A strata-based approach to discussing artistic data sonification

Khosravi Mardakheh, Milad; Wilson, Scott

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A Strata-based Approach to Discussing Artistic Data Sonification

- Milad Khosravi Mardakheh (composer, researcher), University of Birmingham, Department of Music, Edgbaston, Birmingham, B15 2TT, UK. Email: <milad.mardakheh@gmail.com>. ORCID: 0000-0001-9819-1623.
- Dr. Scott Wilson (composer, sound-artist, researcher), University of Birmingham, Department of Music, Edgbaston, Birmingham, B15 2TT, UK. Email: <s.d.wilson@bham.ac.uk>. ORCID: 0000-0003-3510-4240.

Abstract

Much discussion surrounding data sonification for musical and artistic purposes focuses on seeming contradictions that arise from the ways in which this practice differs from that of data sonification as a scientific tool. Over the past 30 years, this debate has become a rabbit hole of questions and arguments regarding the nature of music/sound-art and data sonification, and of their relationships with one another. In the following article, the authors identify three areas/classifications of artistic sonification, using a "strata" metaphor with the hope of bringing clarity to this discussion, as well as enabling reflection on the nature of science-art collaborations using this approach.

Overview

Data sonification involves the use of nonspeech audio to convey information. It is defined in the *Sonification Handbook* as a "subset" of auditory displays ; a process by which "relations within the data are transformed into perceived relations in an acoustic signal for the purpose of facilitating communication or interpretation". Contrary to visual displays, e.g. graphs, charts, etc., "an auditory display can be broadly defined as any display that uses sound to communicate information" (as opposed to visual elements) [1]. Data sonification also includes applications in the arts.

In the artistic domain are an abundance of works utilizing data sonification, including musical compositions and performances (within both electroacoustic and instrumental music genres);

in-gallery multimedia installations; online new media and sound-art works; and interactive interfaces. As such it can be understood as both a tool and a practice. As mentioned, the artistic use of sonification has given rise to debate regarding whether and how to delineate between the scientific and the musical and artistic aspects of this practice, particularly in collaborations, and how and when they might overlap.

To address this, we have outlined three types of artistic sonification, which serve as broad classifications. These are not orthogonal but rather *cumulative*, and works can simultaneously employ multiple characteristics at once. We propose a strata-based metaphor, in which each category rests upon and assumes the presence of the "lower" ones. With that in mind, our identified layers are indicated in Figure 1 below:

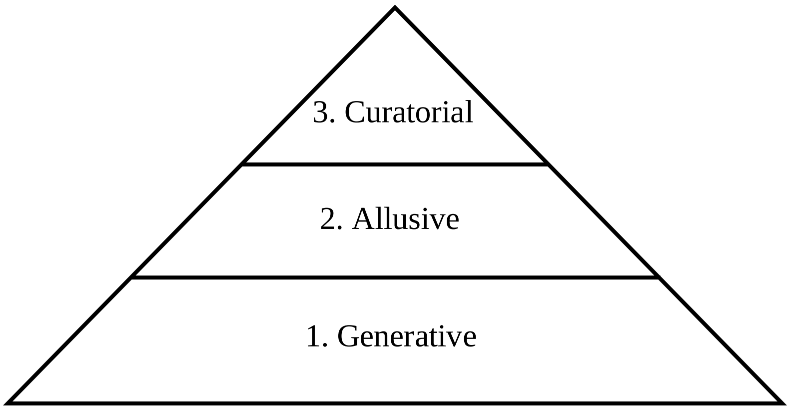

Figure 1. Strata layers

Layer 1: Generative

One attempt to resolve the difficulties in discussing artistic versus scientific sonification has been through alternate terminologies, such as *Data Music* or *Data-driven Music* [2,3]. This makes sense insofar as it designates and validates the use of data sonification as a purely generative tool. Such uses fit within the definition of our lowest layer. Here, we consider "generative" as primarily connoting the intention to create novel musical or sonic material that might otherwise be difficult or impossible to create or arrive at manually. This includes results---consequently---outside of "composerly" intention, or those that embrace aspects of indeterminacy in their creation.

