Ars Informatica–Ars Electronica: Improving Sonification Aesthetics

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Abstract

In this paper we discuss æsthetic issues of sonifications. We posit that many sonifications have suffered from poor acoustic ecology which makes listening more difficult, thereby resulting in poorer data extraction and inference on the part of the listener. Lessons are drawn from the electro acoustic music community as we argue that it is not instructive to distinguish between sonifications and music/sound art. Edgar Varèse defined music as *organised sound* and sonifications organise sound to reflect some aspect of the thing being sonified. Therefore, we propose that sonification designers can improve the communicative ability of their auditory displays by paying attention to the æsthetic issues that are well known to composers, orchestrators, sound designers & artists, and recording engineers.

Keywords: auditory display, sonification, æsthetics

1. INTRODUCTION: SONIFICATION & AUDITORY DISPLAY ÆSTHETICS

Since the emergence of sonification techniques for mapping data to sound, there has been much effort directed to representing data using sound. This field, known as *auditory display* has grown in popularity and is supported the International Community for Auditory Display[1]. Whilst there are several terms used to describe the precise process by which data is rendered in sound, *sonification* is generally used as a catch-all to describe most work in the area. Data can be mapped to sound in one of two ways: direct mappings impose a one-to-one relationship between data items and sonic events (possibly involving some scaling and quantisation) whilst metaphoric or analogic mappings impose interpretive filters or mapping functions to the data before it is rendered. An example of the former is Chris Hayward's auditory representation of seismograph data in which long period seismic waves were scaled up into the audible frequency range [1] allowing sophisticated aural analysis. Blattner, Greenberg, and Kamegai [2] used metaphoric mappings in their work on the auditory representation of turbulence in fluid flow. Through the use of *earcons* (hierarchically-structured melodic phrases) they represented changes in fluid state. The earcons were able to "*...draw attention to specific events that might otherwise be lost in the wealth of graphic information indicated on the screen*" [2].

Gaver was one of the first to promote the use of another type of interpretive mapping, the *auditory icon*, in his famous Sonic Finder project [3]. Unlike earcons, auditory icons take a symbolic or representational approach. For example, a progress bar could be represented by the sound of a jug being filled: the fuller the jug sounds the nearer to completion the task is. Auditory icons can be parameterised so that extra data-specific information can be transmitted (e.g., the timbre of the water sound in the jug could be related to file size in a download operation).

At first, the focus in auditory display was to show how information could be mapped to sound. Many systems were built for a wide variety of information types (such as stock market data, seismographs, program runtime behaviour, chemical spectra, DNA sequences, chaotic attractor functions, etc. – see [4]). Sonification designers concentrated on building systems often paying

[1] See `www.icad.org`.

scant regard to their æsthetic qualities. In the early proof-of-concept stage this was understandble, but now that the field is beginning to mature this issue needs to be addressed. Over the last decade or so many different sonification examples have been built. What is apparent from listening to them is the wide variation in the quality of the æsthetics and the acoustic ecology of the auditory output. Some designers adopted simple quantised data-to-pitch mappings that allowed crude chromatic 'musical' representations, whilst others pursued ad-hoc frequency mappings. Others tried deliberately to use organising principles of tonal music to structure their work, which resulted in more æsthetically-coherent sonifications. Another group explored the electro-acoustic music tradition to fuse tonal and abstract musical expression in their sonifications. What marked out these latter two groups was the use of musically-literate people on the project teams. These teams believed that people with formal musical and artistic training could significantly improve the æsthetic qualities of the sonifications which, in turn, would increase the communicative and expressive capability of the auditory displays.

2. MUSIC ÆSTHETICS

In recommending that sonification designers should employ musical structures and organising principles to build their sonifications Vickers [5] added the following caution:

> In the pursuit of æsthetic excellence we must be careful not to tip the balance too far in favour of artistic form... The vernacular is popular music, the aesthetics of which are often far removed from the ideals of the music theorists and experimentalists.

With hindsight this argument seems too simple as it embodies the thinking of C. P. Snow's *Two Cultures* by creating a division between so-called art music and sonification. The argument is based on the assumption that much art-music would not be perceived as music by the average listener and, therefore, its structures would not be comprehensible. Indeed, Lucas [6] demonstrated that the recognition accuracy of an auditory display increased when users were made aware of the display's musical design principles. Further, Watkins and Dyson [7] showed that melodies following the rules of western tonal music are easier to learn, organise (cognitively), and discriminate than control tone sequences of similar complexity. However, these studies were rooted in tonal and atonal musical forms. But there is an alternative: the electro-acoustic/musique concrète community has long been composing music of the more loosely defined *organised sound* variety which is neither tonal nor atonal. Whilst often lacking discernible melodies and harmonic structures, the music is much easier to organise and decompose cognitively than atonal works. Sonifications could make good use of the æsthetics of electro-acoustic composition techniques.

