

The Sonification Handbook

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Logos Publishing House, Berlin, Germany

ISBN 978-3-8325-2819-5

2011, 586 pages

Online: <http://sonification.de/handbook>

Order: <http://www.logos-verlag.com>

Reference:

Hermann, T., Hunt, A., Neuhoff, J. G., editors (2011). *The Sonification Handbook*. Logos Publishing House, Berlin, Germany.

Chapter 7

Sonification Design and Aesthetics

Stephen Barrass and Paul Vickers

This chapter addresses issues of functionality and aesthetics in sonification by advocating a design-oriented approach that integrates scientific and artistic methods and techniques. Design is an iterative practice-based discipline involving cycles of hypothesis testing and critical evaluation that aims for solutions to specific problems in context. The reviews design methods and practice in sonification and argues for a pragmatic information aesthetic that distinguishes sonification from computer music and psychoacoustics. It argues that the design approach can allow sonification to become a mass medium for the popular understanding and enjoyment of information in a non-verbal sonic form.

Reference:

Barrass, S. and Vickers, P. (2011). Sonification design and aesthetics. In Hermann, T., Hunt, A., Neuhoff, J. G., editors, *The Sonification Handbook*, chapter 7, pages 145–171. Logos Publishing House, Berlin, Germany.

Media examples: <http://sonification.de/handbook/chapters/chapter7>

Chapter 7

Sonification Design and Aesthetics

Stephen Barrass and Paul Vickers

We can forgive a man for making a useful thing as long as he does not admire it. The only excuse for making a useless thing is that one admires it intensely. All art is quite useless.

— OSCAR WILDE, *THE PICTURE OF DORIAN GRAY*, 1890 [106]

Form follows function. Form doesn't follow data. Data is incongruent by nature. Form follows a purpose, and in the case of Information Visualization, Form follows Revelation.

— MANUEL LIMA, *INFORMATION VISUALIZATION MANIFESTO*, 2009 [58]

The craft of composition is important to auditory display design. For example, a composer's skills can contribute to making auditory displays more pleasant and sonically integrated and so contribute significantly to the acceptance of such displays. There are clear parallels between the composer's role in AD and the graphic artist's role in data visualization. Improved aesthetics will likely reduce display fatigue. Similar conclusions can be reached about the benefits of a composer's skills to making displays more integrated, varied, defined, and less prone to rhythmic or melodic irritants.

— GREGORY KRAMER, *AUDITORY DISPLAY*, 1994 [49, pp. 52–53]

Even in Beethoven's time the idea that music could be composed from extra-musical sources was not new; the Greeks composed with geometric ratios, and Mozart threw dice. In the 1930s Joseph Schillinger [85] proposed a "scientification" of music through a mathematical system that has been described as "a sort of computer music before the computer" [30]. With the invention of electroacoustic technologies Iannis Xenakis composed music from statistics and stochastic processes [109] (sound example [S7.1](#)). Computer music today is composed from fractal equations, cellular automata, neural networks, expert systems and other systematic rule-based systems, algorithms, and simulations [76]. Music is also composed from DNA sequences, financial indexes, internet traffic, Flickr images, Facebook connections, Twitter



messages and just about anything in digital form. Generally, the composer is concerned with the musical experience, rather than the revelation of compositional materials. However, when the data or algorithm is made explicit it raises the question of whether some aspect of the phenomenon can be understood by listening to the piece. When the intention of the composer shifts to the revelation of the phenomenon, the work crosses into the realm of sonification. Until recently, sonification has mainly been the province of scientists, engineers, and technologists exploring the functional potential of synthetic sounds as a tool for observation and enquiry. These experiments have sometimes been criticized as unpleasant to listen to, and difficult to interpret. In many cases the most enlightening aspect of a sonification was the process of composing it.

This chapter proposes to address the issues of functionality and aesthetics in sonification by advocating a design-oriented approach that integrates scientific and artistic methods and techniques. Design is an iterative practice-based discipline involving cycles of hypothesis testing and critical evaluation that aims for solutions to specific problems in context. The chapter begins with a review of design methods and practice in sonification. The next section argues for a pragmatist information aesthetic that distinguishes sonification from computer music and psychoacoustics. The penultimate section addresses the issue of aesthetic design guidelines and metrics for sonification. The final section argues that the design approach can allow sonification to become a mass medium for the popular understanding and enjoyment of information in a non-verbal sonic form.