With *generative* sonification, the context behind the data is not significant to the artist (or by extension perhaps the audience). The questions "What is the source data set?" and "Why is the use of it particularly important?" are not matters of interest. The data is purely a means to an end and *could* in fact be random, manufactured, or invalid from a scientific standpoint. This is conceivably akin to some uses of serial/post-serial procedures in instrumental composition – in which sequences of pitches are treated to various pre-defined transformations, or the use of chance operations; both can involve the use of algorithmic techniques *without regard for the nature of the input or its context*. John Cage, György Ligeti, Per Nørgård, and others have employed forms of algorithmic generation of musical events in their works, which might in some cases be understood as a *type* of sonification using instrumental/vocal resources [4]. This analogy is not perfect, however, since some such procedures have no input (which sonification has by definition), or have input that is strictly given (e.g. the integers of Nørgård's infinity series). From a strictly technical standpoint, sonification does occur, but not because of direct mapping between the data and sonic domains, or first-order sonification (to apply American composer, performer, and educator Scot Gresham-Lancaster's terminology); and only as a secondary and more trivial means in the output (Gresham-Lancaster's "second-order" sonification) [5].

It is worth noting that the use of the term *data sonification,* without further explication, could appear as a sort of superficial "label" [6] that might add a veneer of scientific gravitas to the work in question, which may well be a successful and effective musical composition. One example might be Alvin Lucier's *Music for Solo Performer*, which is often cited as an early example of data sonification. In this case, alpha waves generated by Lucier's brain are captured using electrodes attached to his head and then sonified by percussion instruments that are electromechanically excited to produce sound during the performance. The piece also draws on the informal suggestions of the text score (a set of textual instructions for realization), and the musical intuition of other performers involved (though "for solo performer," sound is often freely routed to different percussion instruments by another performer). As musicologist and composer Volker Straebel and artist Wilm Thoben point out:

> *Music for Solo Performer* is by no means a scientific setup where brain waves are automatically transformed into percussion sounds, but an artistic situation that asks for musically sensitive performers and assistants. The iconic image of a soloist performing motionlessly and relying only on brain waves to control percussion instruments is an artistic creation by the composer, not the technical reality of the piece [7].

Therefore, we can consider this work's use of data sonification as substantively *generative*, as it is in essence a system for removing composerly control, intent, and expression in the manner typical of much post-Cageian experimental music, and not "about" brainwaves and their characteristics. We should also consider a layer of *allusive* sonification here. Although the piece is not "about" brainwaves, it does draw the listener's attention to the role of alpha waves in its realization.

In a strict sense, *generative* sonification can even involve the transformation of data into sound without any regard for the distinction between the data itself and any "noise" or framing thereby encoded, i.e. both the signal and the noise are holistically and unbiasedly transformed into sound. This may also imply very straightforward mappings (such as each individual datapoint to an individual audio sample) with no scaling. *The Sonification Handbook* suggests the term "audification" for this straightforward approach [8], but this term is not always consistently applied. Audification can be implemented using software such as Audacity® [9], which allows the binary data in any file to be reinterpreted as audio data. In such a case of audification, there may not even be a direct data point-to-sample correlation, e.g. one might interpret three 8-bit data points as a 24-bit integer sample. Thus, any audible structure or features produced may be unintended. Some examples of this procedure can be considered a practice of sonifying file formats since header data and the internal structure of the file will both contribute to the result.

This area of strict *generative* sonification could be considered more theoretical or experimental than practical, although the results can be understood as art. Carsten Nicolai's *Unitxt Code (Data to AIFF)* is one example where files produced by various applications (Enigma, HyperEngine, Word, PowerPoint, Excel, etc.) are directly sonified and collaged as a 7-minute-long composition [10]. But even in this case, questions regarding artistic choices, such as the file selection, the order sonifications are organized, and the sonification time, are relevant to the result.

Another example is Scott Wilson's *Media Bites* (part of the large-scale sonification work *Müllmusik*), where every byte of a series of images relating to the rise of the year 2000 Second Palestinian Intifada is sonified and used in the composition alongside audio quotes and other Intifada-related source material. Different encodings of the same images are used, thus contrasting the difference between file formats (though this is not explicitly clear to the listener). As the work includes overtly contextual elements, this is an example of both *generative* and also *allusive* sonification (see Layer 2: Allusive), since the narrative elements allude to the context of the data domain, i.e. the context of the images [11].

