COMBINING SOUND- AND PITCH-BASED NOTATION FOR TEACHING AND COMPOSITION

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ABSTRACT

My research is concerned with finding a common notation for pitch-based, sound-based and spatialized music in an attempt to bridge the gap between acoustic and electronic music, also working towards the possibility of a holistic system for algorithmic composition based on music representation. This paper describes the first step towards this goal, focusing on the combination of pitch-based and sound-based musical structures, introducing a graphical notation system that combines traditional music notation with electroacoustic music analysis notation. I present how this was tested in practice in a case study within the framework of composition education at the Royal College of Music in Stockholm, where composition students were working with, and reacting to, the system.

1. INTRODUCTION

As a teacher of composition I have noticed that students often feel they need to take sides with regard to electronic and acoustic music despite encouragement to work in both fields—you're either a studio composer or a score composer. Being a composer of both acoustic and electronic music I believe this to be an unnecessary side effect of the difference in craft and music theory surrounding the two sound worlds—it has little to do with the creative talents of the composers or the possibilities of expression in the media themselves. More serious than the problem of students' aesthetic identity is how this difference in music theory makes combining acoustic and electronic sound sources difficult on a compositional level, part of the reason being that their music theories use different systems to express the same thing, e.g. frequency values and note names. However, translating individual frequencies into note names is easily done, as long as microtonality is considered. The main problem lies in the representation of non-pitched sounds—an important part of electroacoustic music expression. Granted, there is a rich tradition of non-pitch-based music in classical music too, starting with Varèse's *Ionisation* [1] which ranks among the first pieces for percussion ensemble alone in the Western art music tradition, reaching a milestone in Lachenmann's *musique concrète instrumentale* as expressed in *Pression for One Cellist* [2] where the idea of extended instrument techniques is taken to the extreme. However, the notation for this music, particularly in the case of Lachenmann, has little to do with the representation of sound but rather deals with the representation of actions resulting in sound. One strength of traditional staff-based music notation, beside its widespread use, is its double nature both as a means for describing pitch-based musical structures and for prescribing musical performance. Without this feature, traditional ear training would not be possible. Also, the most fundamental aspects of traditional pitch-based notation can be converted into MIDI data, making possible algorithmic composition with pitch-based instruments in mind. For non-pitched sounds, the notation of instrumental works tends to rely on tailor-made solutions such as written instructions or drawings of hands and objects over instrument bodies. Electroacoustic Music representation on the other hand tends to focus on timbre and sound classification, often loosing detail with regard to individual pitches despite Denis Smalley's remarks on the importance of intervals when pitches are present [3]. By combining electroacoustic music analysis notation with traditional notation of pitch, also introducing space as a parameter—another important aspect of electroacoustic music—I aim to bridge the gap between these different sound worlds, also making a new kind of algorithmic composition possible, where pitch-based, sound-based and spatialized music can be visualized, simulated and/or generated using sound synthesis and/or sample banks of concrete sounds.

2. BACKGROUND

Despite the genre's relative youth, electroacoustic music representation has already a long history beginning with Pierre Schaeffer's initial research into the description and classification of sound objects [4], followed by Denis Smalley's theories of Spectromorphology [3], introducing a framework for describing sound in transformation as well as spatialized sound. Lasse Thoresen, assisted by Andreas Hedman, builds on these ideas in *Spectromorphological Analysis of Sound Objects* [5] where they provide a well-developed notation system for the analysis of music as heard. In Pierre Couprie's overview of algorithms and digital technologies in music notation [6] we get a sense of the multitude of notation systems now available, all with different purposes, such as algorithmic notation, interactive notation etc. Some systems expand traditional notation

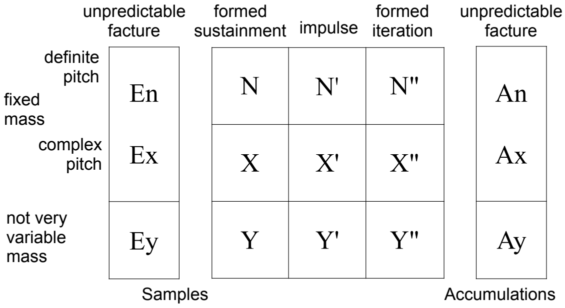

Figure 1. From a larger set of categories in Schaeffer's TARTYP [4], Thoresen and Hedman keep these categories and adapt them for graphic notation analysis [5].

