) König – *Essay*
                        (ii) Stockhausen – *Studie II*
            b) Parametric Graphs
                (1) Visual representations that contain time domain data corresponding to musical parameters (frequency [pitch], duration, amplitude, etc.) with varying degrees of precision
                (2) Examples
                    (a) Stockhausen – *Studie II*
                    (b) Yuasa – *Projection Esemplastic for White Noise*
            c) Graphic Transcription
                (1) Visual representation based on an interpretation of the piece
                (2) Examples
                    (a) Ligeti – *Artikulation*
                    (b) Gobeil – *La perle et l'oubli* for Ondes Martenot and Tape
                        (i) Uses a combination of standard notation, graphic transcription, and audio signal visualization (sonogram)
            d) Audio Signal Visualization (see Adams 2006 [Simoni])
                (1) Time-Domain Representation (Waveform)
                    (a) Displays amplitude changes of a signal over time
                (2) Frequency-Domain Representation (Spectrograph)
                    (a) Displays amplitude of frequencies occurring within a complex sound
                (3) Time-Frequency Representation (Spectrogram/Sonogram)

(a) Time domain representation of the actual resultant audio of a work that displays time, frequency, and amplitude

(4) Examples

(a) Cogan – Babbitt

(b) May – Manoury

(i) Peakgraph

(c) Scores of EA music with sonographs

(i) Gobeil – *La perle et l'oubli*

(5) Problems

(a) Structural relationships can be difficult to discern

(b) Tracing the fundamental not as simple as with standard notation

(c) Differentiating between discrete events is difficult

e) Software Realizations

(1) Software environment designed to realize existing electroacoustic repertory

(2) Examples

(a) Heintz

(i) Stockhausen – *Studie II* (Csound)

a. Re-programmed in Csound

b. Purpose was to explore the correlation between the piece's serial techniques and computer programming techniques

(b) Hajdu

(i) Stockhausen – *Studie II* (Max)

a. Real-time realization of *Studie II* that simultaneously displays the parametric graphics from the realization score while generating the audio.

b. Allows the user to start the score from different events in the timeline.

c. User can create a randomized score using the same synthesis engine

(c) Kramer

(i) Chowning – *Phoné* (Pd)

(d) Battier

(i) Chowning – *Stria* (Csound)

(e) Pd Repertoire Project

(f) Clarke – Interactive Aural Analysis (IAA)

(i) Sybil Software

(ii) Smalley – *Wind Chimes*

(iii) Harvey – *Mortuos Plango, Vivos Voco*

3. The Problem of Representing Spatialization

C. Examination of Existing Techniques

1. Analytical Types

a) Sound Classification

(1) Typo-morphology (Schaeffer)

(a) Reduced Listening

(b) Sound Objects

(i) Balanced Sounds
(ii) Unbalanced Sounds
(c) Method
(i) Identification
(ii) Classification
(iii) Description
(2) Classification (Schafer)
(a) Physical Characteristics
(b) Referential Aspects
(c) Aesthetic Qualities
(d) Sound Contexts
(3) Theory of Oppositions (Cogan)
(a) Spectral Segmentation
(b) Opposition Table
b) Spectral Analysis
(1) Spectromorphology (Smalley)
(a) Note to Noise Continuum
(b) Spectral Space
(c) Spectral Density
(d) Morphology
c) Perceptual
(1) Auditory Scene Analysis (Bregman)
(a) Primitive Auditory Scene Analysis
(b) Schema-Based Scene Analysis
d) Terminological
(1) Language Grid (Emmerson)
(a) Syntax
(i) Abstract
(ii) Abstracted
(iii) Combination
(b) Discourse
(i) Aural
(ii) Mimetic
(iii) Combination
(2) The "Something to Hold Onto" Factor (Landy)
(a) Parameters
(b) Homogeneity
(c) Textures
(d) Programmes
e) Constructivist
(1) *Faktura* (Battier)
(a) Composition and Technology
(i) Symbolic Manipulation
(ii) Physical Manipulation
(b) Digital Instrument

(i) Instrument
(ii) Machine
(iii) Representation

f) Aural/Interactive
(1) Interactive Aural Analysis (Clarke)
(a) Software Environment
(i) Visual Analysis of Recordings
(ii) Reconstruction of Excerpts

