Examining the Analysis of Dynamical Sonic Ecosystems: in Light of a Criterion for Evaluating Theories

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ABSTRACT

This paper presents two possible approaches used in analyzing electroacoustic music works as applied to a special type of interactive performance system: the dynamical sonic ecosystem, which can be considered 'ecosystemic'. These theories of analysis are then examined in relation to Matthew Brown's 'six criterion for evaluating theories' and their usefulness for analysis, in regards to their ability to qualify a work as ecosystemic. Although both approaches are shown to have merit in their ability to increase understanding of a particular work, only the technique that analyzes the process of composing interactions is found to be capable of the necessary requirements needed to work towards building a theory of ecosystemics, in the same way that there exists a theory of tonality.

1. INTRODUCTION

In the opening chapter of Matthew Brown's book "Explaining Tonality" [1], a discussion is presented on "what should be expected from a successful theory of tonality." This discussion is a valuable refresher on the nature of music analysis theories, and one that should be considered when examining the usefulness of a particular analysis approach in qualifying a work as belonging to a specific style (i.e. tonality) or in creating a theory of rules, laws, and concepts that describe that style. This is not to suggest that all analytical methodologies explored within the realm of music theory should be capable of defining a piece in a specific style of music. There are many analysis techniques that serve to add depth to the analysis of a particular work, or are found useful when no other means is quite appropriate in describing what is occurring. Transformational analysis techniques, such as neo-Riemannian for example, have proven particularly useful in analyzing specific passages in the music of composers such as Richard Wagner. His music contains both functionally-tonal and chromatic harmonic elements [2]. This analysis approach does not offer enough information to qualify the music as pure chromaticism, but does offer a way of contextualizing the use of chromaticism within the music of Wagner and his contemporaries. A similar example is the use of 'gestural analysis' techniques centered around musical expectation that serve as a way of classifying motions within improvised music, and allow for the comparison of 'licks', or common musical gestures [3].

This article will consider two styles of analysis that have been suggested for use with electroacoustic music (EAM). These approaches will be examined for their potential to form a theory of analysis around a specific, decidedly non-tonal style of composition; dynamical sonic ecosystems. The goal of this conversation is to start identifying pieces belonging to this canon, and devise analysis methods, and common language that will allow for the eventual development of a music-based 'theory of ecosystemics'.

1.1 Dynamical Sonic Ecosystems

Interactive performance systems, as defined by Rowe, can be considered any musical system that exhibits change at its output in response to data at its input interface [4]. A very simple example of such a system is one that plays a pre-recorded audio sample in response to a key press MIDI-keyboard.

A dynamical sonic ecosystem is a unique type of interactive performance system in a couple of ways. The most important qualifier is that the interface for the system exists in the sonic or acoustic realm. Typically, this means that the room in which the system is installed becomes the interface where data is acquired. This idea is explained in full detail by Agostino Di Scipio as he describes his own *Audible Eco-Systemic Interface Project* [5]. These ideas are further detailed by Meric and Solomos in [6, 7], and Green in [8].

These types of systems are considered *Dynamical* because in theory, the state of the system at any moment could be described by a series of "iterated numerical processes" [9] typically performed on the micro-level, or a series of fixed mathematical rules that the system is built from. Not only will this describe the timbral properties of a moment, but the structure and form of the piece that emerges is likewise related to these same processes.

Such pieces are considered *Sonic* because they rely entirely on sonic data at their interface. It is worth emphasizing, that these systems do not contain the standard mechanical interface (i.e. keyboard or gestural controllers) of other 'typical' interactive systems. Instead these systems usually rely on an ambient room interface, where all *Sonic* energy within the room, including the output of the system itself, has an equal opportunity to enact a change in the state of the system. This is accomplished through microphones that capture the sonic energy present in the room. It is also important to note, that the physical room, and the external agents to the room (human bodies) are part of this interrelationship, as the sonic energy is affected by the acoustic characteristics of the room and the masses moving within it.