while others look for completely new ways of communicating musical ideas. At the heart of most new systems of representation are their relations to artistic problems, such as the need to communicate with music-reading musicians over a network, or the need to communicate the structure of the spatialization of a piece. The artistic problem addressed in this paper is the problem of having two completely different sets of music theory for working towards the same kinds of concepts depending on whether there are electronic sounds present or not. Beside causing artistic problems, the music theory discrepancy described here also has an effect on how the same subject is taught to composers of different genres. The best example is ear training where traditional teaching relates sound to traditional notation while sound-based ear-training borrows from the audio engineering field, focusing on frequencies and measured amplitudes. That being said, there is a fundamental difference between a tone and noise so the challenge is to find a way for both to co-exist within one and the same system where the important aspects of both types of sound are taken into consideration.

3. THE NOTATION SYSTEM

Thoresen, assisted by Hedman, builds his analysis system on sound classification categories listed in Schaeffer's TARTYP table [4], with the starting point in the balanced micro object categories N, X, and Y, as well as the extreme macro-object categories, E and A (see Figure 1), providing notation symbols as well as several additional notation features to describe sounds in great detail. Thoresen with Hedman have renamed and adapted Schaeffer's categories for use with graphic notation and have created new intermediary categories to complete the system. One such category is the *dystonic* sound, a category between pitched and complex sounds (Schaeffer's N and X [4]) to denote clusters and inharmonic spectra. See Thoresen's and Hedman's article [5] for a concise description of their notation system.

For my first prototype of the notation system for pitch, sound and space I place Thoresen's and Hedman's symbols, slightly modified, over a fixed frequency grid, in this case a traditional staff-system, adding indicators for spatialization, notated with circles above the system. As with pitch, durations were also notated with traditional symbols. (see Figure 3). The basic changes to their system at this point had to do with taking advantage of the possibilities of indicating spectral information with fixed values, e.g. instead of showing spectral width with symbol indicators, I introduce the possibility to indicate the frequency range of a spectrum using a dashed vertical line with an arrow that clearly indicates the spectral space occupied by the sound, the arrows pointing towards tendencies of change in spectral width (see Figure 3). Beside minor changes to the notation itself, it was necessary to re-think the notation as symbols of actual measurable sound rather than phenomenological descriptions of a listening experience. One initial problem related to this was deciding exactly where to place the sound object symbols on the staves. For pitched sounds there's no reason to deviate from common practice of placing the symbol at its root frequency, but how about inharmonic sounds and noise?

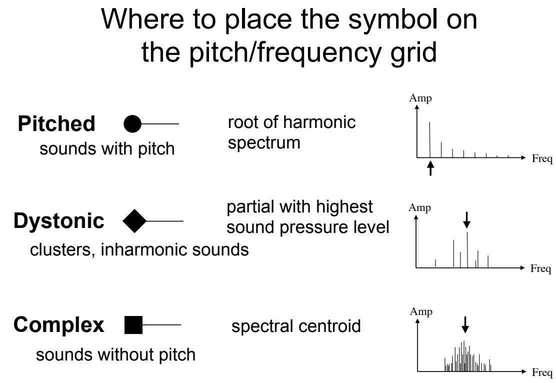

Figure 2. An image presented to the students to show the strategies for deciding at what pitch/frequency to place the symbol for the different kinds of sounds.

Figure 2 shows my solution to this problem with regard to the three basic sound spectrum categories. As in Thoresen's and Hedman's notation system for analysis [5], I encourage indicating additional partials or other sound components that are important for the identity of a sound. For the first prototype of the notation system I suggested a very simple indicator of spatialization where a sound's duration is indicated in the fashion of ambisonics 3D-panning software with two circles—one top view and one front view as can be seen in Figure 3. This was because we would not work specifically with spatialized sound for the course where I first tried the system, as explained below.