7.1 Background

Ⓒ A debate about whether music can have meaning beyond music itself has raged since the 18th century and continues to this day. Formalists argue that music is the most abstract of the arts and cannot represent anything beyond its own world of melody, harmony, dissonance, tension and resolution. Conversely, Beethoven's sixth symphony (the Pastoral) is often cited as an example of program music that has a narrative conveyed by the titles of the five movements and the music itself (sound example [S7.2](#)). The musical telling of the story about peasants dancing under a tree climaxes with a dynamic orchestral rendering of a thunderstorm that is a precursor to film sound today. Beethoven wrote a note in the margin of the manuscript that reads "*Mehr Ausdruck der Empfindung als Malerei*" ("More expressive of emotions than a painting") which "... marks the beginning of a conception of program music where the music does not merely convey a literary narrative through musical imitation of characteristic acoustic objects (think of Smetana's *Moldau*, for instance), but instead creates an imaginary drama or represents a poetic idea" [93, p. 287].

In the silent movie era it was common for a pianist to improvise an accompaniment to amplify the emotions and drama happening on the screen. The invention of the optical movie soundtrack allowed Foley recordings such as footsteps to be synchronized with events on the screen. Film sound designers soon began to explore and expand the functions of sound effects to convey off-screen events, cover cuts and scene transitions, signal flashbacks, and direct attention. A sophisticated theory of film sound developed and Chion [24], building upon Pierre Schaeffer's earlier work proposed three modes of listening: causal listening (attending to the source of the sound), semantic listening (attending to the meaning of a sound), and reduced listening (being concerned with the properties of the sound itself) [24]

(see also section 18.2).¹

The invention of magnetic audio tape ushered in a new era of musical innovation with *musique concrète*, cutup, reversal, looping, and many other possibilities. But musicians were not the only ones exploring the new affordances of tape. Seismologists sped up recordings of earth tremors to listen to sub-sonic events, and were able to distinguish earthquakes from underground nuclear tests [39]. The invention of analogue synthesizers allowed sounds to be controlled with knobs and sliders. Patterson synthesized sounds from the instruments in an aircraft cockpit, to study the effects of amplitude, frequency, tempo, and pulse patterns. His guidelines for cockpit warning and alarm sounds included onset and offset times of 30ms or more, limiting on-time to 100ms, patterns with at least five pulses, linking pulse rate with urgency, and limiting the vocabulary of symbolic sounds to seven [67]. Bly [16] studied the perception of multivariate data in sounds by mapping six-dimensional data to six characteristics of a synthesized tone (pitch, volume, duration, waveshape, attack and overtones). Her participants were able to classify data from the sonification as well as they could from a visual representation. The pioneering researchers in this area were brought together in 1992 by Gregory Kramer who founded the International Conference for Auditory Display (ICAD).² In the introduction to the proceedings of that meeting Albert Bregman outlined a near-future scenario in which an executive in a shoe company listens to sales data to hear trends over the past twelve months. Interestingly, this scenario remains futuristic, though not for technological reasons.³ The participants at that first meeting introduced most of the sonification techniques that are current today, including audification [39], beacons [49], musical structure [62], gestalt stream-based heuristics [107], multivariate granular synthesis [89], and parameter mapping [81]. Scaletti [81] provided a “working definition of sonification” as “a mapping of numerically represented relations in some domain under study to relations in an acoustic domain for the purpose of interpreting, understanding, or communicating relations in the domain under study” [p. 224]. She classified sonification mappings by level of directness: level 0) audification, level 1) parameter mapping, and level 2) a mapping from one parameter to one or more other parameters. Kramer [49] arranged various techniques on a semiotic spectrum from analogic to symbolic, with audification at the analogic end, and parameter mapping in the middle. However, the suggestion that audification is more direct and intuitive is complicated by Hayward’s observation that although seismic data could be readily understood, stock prices sounded like opaque noise because they are not constrained by the laws of physics [39]. Kramer [50] also observed that different auditory variables have different perceptual weightings, and suggested that psychoacoustic scaling could balance the perception of multivariate sonifications. Bly [17] presented an experiment in which three sonifications produced different understandings of the same data structure.

¹It was Chion who enumerated the three modes of listening described above, but the name for reduced listening was first given by Schaeffer [82] in his treatment of the *quatre écoutes*.

²See <http://www.icad.org>.

³It is interesting to note that Bregman’s scenario was already anticipated in fiction. In Douglas Adams’ 1988 novel “Dirk Gently’s Holistic Detective Agency” [1] the leading character made himself wealthy by devising a spreadsheet program that allowed company accounts to be represented musically [97].