Finally, these systems are considered *Ecosystemic* because every component of the system is crucial to describing the current state of the system and every component of the system is involved in a complex interrelationship between every other component of the system. Within these sonic ecosystems there is a reliance and connection between each component and agent of the system such that changing or removing any of these will alter the entire relationship structure.

A major example of this type of composition is Agostino Di Scipio's *Audible Eco-Systemic Interface* (1993-2005) project. Based on these ideas, Gordon Mumma's *Hornpipe* (1967) and Nicolas Collins *Peasoup* (1974, revised 2002-11) may also serve as earlier examples and might be considered as part of the defining canon [10, 11].

Given the interconnected nature of the agents within Dynamical Sonic Ecosystems, it would follow that there has been a shift in the compositional approach. This is explained by Di Scipio, as a move away "from creating wanted sounds via interactive means towards [composing] interactions having audible traces" [5]. This change in compositional approach does not qualify a work to the ecosystemic style in the same ways as the terms previously defined do. However, this acknowledgment in compositional shift is what drives this paper's interest on further exploring the analyses of such systems.

The importance of Di Scipio's work has become evident, and has inspired many to further explore his systems and his philosophies. One prominent example is the special issue of *Organised Sound* featuring Di Scipio exclusively, which was published between the initial submission of this article and this current version [12]. Within that issue, there are articles that touch on issues of analysis of his music [7, 13]. Those articles further emphasize the need to examine analysis approaches that move beyond some of the earlier EAM approaches.

As will be shown, traditional techniques of EAM analysis using computer-aided computation, based from recorded performances can;

1. aid in a better understanding of what is sonically happening,
2. aid in finding forms and structures that can emerge,
3. help with the identification of possible segments in the piece,
4. and assist in identifying common motifs that occur throughout the piece.

However, they do not allow the analyst to discuss whether the piece is "ecosystemic". They also fall short in providing a sufficient way of comparing pieces within the style.

The defining characteristics of ecosystemic music and knowledge of the common compositional practices allow for the alteration of Brown's primary objective slightly, by adapting it to this specific style. Brown is interested in what makes a successful theory of "tonality", which gives the theorist an ability to say, "Why a passage is tonal?" [1]. Instead, the concern becomes what makes a successful music-based theory of "ecosystemics." This will answer, "Why a system is ecosystemic?"

1.2 Emergent Properties in Ecosystemics

An idea discussed around dynamical sonic ecosystems is that of 'emergence' [6, 14-16]. It is important to quickly define this term, because it will be used in this discussion of systems. The music created from the interconnected interactions of a sonic ecosystem is said to 'emerge' from the system. This can occur on multiple levels. Longer phrases and structure will emerge from the recursive iterated functions that are being applied at the micro-time level. Forms and structure also emerge from the relationship coupling between the physical architectural characteristics of a space and the composed interactions. For example, in Collins' *Peasoup* (which will be discussed below), the slow sliding frequencies that emerge are a result of feedback, which is dependent on the dimensions of the room and the short time delay introduced to the signal by the phase shifter.

Music also emerges from the microstructure reactions occurring in pieces such as Di Scipio's. These micro-time interactions are concerned with the underlying composed interaction of numerical processes. Experienced individually, they are often just a grain of sound, or a short moment. However, when experienced together, they create greater musical structures. This has some similarity to granular composition techniques. However, where a composer would focus on the whole of the grains in traditional granular composition, here s/he is concerned only with the interaction of each individual agent. This allows the form, structure and musical lines to emerge from the recursive interactions of these agents.