Layer 2: Allusive

Moving past layer 1, we now consider the possibility of a bridge between the worlds of science and art, or data and creative work. Such a bridge can function as a popularizing device that transforms complex, esoteric scientific information into a more accessible artistic domain that appeals to sensory and emotional experiences. This is what gives sonification its appeal and may be why it has become a common tool in artistic and scientific collaborations. “When successful, a sonification in the form of abstract numeration creates something tangible, a direct experience of the sonification of that data” [12]. Alexandra Supper, who grounds her work in the aesthetic sublime as discussed by Immanuel Kant and Edmund Burke, considers the appeal a result of the evocation of a sublime feeling or effect. This feeling can be attributed to some level of familiarity with, or knowledge of the science behind, the data being sonified, i.e. the *auditory sublime* [13]. Allusions to the Kantian sublime aside, we would argue that the sonification of abstract data, through its “tangible experience,” creates a situation in which an empirically inconceivable or inaccessible phenomenon can become somehow more comprehensible, or at least “experienceable” to the listener. This can function as the application of reason through analogical means, aiding the understanding and experience of complex scientific phenomena, by means of an alternate medium and perspective. Therefore, we can consider some prior knowledge of the source data and/or its context (or a way of acquiring it as part of the sonification experience, e.g. technical or program notes) to be crucial in achieving this outcome. If such contextual information is absent, the resulting sonification will be experienced as arbitrary, or *generative*.

Allusive sonification is predominantly an artistic tool, one used for creating art as opposed to auditory displays, and thus does not aim to convey important implications or salient aspects of the source data set through sound. In *allusive* sonification, it is important that the audience understands the source of the data, even if it is not clear exactly how they are ‘hearing’ it. The resultant sound comes to connote the source of the data set, enriching the audience’s experience through allusion to a meaningful context. *Allusive* sonification may also entail consideration of the nature, meaning or context of the source data in making choices about mapping or other aspects of the realization.

Let us now consider some examples: Carla Scaletti used particle collision data from experiments conducted using the Large Hadron Collider (LHC) at European Council for Nuclear Research (CERN) to compose music for a dance piece called *QUANTUM* [14]. The work's inspiration and aesthetic directives derive from the data set used and its context. While the sound material is generated by mapping collision data parameters to sound synthesis parameters, certain compositional strategies, such as circular panning gestures or motion, immediately invoke a sense of "spin" and "acceleration" relevant to the LHC and particle collision experiments. "What the piece is about" (its context)---the significance of which is also reflected in the work's title---is bound to what the data is "about." Other elements of the work, e.g. choreography, lighting, and set design [15], are also inspired by particle collision experiments.

Similarly, the *Dark Matter* project by the Birmingham Ensemble for Electroacoustic Research (BEER) uses particle collision data in improvised sonifications within the medium of live coding [16]. The context of the underlying data influenced both the sonification design and the utilization of material produced in the composition and performance of the work. One consideration that BEER has adopted is ignoring the order of individual particle collisions in the data stream they use, as subsequent collision events are unrelated, and their ordering---although tempting to reflect in music as a time-based medium---is meaningless. This creates flexibility that complements the improvisor's freedom of choice. More broadly, the LHC project serves as an inspiration for *Dark Matter*; it is *about* the project in the same sense that music can allude to any subject through diverse means of explication, as well as implicitly through context. Metaphorically, the search for "new physics" is mirrored in the performers' exploration of the musical potential of vast data sets.

In *allusive* sonification, the contextual and semantic concepts relating to the source data are *alluded to* in a composerly manner, making use of artistic tools such as abstraction, analogy or metaphor, dramatization, juxtaposition, superimposition, etc. The result is a work of art, not an auditory display. *Allusive* sonification can delineate where the practical and conceptual tools of art- and music-making meet the intricacies and technicalities of the science, "collaborating" to bring into existence a novel artistic expression that carries with it additional conceptual weight.

Layer 3: Curatorial

The goal of *curatorial* sonification is to accurately convey certain salient features of the data to the listener through sound in a meaningful way so that they are understood, i.e. to create auditory displays. Analogous to data visualization, such as a graph, the information represented is selected, filtered, and focused upon by the designer, disregarding what may be uninteresting or considered noise, making it *curated* for the viewer. The parameter-mapping sonifications of particle collision data produced by Lily Asquith at CERN [17] or Mark Ballora's (et al.) numerous sonification projects such as "Heart Rate Sonification" [18] and "Sonification of Web Log Data" [19], are examples of such an approach.