4. CASE STUDY

4.1 Introduction

For several years composition students at the Royal College of Music in Stockholm have been exposed to Lasse Thoresen's and Hedman's spectromorphological analysis notation [5] with the aim of bringing awareness to timbral structures in other works as well as their own. The course module, simply called *Sonology* and part of the

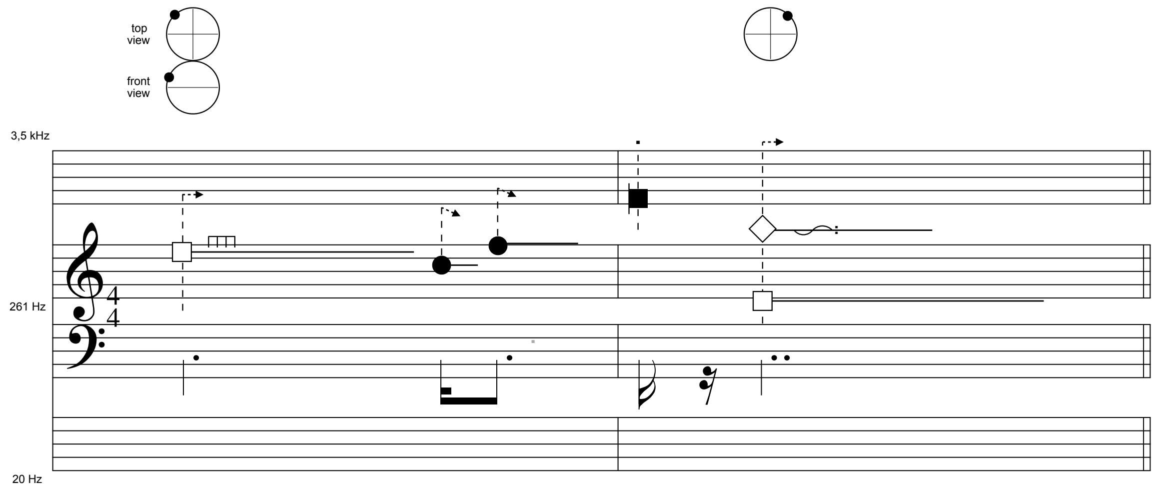

Figure 3. A notation example to demonstrate the combination of sound-based notation, traditional staff-systems to indicate pitch, and ambisonics-style indicators of spatialization above.

course *Sonology and Studio Technology* [7], introduces basic ideas from Schaeffer's typo-morphology [4] before introducing Thoresen's and Hedman's development of Schaeffer's ideas and how this is expressed as symbolic notation. The students work with both analysis and composition. This year, I introduced the ideas described here, providing the students with a new system where spectromorphological analysis notation symbols are placed over a fixed frequency grid. With the students' written consent, I let the course module form a case study where I could try out the functionality of the notation. Due to the course's overall focus on sonology and basic studio technology I decided to limit the study to electroacoustic music work, leaving the inclusion of acoustic instrument performance for the next stage of my research. What I hoped to learn from the study was:

- If there could be agreement in interpretation of the symbols
- A sense of the notation system's intelligibility—if there were aspects of the notation system that were particularly hard to grasp
- Whether problems occur when analysis notation is placed over a fixed frequency grid
- Whether problems occur when new symbols are combined with traditional notation
- A sense of the artistic relevance of working with this system of representation for composition

4.2 Participants

Seven students (4F, 3M; average age 27.7, SD = 6.9) attending the course agreed to participate in the study. They were all Swedish citizens. All participants were composition students at the bachelor level, familiar with traditional music notation, while none of them had worked with aural sonology notation before.

4.3 Method

The process for the case study was as follows:

1. Construct a notation system prototype that would qualify to meet the demands of the course module in aural sonology [7] while introducing the concepts mentioned above, with the exception of spatialization
2. Have composition students realize a given score using this notation also reflecting over their experience
3. Make initial improvements to the notation system based on initial feedback as well as my own teaching experience
4. Have composition students create and realize a short score of their own, using this notation, also providing a written reflection of their experience
5. Evaluate the study

The students' reflections from the first notation assignment were given verbally from the time of the assignment to its presentation and any new input with regard to the functionality of the notation was noted and eventually documented. The final assignment had a required written reflection. This division was practical since the students' initial questions with regard to the notation emerged gradually as they grew more familiar with the system.

There were no particular restrictions regarding the tools and/or technology used for the course module assignments. We listened to, and discussed the assignments together in a studio for electroacoustic music. For their own notation, I provided a pdf with empty staff-systems with clefs and a frequency scale on the left side. I instructed the students that they could print the pdf and write by hand, use it as background in graphics software, or construct an equivalent staff-systems in a notation software of their choice. Regardless of these choices they were required to hand in the finished scores in digital form.