2. A TRADITIONAL EAM APPROACH

Traditional music analysis has focused on two types of score objects: the graphic object and the sound/sonic object . Since most electroacoustic music (EAM) is not created from a graphic-based score object, at least not a traditional notated score, analysts have obviously privileged the latter [17]. Not only is this a necessity because most EAM works do not have a score, but because many EAM works are primarily "concerned with aspects of timbre, amplitude, and spatialisation" [18-20]. It has been evident for some time that traditional approaches to music analysis are not appropriate for the newer music of the 19th century. This has been obvious since the 1950's as electronic music compositional practices were developing [21]. From the very early years of electroacoustic music, the analyst has focused on the sound object. Following Pierre Schaeffer's lead, these sound objects have primarily been considered acousmatically. "The [recorded and blind] sonic manifestation of the music [was] the point of departure" [22]. Analysts would privilege the well-trained ear, listening to the piece, picking out salient features and allowing relationships to develop from focused

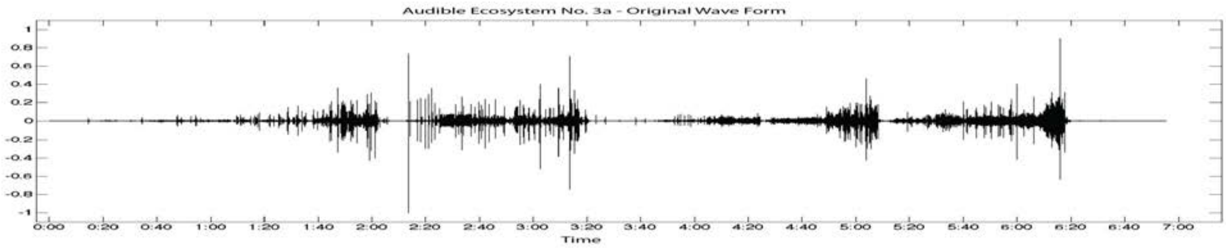

Figure 1. *Hörbare Ökosysteme Nr. 3a -Background Noise (Audible Ecosystem); Original waveform*

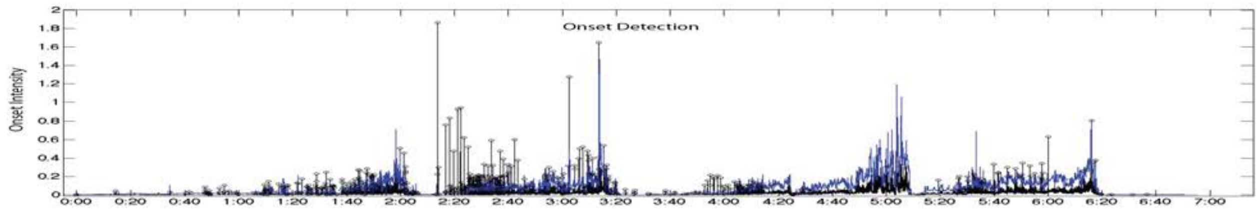

Figure 2. Computationally assisted onset detection

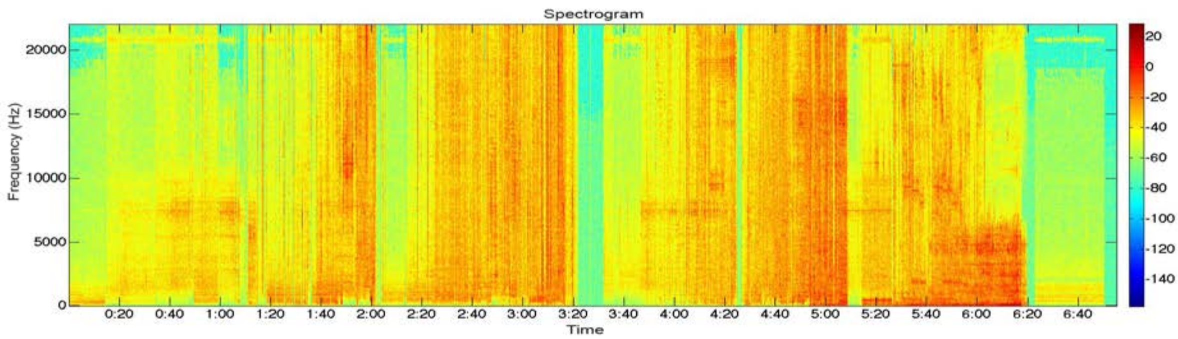

Figure 3. Spectrogram representation. (window size = 2048, window type = hann, overlap = 50%)