One criticism levelled at this argument is that the musical grammars add another language level to the interface which would get in the way of the underlying data – the music would be another language to learn. However, applying the argument to external visual representations shows it to be fallacious. Structured external visual representations are common in the computing world. The diagrams themselves are graphical abstractions of the underlying data or concepts they represent. No complaint is made that the syntax (or organising rules) of the notations interfere with understanding what they represent. Rather, it is considered necessary to have formalised rules by which diagrams and other notational structures are organised. It is held by some that musical/sonic syntaxes somehow require greater cognitive load than visual representations. There are two things being missed here. First, even visual notations require training in how to read them. Secondly, people are already familiar with decoding the organising principles of at least one sonic grammar. If it were not so, it would be impossible to appreciate music without formal training, yet melody recall has been shown to be an innate skill. Popular music would not exist unless it could communicate its message to a wide population with the minimum of cognitive overhead. It is true that people differ in the analytical level of their listening, but there does seem to be a cultural, or æsthetic, baseline in popular music systems that is accessible to the untrained listener.

3. ARS INFORMATICA, ARS ELECTRONICA

We may imagine a line, a continuum, with sonification (or, ars informatica) at one end and electronic & electro-acoustic music (ars electronica) at the other (see Figure 1). At the ars

informatica end of the continuum lie sonifications without pretense to artistic content (though whether they are perceived as such is another matter): their intent is to create as pure a mapping from data to sound as possible. At the ars electronica end are those pieces of music and sound art that exist as pure art forms whose purpose is not necessarily to communicate concrete ideas from the real world. Of course, it is debatable whether any such pieces exist, for all composers and creators of art typically try to communicate something in their work no matter how abstract. However, this classification is a useful abstraction for our purposes here.

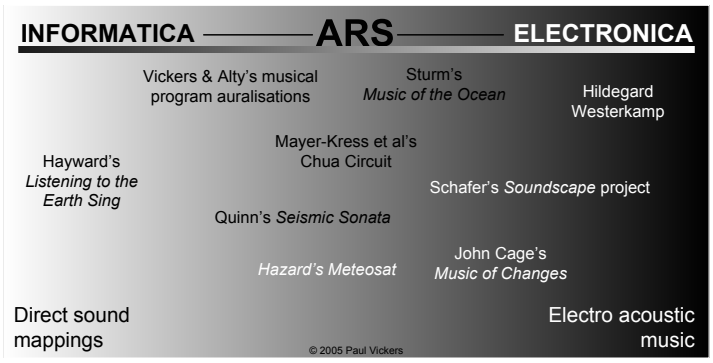

FIGURE 1: An Ars Informatica–Ars Electronica Continuum

The interesting area is towards the middle of the continuum where sonifications have been deliberately designed with artistic sensitivities (e.g. Mayer-Kress, Bargar, and Choi's sonification of the chua circuit chaotic attractor funtion [8]) and where music has been composed purposefully according to some underlying data or process (e.g. John Cage's *Music of Changes* (1952)). The line between sonification and music is blurred when we consider that common techniques are shared by sonification practitioners and artists. For example, Hayward's [1] sonic seismographs were realised simply by multiplying the data until its frequencies were in the audible range. The composer Hildegard Westerkamp[2] slows down found environmental sounds in order to extract their unheard musical characteristics. The technique of manipulating the speed of the data is the same, but the intended outcomes are different.

The melting pot is further stirred by sonifications that were designed as music, such as Quinn's *Seismic Sonata*[3] or Sturm's *Music from the Ocean*[4]. These works are not just sonifications for they aim provide a musical experience too. Quinn maps multivariate earthquake data to a tonal sonata form; Sturm's sonifications of ocean buoy data sound more abstract and resemble electro-acoustic compositions (such as Hazard's *Meteosat*[5] and Ian Boddy's *Continuum*[6]), though the mappings are nevertheless deliberate and planned. Often, the way one can tell sonifications and compositions apart is by the production quality of the recording: electro-acoustic compositions are well-mixed and mastered so every instrument/timbre has its own clearly-defined place in the acoustic space of the piece. Musical sonifications may be well composed or orchestrated, but they often lack the quality of a professionally mixed, engineered, and mastered commercial recording.

In generative composition, data and algorithms are by-products of the creation of the intended product (the music). In sonification, the data (or algorithms) are the focus, and the intended product is the successful aural communication of that data: the actual sounds and their orderings that occur, are to some degree, by-products of the sonification process. Of course, to maximise the communication the sonification designer intentionally selects mappings and timbres that are believed to offer the listener the best chance of interpreting the underlying data or phenomena. But this is what composers and orchestrators do all the time. So, rather than sonifications and compositions lying on a continuum we propose, instead, a circular (or even spherical) space in

[2]See `http://www.sfu.ca/~westerka/`.
[3]Marty Quinn, "*Seismic Sonata: a Musical Replay of the 1994 Northridge, California Earthquake*", 2000.
[4]Bob Sturm, "*Music From the Ocean*", composerscientistrecordings (www.composerscientist.com), 2002.
[5]Hazard, Fennesz, & Biosphere, "*Light*", Touch Records, 2001.
[6]Ian Boddy, "*Continuum*", Something Else Records, 1996. A two-CD abridged recording of a live eight-hour performance of electronic music by Ian Boddy at the Newcastle Comic Arts Festival in 1996.

which the ends of the continuum have been joined (see Figure 2). The right-hand side represents the composition space, the left-hand side the sonification space. On one compass point of the circle we place those *compositions* that *sound* most like non-abstract tonal/atonal music, and at the opposite point those *sonifications* that *sound* least like music (or possess the least musical quality). This division between non-abstract music and least-musical is contentious for it requires a consensus as to what constitutes music in the first place, but for now it is a useful distinction that we will shortly discard or rather, transform.