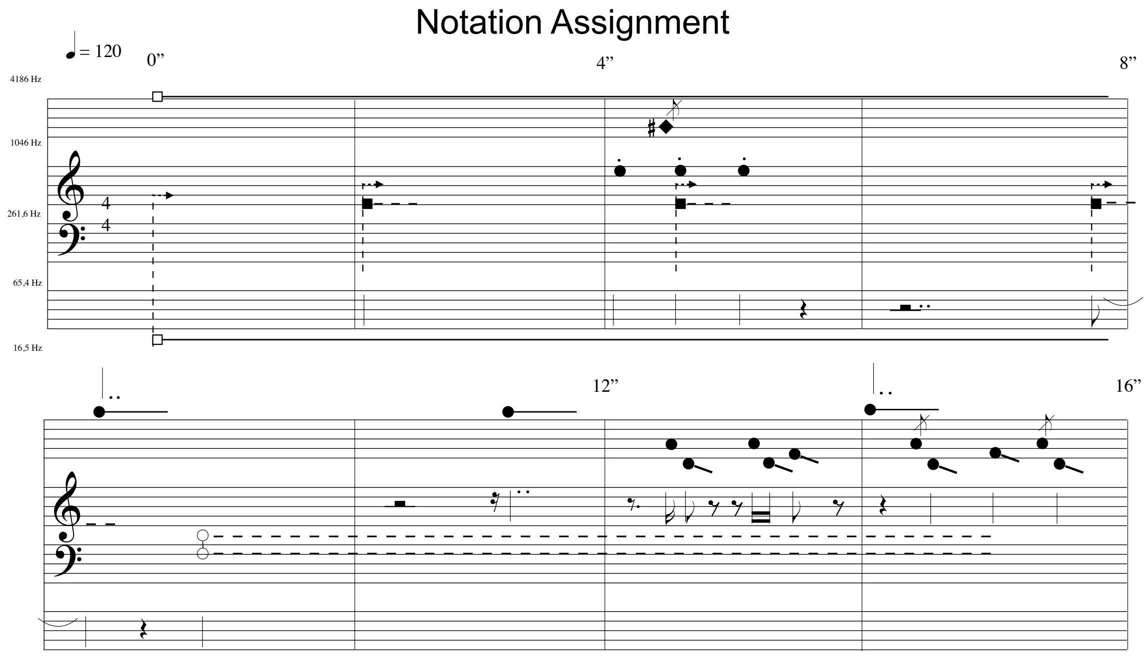

Figure 4. The score of the first notation assignment, which all students individually were asked to realize, using concrete sounds.

4.4 First Notation Assignment and Feedback

Because of the underlying idea of exploring artistic relevance, the first notation assignment was based on a short electroacoustic composition I made with a combination of electronic and concrete sound material, starting with buzzing electronic noises and ending with the characteristic sounds of seagulls (see Figure 4—the audio file can be accessed at *https://kmhsweden.box.com/v/tenor2018*). I created a score from this short composition and presented it to the students without playing the original composition. Incidentally, the original composition contained additional sounding details that I chose not to include in the score so as not to unnecessarily complicate the assignment. For the notation of time, I used a combination of traditional symbols in tempo 60, and time indicators in seconds, placed over the score. While note stems indicate durations, extension lines were necessary to show modes of energy articulation. Each student was given the task of realizing the score, using only concrete sounds—this was important in order to avoid the assignments becoming archetypal translations of the notation symbols i.e. using noise generators for complex sounds and pure oscillators for pitched sounds. I wanted artistic interpretations, not simulations of the score. Also, in not allowing synthesis, they had to listen to the sounds around them and reflect on their possible connections to the notation symbols at hand. However, I allowed transposition and filtering of the concrete sounds—it would otherwise have been difficult to meet the demands of the sound objects' positions in the frequency space. Upon hearing the sounding results of the students' assignments I got the sense of hearing different interpretation of the same piece. Because of the freedom in selecting sounds and the lack of indication of dynamics, the interpretations were quite different, but the shared structure with regard to sound objects and their spectral contents and placements in time, made for a relatively coherent collection of pieces. The questions and/or problems that arose as a result of the first notation assignment, can be divided into four categories:

1. The concept of classifying sounds and their energy articulation
2. New symbols combined with traditional notation
3. Conflicting information within the new notation system
4. Musical features missing in the notation system