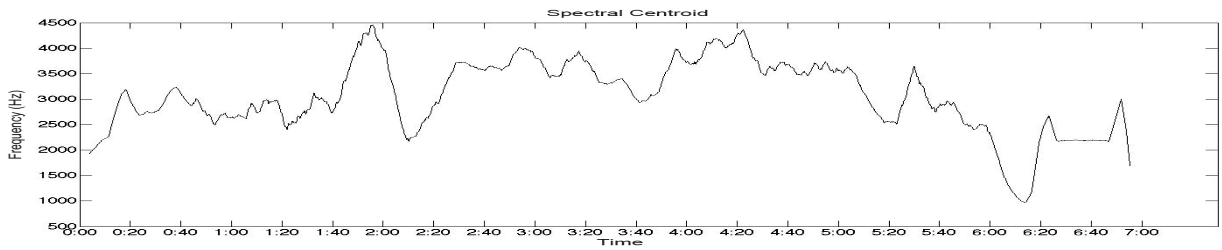

Figure 4. Spectral centroid of signal. (window size = 2048, window type = hann, mean filter size = 50 frames)

listening. Using Schaeffer's *Traité des Objets Musicaux* [23], analysts would classify "morphological features" of a composition, based on salient features within this sound-based score. This allowed analysts to create a set of morphologies that were then used to compare compositions, allowing musical values to be "abstracted" [22].

The skilled analyst, one who is familiar with EAM compositions, will be capable of picking out specific events and sound objects that emerge from the recording, and will be capable of assigning them to the published morphologies. Much in the same way that other analysts will do when aurally identifying pitch sets in atonal music [24]. The goal is to "create a descriptive tool based on aural perception," "ignoring the technology used" [25]. This process can be augmented and aided with the assistance of computational tools, such as those developed in the field of music information retrieval (MIR) [20]. This helps confirm the analyst's perception, and can assist in illuminating what to listen for during the analysis via visual references, or process the recording in a way that emphasizes different qualities of the composition.

2.1 As Applied to Music

A traditional EAM approach would have the analyst and listener consider the piece acousmatically, that is, not concerning themselves with the sources of the music. In a piece such as Di Scipio's *Hörbare Ökosysteme Nr.3a (Audible Ecosystemics) - Background Noise Study,* which is so closely tied to the relationships between the system, participants, and physical space; this is difficult to expect. For the moment only a sound-object based score, in this case a recording from a particular 'performance' of the piece, will be considered.

The quality of sounds present in this piece could be described as consisting of broadband "pop", "click", and "hiss" noises. The performance starts with low-level 'machine-like' noise. From this, small bursts or grains of sound start to emerge and eventually start fusing together. This has the effect of creating longer motivic lines, movement and sonic interplays. Early on, this gives way to sudden pops, which emphasize the high end of the frequency spectrum. As the piece progresses, the timbral quality of the events change, with a spectral centroid that slides up towards 2 minutes (2:00). At this point, a "reset" seems to occur, before the progression begins again. This intensifying of events, which is born out of a low-level background noise, occurs multiple times throughout the recorded performance. The major change heard in the second half of the performance, is the clear presence of sustained tones, which seem to sound for up to10 seconds at a time, before modulating.

The use of visual aids, produced from MIR based computational analysis of the recording, confirms these observations and can help solidify them as well as guide the listening. The spectrogram in Figure 3, for example confirms the true nature of the broadband noise observed. As is clearly visible, solid red vertical lines mark the moments of clicks and pops. Likewise, simple sustained tones, which are created in the latter half of the piece, appear as horizontal red lines. Upon inspection, it is possible to see, starting around 3:50 a sustained tone around 7.5 kHz. This same tone comes back around 5:10, supported in the lower frequency range by complimentary tones of the same duration.