7.2 Design

The field of sonification was consolidated by the attendance of more than a hundred researchers at the second ICAD in Santa Fe in 1994. The first session on Perceptual Issues followed on from the observations of the need for psychoacoustic underpinnings at the first ICAD. Watson and Kidd [104] discussed the cognitive aspects of auditory processing that included type of task, length of training, and complexity, and suggested that auditory science could provide principles for the design of effective displays. Smith et al. [88] psychometrically evaluated the perception of data structure from a granular synthesis technique. Barrass [6] described a psychometric scaling of sonification sequences modeled on the scaling of color sequences in scientific visualization. Other sessions were divided into topics of Spatialization, Systems Issues, Sound Generation, and Sonification and Speech Interfaces. The third ICAD at Xerox Parc in 1996 introduced a session on Design Issues in Auditory Displays in which Tkaczewski [95] presented an overview of aesthetic, technical, and musical issues in commercial sound design, and Back [3] introduced a sound design theory of micro-narratives. Walker and Kramer [102] presented an experiment in which participants interpreted an increase in the frequency of a tone as an increase in temperature, but as a decrease in size. In a further study, sighted participants interpreted an increase in frequency as representing more money, whilst visually impaired participants interpreted it as less [103]. They suggested this may have been because people in the visually impaired group were using a physical metaphor to interpret the sounds. Barrass [7] presented the TaDa task-oriented approach for designing sonifications described by the diagram in Figure 7.1, in which the upper facets of Task analysis and Data characterization specify the information requirements of the design brief, which is then realized by a perceptual representation and device rendering shown by the lower facets.

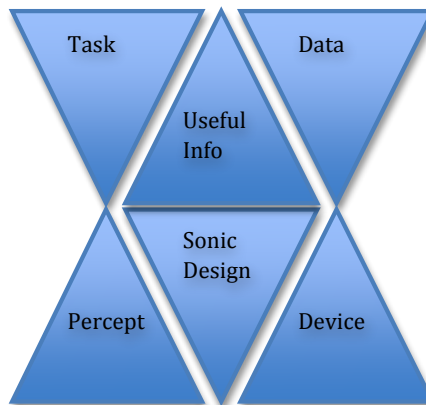


Figure 7.1: TADA Sonification Design Process, reproduced from the original in Barrass [7]

The TaDa design approach reworks the definition of sonification to focus on functionality rather than representation: “Sonification is the design of sounds to support an information processing activity” [7]. This design-oriented definition augments the National Science Foundation White Paper on Sonification in which sonification is defined thus:

... the use of nonspeech audio to convey information. More specifically, sonification is the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation [51].

Another approach takes a view that exploration of a data set with sonification should be a more open-ended process. de Campo's Data Sonification Design Space Map (DSDSM) begins with the characterization of the data set in terms of size and dimensionality [28]. Techniques labeled audification, parameter mapping, filtering, textures, grain clouds, and model-based are shown as regions between the x -axis (number of data points) and y -axis (number of data dimensions). A third z -axis is used to describe the number of perceptual auditory streams produced by each technique. Techniques are grouped in regions labeled Discrete-Point, Continuous and Model-based. The Discrete-Point region contains note-based sonifications and parameter mappings that provide low levels of data transmission. The Continuous region contains Textures and Grain Clouds with higher densities and transitions to Audification. The Model-based region contains techniques that employ a mediating metaphor, such as a simulation of a gas-cloud or crystal growth [42]. The design process is shown by lines in the DSDSM that make implicit knowledge (often expressed as intuitive ad-hoc decisions) explicit and therefore available for reflection, discussion, and learning [28]. These lines depicting process can allow an understanding of the effect of decisions on the perceptual features of the sonification [29].

Methods for designing sounds from theatre, film, ethnographics, computer games, sound art, and architecture have also been introduced in sonification. Somers proposed that theatre sound provides a framework beyond theories of ecological sound and abstract music [91]. Saue [80] proposed a first person point of view for navigating spatial data sets. Macaulay and Crerar [59] employed ethnographic techniques to study auditory displays in an office environment. Cooley [25] took an art theoretic approach to argue that sonification had much to learn from the narrative qualities of computer game sound. In a study of an auditory display of the New York subway system, Rubin [79] concluded that future practice should include information design, sound design, and music as equal partners alongside the more traditional psychological methods. Design patterns, first developed in architecture [2] and applied more broadly in software engineering, were introduced to sonification by Barrass [9] and evaluated by Frauenberger in a study with a context space containing links to artifacts, examples, and problems [34].