The first category was expected and is something I face every year when introducing the concept of aural sonology to composers not yet familiar with this way of categorizing and describing sound. Particularly the concept of energy articulation and *facture*—the combined experience of energy over time—can be hard to grasp for someone used to traditional notation. But even basic understanding of what complex, non-pitch-based sounds are and how they behave can't be taken for granted. That being said, much of the confusion expressed with regard to understanding the score (Figure 4) could be related to the second category, that traditional music notation was combined with new notation. While the traditional notation of rhythm was helpful in describing the rhythmic sounds of seagulls, its placement inside the staff system made it at times confusing, particularly quarter notes whose stems could be mistaken for a new sonology notation feature. Another issue was how to make sense of non-pitched sounds placed over a traditional staff system. The most frequently misunderstood sound object was the interval of two pitched notes with iterated energy articulation starting in bar five and continuing to the end. This confusion emanated from the third category—conflicting information in the notation system. In the notation compendium that I distributed with the assignment there were summaries of Thoresen's and Hedman's sound categories which were not compatible with my instructions for how to combine symbols on the musical grid. The fourth and last category concerns elements missing in the score and these questions were raised particularly with regard to dynamics. Naturally the lack of dynamic indicators in the assignment's notation led to the greatest variations overall in the interpretations of the score. During the presentation of the assignments in class we discussed different solutions for this.

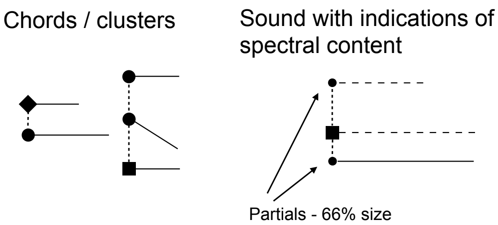

Figure 5. Example of one modification to the notation system following the discussion after the first assignment—using smaller note heads to indicate when a sound component functions as a partial in another sound's spectrum.

4.5 Modifications

Some of the problems mentioned needed to, and could be, addressed immediately. Therefore, I made some clarifications and modifications to the notation for the second assignment:

- Use small note heads (66% of original size) to specify when symbols are partials to a main sound rather than equal chord/cluster components (see Figure 5).
- Use the same dashed vertical line for indicating spectral width and for connecting partials/chord notes
- When combining indicators of spectral width and traditional notation of time, place rhythmic information on separate single staff lines to avoid confusion.
- A more detailed frequency scale is placed next to the clefs to help with placing non-pitched sounds and their spectral width on the staff-system—this was practical since most students relied on software spectral analyzers to discover the bandwidths of their non-pitched sounds.

Figure 6 shows what the first four bars of the first notation assignment would look like with these changes in place.

4.6 Second Assignment and Feedback

For the second assignment the students were asked to create and realize a short score of their own with a total duration of 30 seconds, again using concrete sounds. The score had to include at least seven unique sound objects. The assignment also included providing the individual sound objects as separate sound files, and a written reflection detailing their process. I provided a pdf with empty staff-systems with frequency indications for the students to use with their computers or for writing by hand. There were less questions and problems addressed following the second assignment. Already as the assignment was given, students expressed how having control of the notation in this assignment rather than working with a predefined score, made their task easier. The problems that were addressed by the students following the presentations of the second notation assignment can be summarized as follows:

1. Introducing spectral information and non-pitch based sound to traditional staff-systems takes time to get used to
2. Few chose to write their notation before creating the music—it was easier to think of the system in terms of analysis
3. Notation of dynamics continued to be an important issue
4. It was hard to make room for all symbols on one four-staff system

The first category was expected. The second doesn't surprise me either—it was easier to make the music first and then notate the music. This way of composing, starting with the sounds themselves is common for works of musique concrète, being discussed by Schaeffer at an early stage of the genre's development [8]. Some provided new ideas for the notation of dynamics, varying the sizes of sound symbols or their extension lines. Many expressed difficulties in getting all the notation symbols into one single four-staff system, as if this had been a requirement for the assignment. This is understandable considering that the score I produced for their previous assignment had all symbols on one system. Indeed, for analysis and composition overview purposes having all sound objects sharing a system is convenient, in the same way as a piano reduction is practical to get an overview of an orchestral work. But I realized that in shaping the previous assignment in this way, I had myself used a descriptive approach to the notation symbols despite the assignment's explicit goal to explore the notation's prescriptive potential. It would have made sense to give them a score with the musical layers divided between different staff-groups as shown in the modified example of the first notation assignment (see Figure 6).