The spectrogram (Figure 2) shows information that was also not perceived during initial listening, which can add to the connections observed within the piece. For example, the 7.5 kHz tones that were noticed in the latter portion of the piece are also present during the opening, occurring from the very start through 1:10. Finally, the spectrogram helps visualize the intensity of low-frequency noise throughout the piece. The opening background noise is clearly visible from 0:00-0:13, which is where the first 'click' of the performance is perceived. The low-frequency noise then comes back again at 0:50, 1:19, and 1:38. There is an increasing amplitude intensity of this motif, which is represented on the spectrogram as darkening shades of red at these moments.

The spectral centroid computational analysis also confirms the rise and fall heard into 2:00, Figure 4. This figure goes on to show the influence the low-frequency noise motif has on the center of mass. Every moment identified above is shown as a drop in spectral centroid. This trend also continues in the second half of the piece. As the total intensity of the performance builds, the spectrum is supported from the low frequency noise and tones. This pulls the center of frequency mass down from a high point at 4:21, to what might be considered the climax of this performance at 6:19.

The initial click of the performance is identified on the Onset Detection analysis, Figure 2. This figure also helps the listener identify the four build-and-release phrases that occur. With releases occurring at 2:02, 3:18, 5:10, and 6:19. In this figure, small black circles where the black onset line crosses the blue adaptive threshold line identify primary onsets. The lack of primary onsets detected between 4:00 and 5:20 helps confirm that the sustained tones dominate the composition during this third section.

Finally, the MFCC self-similarity matrix of Figure 5 can be used as a way of defining unique sections by comparing the timbral similarity of every moment to every other moment. The dark blue color signifies moments of high similarity, whereas lighter colors can serve as boundary markers. The boxes created by light blue lines, which are at the same time intervals as identified above, confirm the sectional analysis of this performance.

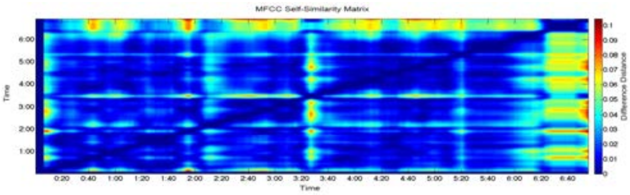

Figure 5. MFCC Self Similarity Matrix

2.2 Is It Successful?

This is clearly, not an in-depth analysis of this piece, as it only touches on a few points, and could be greatly expanded upon through the use of additional computationally-assisted techniques, such as 'companded listening' [20], which might further highlight similarities and differences between the four build-and-release sections. But, the general methodology could be continued if these techniques were to be used. This would produce a narrative description of the events heard during this single performance. These would then be supported by visual aids. Likewise, the exploration of these computationally assisted visual aids would guide future listening.

The question becomes, does this style of analysis have the capability of describing whether this system is sonically ecosystemic? By aurally and visually identifying sound objects, it is not possible to describe the ecosystemic relationships of motifs or sound objects to those that came before or after. It is possible to find perceivable connections between the events, motifs, and lines. However, these connections do not necessarily offer a predictive power or set of rules for what will come next, or how the system will perform in a different physical space. Also, even though some of these sound objects are clearly tones resulting from feedback, it is not possible to say exactly what processes are allowing them to occur, or how they are able to modulate to new frequencies.

These techniques do make it clear that sound objects are related. For example, they have similar timbres, and events that contain similar rhythmic consistency. There are also clearly high-level structures emerging. Finally, there is a set of common frequency tones that can be identified. This analysis, and these observations may help a listener follow the music, and they illuminate the results of the composed interactions. However, as just shown, these descriptions cannot serve as the base to qualify this as a dynamical sonic ecosystem.