7.2.1 Aesthetic awareness

In their call for art submissions for the ICAD conference in Japan in 2002 Rodney Berry and Noatoshi Osaka identified the need for more consideration of the aesthetic aspects of sonification highlighting the important role of aesthetic practice in the process of meaning-making that is sonification:

In this year's ICAD we have included an art section in the hope that future ICADs might continue to explore some of the arguably less utilitarian aesthetic implications of auditory display. Due to budget and space restrictions, we could only manage to host one installation work this time. The work presented here is Acoustic Acclimation by Singapore-based artists and composers, Lulu

Ong and Damien Lock who work together under the name Coscilia. The work itself is not a literal “aesthetically pleasing sonification of data-sets” kind of piece. Rather, Acoustic Acclimation explores the relationship between sound and meaning, together with how they combine to establish a sense of place. It is hoped that exposure to such works in future ICAD events might stimulate attendees’ thinking about the crucial mapping stage of auditory display, and the interplay between data, information and meaning that concerns both scientists and artists. [15]

- At the same conference Bob Sturm announced the release of a CD of sonifications of ocean buoy spectral data titled *Music from the Ocean* [94] (sound example [S7.3](#)). The proposal that sonification could be a musical experience was reiterated at ICAD 2003 in Boston where Marty Quinn released a CD of sonifications composed from data about the September 2001 attack on the World Trade Centre titled *For those who died* [72]. Barra et al. [5] explored ways to reduce listening fatigue by composing sonifications with “musical structure that’s neutral with respect to the usual and conventional musical themes”, inspired by futurist composer Luigi Russolo (1885–1947), Pierre Schaeffer’s *musique concrète*, Edgard Varèse’s *Poème Electronique* (1958) and John Cage’s aleatoric compositions (e.g., *Music of Changes* (1951)) [4, p. 35]. The aesthetic potential of sonification as a medium has been developed by sound artists like Andrea Polli who made extensive use of sonification techniques in a public sound art installation on climate change [69] (sound example [S7.4](#)). Guillaume Potard’s sonification of the Iraq Body Count site also demonstrates that sonification can be a political medium [70] (sound example [S7.5](#)). The growing attention to aesthetics in sonification was recognized by the introduction of a session on the Aesthetics of Auditory Displays at the ICAD conference in Sydney 2004 [12]. Vickers [98] reviewed long term process monitoring sonifications from an aesthetic perspective and called for sonification design to become more interdisciplinary and Leplâtre and McGregor [55] conducted an experiment in which it was found that the functional and aesthetic properties of auditory displays are not independent and the one impacts on the user’s experience of the other.

- The potential for sonification as a musical experience was tested by the introduction of a concert of sonifications that was ticketed to the general public and staged at the Sydney Opera House Studio [14]. The call for submissions for the Listening to the Mind Listening concert of EEG data asked for sonifications that were “musically satisfying” whilst also being “data driven” [13] (sound example [S7.6](#)). In their descriptions many composers wrote of meeting both criteria. Three used a notion of revelation or inherence, with a related idea that the data was musical in itself. One described the goal to be to “find naturally occurring rhythmic and musical structures in the data”. Another also invoked Nature: “Nature itself creates the structure and balance upon which aesthetics are based. It stands to reason that data captured from such activity is naturally aesthetic when interpreted properly”. At the same time, several identified the need to create or maintain musical “interest” and others noted that they selected or “highlighted” aspects that were more musically satisfying. Three recognized the duality of music and sonification as constraining, or even inherently conflicting. One wrote: “It is not to be expected that a sonification produced in a deterministic manner from the data will have any of the normal characteristics of a piece of music”. Some contributors emphasized information and perception rather than music, and only a small subset used both musical and perceptual discourses. Several identified with non-music sound practices, using terms such as audio, soundscape, or composition rather than music to describe the results.