4.7 Case Study Conclusions

Comparing this study to previous runs of the sonology course module, the fixed frequency grid made the task more difficult for the students because they had to learn how to analyze sounds and extract their spectral information, though this is highly accessible these days thanks to analyzers and sonogram possibilities in open source software. On the other hand, by grounding their work in real measurable sound, their work was easier to assess—the

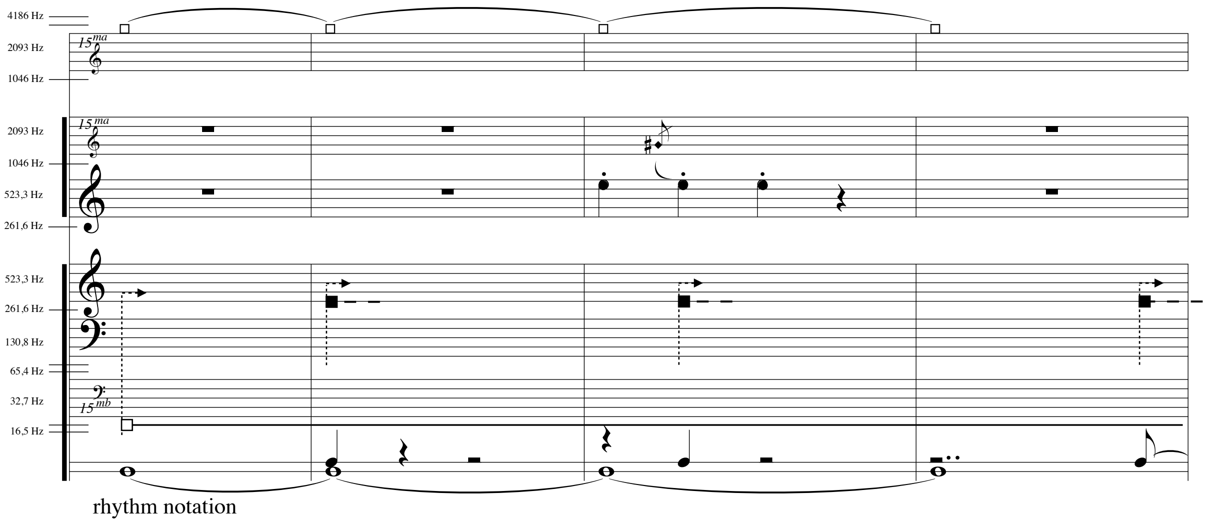

Figure 6. The first four bars of the first notation assignment with modifications following the feedback from the students.

symbols they put on their music staves had a real and measurable counterpart in sound. While proving a difficult task, working with combinations of complex, pitched and dystonic sounds as described here was not impossible for any of the students participating in the study. They all provided good work both in terms of artistic output and notational accuracy. I also found that by having them take part in the assessment of the system itself there was a sense of ownership of the notational language that made some students very active in discussing the functionality and possibilities of the system. Since this course module will run again, I will gradually gather more data with regard to the possibilities and challenges surrounding the usefulness of this system for composing and teaching. While my, perhaps utopian, research objectives raise fundamental questions regarding the nature of music notation, I hope that the pragmatic method described here will begin to show both the possibilities and the limitations of my approach to achieving these goals.

5. FUTURE WORK

When I will adapt the system for our electroacoustic music ear training course module, I will introduce a further developed notation for representing space. Here I will look with interest at the development of the Spatialization Symbolic Music Notation at ICST [9]. This notation system for spatialization already addresses another area I'm aiming towards in the near future, algorithmic composition, by introducing the possibility of moving between written symbols and data.

Also planned is a composition of my own for violin and electronics using the notation system for algorithmic composition, which will require transferring the graphical symbols into the digital realm. I will also work with a collaborative project where live-electronic instruments are explored and mapped using this notation in order to make them available for new ways of composing. Provided that these various tests prove to be fruitful, I imagine that a holistic system of representation as described here, that builds on acoustic music composers' and electroacoustic music composers' prior knowledge in their respective fields could be useful both for composition and teaching, doing its part to bridge the gap between the two sound worlds.

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