3. AN ALTERNATIVE APPROACH

If the traditional EAM analysis technique that favors the acousmatic examination of the recorded score object does not provide the needed information to qualify a work as sonically ecosystemic, then a different approach must be considered. Knowing that composers of this style have privileged the compositional process over the final work, or as stated earlier, they compose interactions as opposed to specific sounds, the analyst might focus on these interactions. This stretches the required skills of the analyst much further than if they were performing a traditional EAM analysis (let alone an analysis of a "tonal" piece). In order to analyze the interactions, the analyst is required to know the technology of the composer [26]. However, this could be considered a similar requirement to that of the analyst of traditional tonal music needing to know the specifics of tonal harmony.

Bown, Eldridge, and McCormack [14] propose the term "Behavioral Object," as a way of describing the electronic modules (be they software or hardware, as in the case of Mumma), that have the potential to exhibit strong musical changes and "become the creative tool of the composer." These objects act equivalently to phrases in a traditional score, even though they do not contain the typical notes and staves. The object, which is represented either through software code, signal flow diagrams, or electronic schematics serves as the record of composition for these interactions [26]. This also serves as a way of breaking an analysis down into a set of organized sections. Which can then be examined individually, or in their relationship to the whole.

3.1 Applied to a Simple System

In a work like Nicolas Collins' *Peasoup* a relatively simple diagram represents the behavioral object [10][1]. An analysis of this module could include the following description:

This system, at its most simplistic, is built around a feedback loop. A microphone signal is passed to a signal processing section and the resulting signal is amplified back into the physical space. The primary interaction of this behavioral object is an automatic audio delay circuit. The time delay is facilitated by a phase shifting hardware unit (or a max patch in later iterations), whose delay amount is a function of an amplitude envelope follower. A limiter serves as a last line of defense against potentially uncontrolled feedback in the system. The automatically controlled delay unit tames any feedback by lengthening the delay length. This interaction occurs in response to amplitude increases of the feedback tone in the space. This change in delay length causes the emergent music to shift in frequency as the delay line lengthens or shortens, thereby emphasizing unique sonic characteristics of the physical space that the system is installed in. This relatively simple piece produces rich music that has the potential to vary wildly throughout a performance and between different performance spaces.

Even though this is a simple system, the previous statements still only serve as a surface level analysis. However, through these short statements, it is possible to fulfill one of the key necessities of Brown's criteria to judge analyses theories. It is evident from the graphic-score that the interface for the *Peasoup* system exists in the physical acoustic realm. Also, this analysis demonstrates the system clearly produces output, which results in further changes to its own state. As feedback frequencies build up, the change in amplitude at the interface (which is the acoustic space of the room) causes the envelope follower to adjust the phase shifter in response. This reaction demonstrates that the system is capable of reacting to its own agents. Finally, even though it is difficult, it would be possible to determine the resonant frequencies of the physical space, based on the architectural properties of the space as a function of the speaker and microphones position. These three points, allow this system to meet the minimum qualifications for a dynamical sonic ecosystem. Which is the primary goal of any theory of ecosystemics.

3.2 Analyzing Schematics as the Score Object

An analysis of a more complex system, such as Di Scipio's *Hörbare Ökosysteme Nr. 3a*, will follow the same style as the *Peasoup* analysis, while borrowing organizational elements of traditional analyses, such as looking at smaller phrases or behavioral objects. First, when possible, it is useful to consider the greater structure of the work before analyzing the details. Di Scipio provides a general schematic of the system in the written score, and description [27][2]. The written portions of the score instruct the microphones to be placed near sources of 'noise', which informs the analyst that the piece is intended to utilize the naturally occurring noise of the physical space. This is clearly re-enforced by the subtitle of the work '*Background Noise Study'* [27]. The description at the bottom of the schematic also confirms one property of an ecosystemic system, by explicitly stating that the system "recirculates" and considers sound from itself. Finally, this schematic informs the analyst that the system is composed of three main modules. Below the schematic of the score are the following written descriptions for these modules: 1. Network of control signals, 2. Audio processing, and 3. Output signal routing. This serves as the 'structure' of the piece. It also mirrors Blackwell and Young's suggestion for a *PfQ* organization of modules [28]. The *P* module handles analysis, in Di Scipio's case, the extraction of control signals. The *Q* is the final synthesis module. The *f module* sits between the two modules managing the flow of data and signals, and organizational decision-making.