It is noteworthy that in *curatorial* sonification, artistic design is still very much in play. This is reflected in the design of auditory displays that consider certain aesthetic and musical factors, not only to make the experience more sonically pleasant for practitioners but also to enhance communication, i.e. careful application of aesthetic choices can highlight the salient aspects of data or emphasize to the audience what is important about it. This characteristic can also be observed in data visualizations designed in a visually appealing manner while remaining accurate and reliable. David McCandless's visualizations at *informationisbeautiful.net* provide examples of the latter in which good design results in curated, meaningful, and aesthetically pleasing presentations of complex information [20]. Aspects of this design serve to draw viewers' attention to important features by engaging their imagination, aesthetic senses, and reason.

As for sonification, Lily Asquith makes the claim that (at least from a poietic point of view) "parameter-mapping encapsulates all of science and art in sonification," i.e. the science is in the rigorous mapping of the data to properties of the resulting sound, and the art is in determining where and how these mappings are implemented [21]. Similarly, Ballora describes how his design choices, for instance using specific accented percussive sounds for the indication of chronology or time, in contrast with the microtonal pitch for data values, are a result of both pragmatic and aesthetic considerations [22]. Such a combination of scientific and artistic considerations points to the constructive dialogue between these two worlds, creating as a result a vast potential space for experimentation and exploration within the science-art polarity.

The strata co-dependencies

A *curatorial* method builds on *allusive* and *generative* approaches. The aim of *curatorial* sonification rests on conveying *salient features* within the underlying data sets. The salience must first be defined and understood relative to the *context* of that data, which *allusive* sonification aims to connote. An *allusive* approach by default encompasses a *generative* one. This can easily be demonstrated by removing any accompanying contextual information from *allusive* sonification. Simply put, the clearer and more precisely comprehensible the communication of information through sound is, the higher the layer a sonification will embody.

Conclusions

The “strata” model has useful implications for the collaborative process between artists and scientists in navigating some of the friction that may arise due to different motivations participants may have for undertaking such projects. Purely *generative* sonifications seem likely to be “one-way” collaborations, in that the artists will benefit from access to productive source material, but there is likely to be little or no benefit to the scientific project. *Allusive* approaches bring us into the realm of outreach, possibly providing an aesthetic “scaffold” upon which listeners may “hang” their experience of the science, making it experienceable through the evocation of Supper’s *auditory sublime*. *Curatorial* works go further into the realm of the pedagogical, educating listeners about aspects of the science in addition to evoking an aesthetic response.

The three layers are differentiated based on the importance of the underlying data set, its context to the designer and the target audience, and how it is presented. A single work may be received on one or more of these levels, perhaps in different aspects of their realization. We have provided these strata and their characteristics for clarity in Table 1.

We hope that this strata-based approach contributes to validating and classifying endeavors involving artistic data sonification, and that this might both inspire further investigation and research into the efficacy of this approach in the analysis of existing works and be of use to those embarking on new science-art collaborations.

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Sonification Approach	**Description**	**Examples**
Curatorial	- *More scientific* - *Can function as auditory display* - *Conveys salient aspects of data*	- Asquith's parameter-mapping sonifications of particle collision data - Ballora's *Heart-rate data sonification*
Allusive	- *The source/context of the data matters and is alluded to*	- Scaletti's Compositions for *QUANTUM* - Wilson's *Media Bites* - Lucier's *Music for Solo Performer*
Generative	- *Primarily 'musical'* - *Source of the data does not matter*	- Nicolai's *Unitxt Code (Data to AIFF)* - Lucier's *Music for Solo Performer*

Table 1. Strata-based Approaches to Artistic Data Sonification

Biographies

MILAD KHOSRAVI MARDAKHEH is a composer, programmer and published researcher. He holds a Bachelor's degree in Computer Engineering and a Master of Music degree in Composition from the Royal Welsh College of Music, and completed a PhD in Music Composition, focusing on data sonification and computer music, at the University of Birmingham (UK).

SCOTT WILSON's music/sound art combines aspects of instrumental composition, field recording, multichannel electroacoustics, cross-cultural collaboration, live-coding improvisation. A longstanding member of the SuperCollider development community, he was lead editor of *The SuperCollider Book*. He is co-director of Birmingham ElectroAcoustic Sound Theatre (BEAST) and teaches at the University of Birmingham (UK). https://scottwilson.ca