2. Analyses (This is a list of possible pieces from which I will choose)

a) <u>Milton Babbitt (1916–2011)</u>
(1) *Composition for Synthesizer* (1961)
(2) *Ensembles for Synthesizer* (1964)

b) <u>François Bayle (1932)</u>
(1) *Vibrations composées* (1973)
(2) *Tremblement de terre très doux* (1978)
(3) *Toubie dans le ciel* (1979)
(4) *Motion-Émotion* (1985)

c) <u>Luciano Berio (1925–2003)</u>
(1) *Perspectives* (1957)
(2) *Omaggio a Joyce* (1959)
(3) *Momenti* (1960)
(4) *Visage* (1961)
(5) *Chants parallèles* (1975)

d) <u>John Cage (1912–1992)</u>
(1) *Williams Mix* (1953)
(2) *Fontana Mix* (1958)

e) <u>John Chowning (1934)</u>
(1) *Sabelithe* (1966)
(2) *Turenas* (1972)
(3) *Stria* (1977)
(4) *Phoné* (1980-81)

f) <u>Mario Davidovsky (1934)</u>
(1) *Electronic Study No. 1* (1961)

g) <u>Herbert Eimert (1897–1972)</u>
(1) *Klangstudie I/II* (1953)

h) <u>Jonathan Harvey (1939–2012)</u>
(1) *Mortuos Plango, Vivos Voco* (1980)
(2) *Ritual Melodies* (1989–90)

i) <u>Gottfried Michael König (1926)</u>
(1) *Klangfiguren I/II* (1955–56)
(2) *Essay* (1957-1958)

j) <u>Paul Lansky (1944)</u>
(1) *As It Grew Dark* (1983)
(2) *Idle Chatter* (1985)
(3) *Late August* (1989)

(4) *Night Traffic* (1990)

k) György Ligeti (1923–2006)
   (1) *Glissandi* (1957)
   (2) *Artikulation* (1958)

l) Otto Luening (1900–1996)
   (1) *Low Speed* (1952)

m) Roger Reynolds (1934)
   (1) *Still* (1975)
   (2) *Eclipse* (1979)
   (3) *Vertigo* (1985)
   (4) *Watershed IV* (1995)

n) Jean-Claude Risset (1938)
   (1) *Computer Suite from Little Boy* (1968)
   (2) *Mutations* (1969)
   (3) *Songes* (1979)
   (4) *Sud* (1985)

o) Pierre Schaeffer (1910–1995)
   (1) *Cinq études de bruits* (1948)
   (2) *Symphony pour un homme seul* (1950)

p) Denis Smalley (1946)
   (1) *Pentes* (1974)
   (2) *Vortex* (1982)
   (3) *Tides* (1984)
   (4) *Wind Chimes* (1987)
   (5) *Valley Flow* (1991–92)
   (6) *Empty Vessels* (1997)
   (7) *Base Metals* (2000)

q) Karlheinz Stockhausen (1928–2007)
   (1) *Studie II* (1954)
   (2) *Gesang der Junglinge* (1955–56)
   (3) *Kontakte* (1958–60)
   (4) *Telemusik* (1966)

r) Morton Subotnick (1933)
   (1) *Silver Apples of the Moon* (1967)
   (2) *Touch* (1969)

s) Trevor Wishart (1946)
   (1) *Vox 5* (1979–86)
   (2) *Red Bird* (1977)

t) Edgard Varèse (1883–1965)
   (1) *Poème électronique* (1957–58)

u) Iannis Xenakis (1922–2001)
   (1) *Diamorphoses* (1957)
   (2) *Orient-Occident* (1959–60)
   (3) *Bohor* (1962)
   (4) *Mycenae alpha* (1978)

(5) *Gendy3* (1991)

v) Joji Yuasa (1929)

(1) *Projection Esemplastic for White Noise* (1962)

IV. Interactive Realization Analysis

A. Preliminary Steps

1. Finding sources conducive to reconstruction
2. Distilling technical instructions to universals (Compositional Invariants)

a) Technical instructions that refer to specific technologies must be translated to apply to any general system

(1) Based on general principles of synthesis and sound processing

B. Creating an Interactive Environment

1. Visualization of Events

a) Sonogram

b) Breakpoint Editors

2. Control of Time

a) Flexible Sequencing

(1) Fast-Forward

(2) Reverse

(3) Out of Time

3. Synthesis and Signal Processing

a) Modularity

b) Pedagogical Comments

C. Sample Analysis

1. Part of or Entire Composition Recreated Using Software

a) König – *Essay*

V. Conclusion

A. The Place of Interactive Realization in Analysis

1. Inherent Difficulty of Transmitting Interactive Realization Analysis Through Written Word
2. Need for New Standards of Communicating Scholarly Work Moving Further into the Twenty-First Century

a) Interactive Documents

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