After looking at the "larger structure of the piece" and breaking it down into modules, an analyst would start to work through behavioral objects of each module. No order of exploration is necessary, but for clarity sake, it is sometimes best to start with the *P* module. In *Audible Ecosystemics No.3a,* this is the 'Signal Flow 1 (network

[1] See the related Reference for a link to this diagram

[2] Readers are encouraged to retrieve this score and follow along.

of live-generated control signals)' schematic. This example analysis will start at the "background noise input source" side of the chain and following it throughout one of its branching paths. Starting there, the analyst finds the two "input sources", and sees that they are immediately fed through a high pass filter with parameters that are controlled from a control signal "InAmp0". These signals are then combined, before the first 'split' of the signal occurs. This split sends the signal to a delay module and to an integrator. Following the upper 'delay' path, the analyst sees that the signal is delayed by 20". This, as is observed from the second flow chart and the initial score notes, is the same delay length that all audio signals are subjected too before being routed to the signal processing modules. This has the effect of creating standardized memory within the system, and allowing it to be aware of its past and present. Following this delay module, the signal is passed through an 'integrator' module with a time of 0.01" and then an additional 'delay' module, with a delay time of 0.02" and a feedback ratio of 0.99. This has the effect of smoothing the amplitude envelope. This also likely has the effect of accentuating a harmonic spectrum with a base frequency of 100 Hz. Finally this signal is split again and assigned to amplitude variables; *InAmp1,* which is a signal subtracted from the value 1; and *InAmp2,* which is the signal unaffected. These are in addition to *InAmp0,* which was the other side of the initial split from the combined microphone signal; this split represents different behavioral objects. These control signals are now used as information that informs the rest of the system about the state at the interface (physical room). These control signals are used to control the cut-off scale of a high-pass filter that the microphone signal passes through. These are also used to control the output level of the system, creating an inverse relationship between the amplitude in the room and the systems own output gain.

These control signals assist the system in filtering the majority of the room's sound out. In effect, the majority of the audio signal is consumed during the control signal analysis and processing stages, leaving only traces and background noise for the signal processing and synthesis modules.

3.3 What Does This Mean?

This analysis shows how the audio signal can be affected by future energy in the system that becomes control signals. This also demonstrates the recursive nature of these functions, via the room as interface. Sound that makes it out of the loudspeakers is picked back up by the microphones, and ran through the same process again. This gives a glimpse at the highly interconnected, and self-reliant nature of a dynamical sonic ecosystem.

Between these two pieces alone, it is not possible to begin to define concepts and law-like properties of a theory of ecosystemics. However, there are ideas starting to emerge. For example, the inverse amplitude relationship is clearly an important element of this type of system. Both of the discussed systems are responsive to tracked amplitude levels at the input of the interface. In Collins' work louder amplitudes cause the delay time to lengthen, thereby disrupting the current feedback cycles and taming the potentially large amplitude build-ups in the room. Likewise, in Di Scipio's system, a direct inverse relationship is created between tracked amplitude and audio signal scalar values throughout the audio signal-processing module. This idea will likely become a procedure, just as there are procedures for proper voice leading in four-part chorales belonging to the 'functionally tonal' style.

4. DISCUSSION

The analysis techniques that address the 'composed interactions' of the system more closely meet Brown's primary criteria, if the goal is altered and applied to *dynamical sonic ecosystems*. An analyst is more capable of qualifying a system as 'ecosystemic' when analyzing the interactions via graphical-score objects[3], instead of holding the sound-score object as the primary source. This technique moves towards Brown's six criteria for evaluating a theory. It easily meets the first three, but does falter in the latte set.

1. Accuracy
   This system for analysis is accurate, providing explanations of how a process occurs. Once more of the ecosystemic based canon is analyzed and compared, there should be law-like properties and procedures that emerge, allowing the analyst greater predictive power over how a system is composed. This will also render better predictions for the sonic outcomes that can be expected.