As we travel around the circle in either direction we meet those works that possess to a greater or lesser extent attributes of both musical composition and non-musical sonification. The really interesting point is where it is hard (or even impossible) to discern the origins of a piece: composition or sonification. This implies that the distinction between the two pairs of categories – musical & tonal/atonal (bottom of the circle) and non-musical & abstract/musique concrète (top of the circle) – become blurred. A change in our perception of a piece can transform it, for example, from being non-musical into abstract/musique concrète, or from a musical piece into the tonal/atonal category (and vice versa). The musical–non-musical continuum is useful as a starting point but can soon be discarded in favour of the more precise tonal/atonal–abstract/musique concrète spectrum. By way of example, consider the *Listening to the Mind Listening* concert at ICAD 2004[7]. The concert comprised ten five-minute sonifications of fifteen channels of EEG data previously recorded from a subject who was listening to David Page's *Dry Mud*. The compositions were driven by the same data but the mappings were defined by their creators. Gordon Monro's *What Are You Really Thinking* sounds very much like an electro-acoustic composition. At the other end of the spectrum (on the other side of the circle) is Hans van Raaij's *Listening to the Mind Listening* in which the data were mapped onto just two auditory streams, a piano and bass, creating a kind of tonal free jazz improvisation, a very different æsthetic form from Monro's work. By considering the two pieces in terms of tonality and abstractness we see how our perception has moved the works from the sonification side of the space into the composition side. The difference, then, between sonification and musical composition is largely one of perspective.

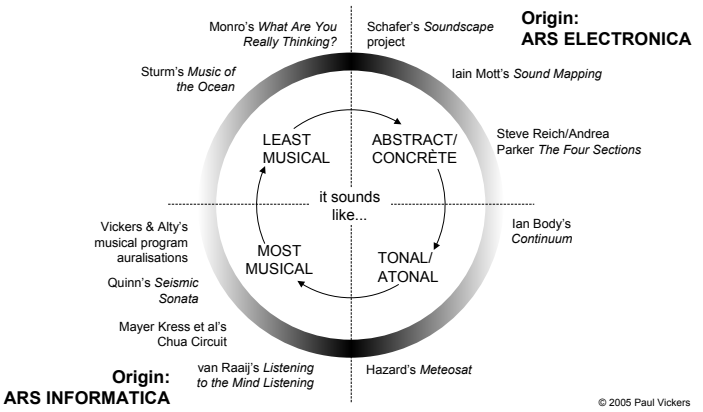

FIGURE 2: The Ars Informatica–Ars Electronica Circle Space

4. CONCLUSIONS: ACOUSTIC ECOLOGY AND ÆSTHETICS

We conclude that to distinguish between musical and non-musical sonifications is not necessarily helpful (or even meaningful). Earlier we stated that the acoustic ecology of many sonifications is poor. In fact, the language of acoustic ecology is very helpful in considering the ars informatica–ars electronica circle. Wrightson [9] invokes R. Murray Schafer [10] who "*suggests that we try to hear the acoustic environment as a musical composition and further, that we own responsibility for its composition*" [9]. A reason for trying to hear everything as a musical composition is that it forces us to move from being hearers to being listeners. What then becomes important for sonification designers is not how 'musical' their work sounds, but how easy they have made it for the audience

[7]Binaural recordings of all ten works, and the EEG data on which they are based, are available to download at `http://www.icad.org/websiteV2.0/Conferences/ICAD2004/concert.htm`

to listen to it, and by *listen* we mean 'attend carefully'. Timbres should be chosen so that they do not mask other timbres (unless masking is an important feature of the underlying data). Careful thought needs to be given to the spatialisation of the sounds – mono, stereo, and multi-channel sound can all be used to good effect but only if used well.

In our own sonification practice we have attempted to consider the æsthetics of the auditory mappings as an integral part of the process. We do not distinguish between æsthetics and mappings – the two are intextricably linked (see [11]). More recently we have argued that different æsthetics (e.g. world music systems) could be used in sonification [5, 13]. These arguments are based on the principles of *æsthetic computing* (see [14]). Composers, sound designers, sound artists, orchestrators, and recording engineers are successful because they are conversant with the æsthetics of sound. We have proposed that sonifications can be viewed as electro-acoustic art works and, as such, would benefit from the application of the æsthetic practices employed by such artists. The foremost skill that a sonification designer needs to develop is that of listening, for it is upon this that all higher sound art skills are predicated. Once sonification designers have learnt to listen like composers, sound designers, and recording engineers they will be much better placed to create sonifications that maximise the communicative potential of the auditory channel. Designers of visual interfaces have been drawing upon the skills of the graphic design community for years: it is time the auditory display community did something similar.

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