2. Scope – "Just as we want our theories to be as accurate as possible, we also put a premium on their breadth of coverage" [1].
   The scope of the current analysis technique is currently presented as appropriate for only this particular subset style of interactive performance systems. However, much like other music theory systems, this approach is applicable as an analysis tool for other electroacoustic music and interactive performance systems. These techniques would be as equally powerful in better understanding pitch-driven interactive performance systems and generative music systems.

3. Fruitfulness
   Compared to the analysis of the sound object alone, this technique is able to describe the system in greater depth and provide better predictions for the musical outcome. Likewise, by analyzing the algorithms, and schematics of the work the analyst is able to examine all aspects of the piece, not just a "smattering of special cases."

[3] Ideally this would also include a detailed analysis of the code, which represents another level of the graphical-score object.

4-6. Consistency, simplicity and coherence

This is where the system falls quite short at the moment. This is primarily due to its lack of output and maturity. There is no standard terminology yet for analyzing a dynamical sonic ecosystem. This makes it inconsistent from analysis to analysis and even between analyses of modules within a single sonic ecosystem. This lack of consistency also clearly indicates that the analysis system has not matured to a state of simplicity. Likewise, it is not coherent with other forms of analysis techniques and will take time to prove its validity as an acceptable approach.

The needed refinements and consistency of the analysis system will grow with time and as published analyses of dynamical sonic ecosystems start to occur. As mentioned, others have written about the need to approach the analysis of this style of music with different techniques than are appropriate for other style of EAM or classical music [7, 25]. In the mean time, this author intends to consider and start applying a consistent language to any analyses of these ecosystems, whether composed by the author or others. As with most discussions of EAM works, this language will initially come from other fields, being adapted as necessary for the task at hand. In particular though, it would seem the field of music cognition, specifically the study of anticipation [29], will start to prove a useful mine of ideas and language. By describing the composed relationships in-terms of anticipation or more broadly, cognition, the analyst may be capable of identifying a common composed reaction between multiple pieces more easily. Considering that these systems also aim to reach states of stasis and transition between all of the interconnected elements within the ecosystem, it seems as though the language we use to describe similar states between people or nature may prove insightful for analysis techniques.

5. CONCLUSION

There has been a lot of interest in controlled feedback loops since the start of the electroacoustic music revolution. This rather simple phenomenon has proven fruitful for many composers wanting to exploit interconnected sound systems. This eventually led composers to create more complex, controlled systems, where they are interested in the compositional process more than the specifics of the final sounds. Ultimately this leads to the stated and explicit shift towards composing interactions. No standard analysis approach yet exists for this style of composition. The two analysis systems described above are both useful. However, only the analysis of the interactions themselves, via a graphical-score object, allows the analyst to qualify a work as ecosystemic. It would seem that this is not too different from the techniques of traditional functionally tonal music analysis. In that setting, the analyst examines the relationships, and interactions of specific voices to each other over time. In the case of ecosystemics, the analyst considers the relationships and interactions of agents within the system.

It is not the goal of this paper to suggest that the process of analyzing EAM works via a recording that is serving as the sound-object score is fruitless. In fact, that technique can provide useful information for listeners of these works. It also can assist the analyst in identifying the possible sonic traces of the interaction s/he identifies through an interaction-based analysis.

This system for describing interactions needs much more refinement. There is no standard way of describing interactions, with analysts resorting to hyperbole, synonyms, and comparison. However, it does provide a way of analyzing music that has not left a traditional score and does not fit in to the traditional sound object based EAM analysis approach. By finding a common language to describe the composed relationships of dynamical sonic ecosystems, the analyst will begin to have the information to better compare similar works and define the tropes that are common within the style. Ultimately this will lead to an ability to easily classify a work as 'ecosystemic'. This will also allow for a broader acceptance of this style among academics, musicians, and artists by given them a common language with which to discuss these works.

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