A second concert of sonifications was organized by Alberto de Campo for ICAD 2006 in London. “Global Music, The World by Ear” premiered eight sonifications of socio-economic data in an 8 speaker surround system at the Institute of Contemporary Arts [27].⁴ The cross-fertilization between sonification and sound art was furthered by the organization of ICAD 2009 in parallel with the Re:New symposium on sound art which included three nights of performances in Copenhagen in 2009. A session on Sound Design Theory and Methods included a review of a workshop on design in sonification that highlighted the fact that knowledge in the field is currently focused on applications and techniques, and there is a need to consider users, environments and contextual issues more in the future [10]. Brazil and Fernström [19] reviewed a cross-section of subjective experience methods that are centered around early conceptual design. (See also Brazil’s review of existing sonification design methods and frameworks [18].) Hug [44] presented a participatory design process narrative sound strategies from film and video game production. Fagerlönn and Liljedahl [32] described the AWESOME tool that enables users to become part of the sonification design process. Larsson [52] discussed the EARCONSAMPLER tool that was used in focus groups to help evaluate and improve the sound designs of auditory displays. Sessions on Design and Aesthetics, Philosophy, and Culture of Auditory Displays appeared on the agenda at ICAD 2010 in Washington. Straebel [93] provided a historic grounding that related sonification design to musical movements (especially Romanticism), concepts, and theories. Continuing the theme of participative design, Schertenleib and Barrass [84] introduced Web 2.0 concepts of community of practice, knowledge sharing, and cultural dynamics. Jeon [47] described an iterative sound design process used in industry whilst Vogt and Höldrich [101] discussed a metaphorical method that asked experts to imagine sounds to represent concepts from high energy physics as a basis for sonification design. Following the metaphor theme Fritz [35] proposed a design model based around the intersections of universally (culturally) perceived musical features. Goßman [36] worked from an ontological perspective to discuss the role of the human body as a mediator between external sounds and internal perceptions. Of particular interest here is the assertion that “the contribution of musicians, artists, composers etcetera is not so much in the area of creating aesthetic experiences related to the data, but in the expansion of cognitive models available to the actively exploring listener”. The, by now, traditional ICAD concert was organized by Douglas Boyce on the theme “Sonic Discourse – Expression through Sound” with a program that included Spondike’s “*Schnappschuss von der Erde*” which premiered at ICAD 2006, and Katharina Rosenberge’s “Torsion” that establishes relationships between parabolic spirals found in sunflower heads and spectral analysis of the lowest octave of the piano. Other works emphasized the role of performers in musical performance as embodied techniques.⁵

The effects of aesthetic aspects of sonification have begun to be studied particularly in interactive sports and fitness applications. When a sine-wave sonification of the acceleration of a rowing skiff was played to elite athletes and coaches they commented that the sound was pleasing because it provided useful information that was difficult to see from a video [83]. However, Chris Henkelmann who was involved in a study of sonification on a rowing machine observed that a sine-wave sonification became annoying [40]. He hypothesized that computer music techniques, such as a timbre model and a formant synthesis, could improve the longer term experience. Some of these techniques were included in a study

⁴The full program, together with the audio tracks, may be heard at <http://www.dcs.qmul.ac.uk/research/imc/icad2006/proceedings/concert/index.html>.

⁵The full concert program is available at <http://web.me.com/douglasboyce123/icad/>.

of preferences between six different sonifications of kinetic data that included a sine-wave Sinification (sound example [S7.7](#)) [sic] pattern, a phase aligned formant Vocal pattern (sound example [S7.8](#)), a wind Metaphor pattern (sound example [S7.9](#)), a Musicification pattern using FM instruments (sound example [S7.10](#)), and a Gestalt stream-based sonification pattern (sound example [S7.11](#)) [11]. The participants could select between these sonifications on an iPod while involved in an outdoor recreational activity of their choice, such as walking, jogging, martial arts, or yoga. Selections between the sonifications were logged during the activity, and participants were interviewed about the experience afterwards. The interviews discovered a general preference for the Sinification and Musicification patterns and this corresponded with the data logs of time spent with each pattern. The interviews also revealed that the two most preferred patterns were also least preferred by some participants. It might be that recreational users prefer a more conventionally music-like experience whilst competitive athletes prefer more everyday informational sound. These observations show that aesthetics are as important as functionality, and the need to consider the expectations of the users and the context of use when designing a sonification.

The increasing interest in aesthetic dimensions in research studies and the development of sonification as an artistic medium have made it increasingly difficult to distinguish sonification from other practices. Hermann [41] sought to clarify the distinction by recasting the term to plant it firmly in the domain of scientific method by adding four conditions that a work should meet to be considered a sonification:

1. The sound reflects objective properties or relations in the input data.
2. The transformation is systematic. This means that there is a precise definition provided of how the data (and optional interactions) cause the sound to change.
3. The sonification is reproducible: given the same data and identical interactions (or triggers) the resulting sound has to be structurally identical.
4. The system can intentionally be used with different data, and also be used in repetition with the same data. [41]

However computer musicians use the same technologies, tools, and techniques to systematically synthesize sounds from data and algorithmic processes as sonification researchers, and vice-versa. The further statement that the “distinction between data and information is, as far as the above definition, irrelevant” [41], does not make sonification any more distinct. In this chapter we propose that it is the functional intention, rather than a systematic process, that sets sonification apart from other fields of sonic practice. Sonification is a rendering of data to sound with the purpose of allowing insight into the data and knowledge generation about the system from which the data is gathered. We propose that the defining feature of sonification is a pragmatic information aesthetic that combines the functionality of information design with the aesthetic sensibilities of the sonic arts. Casting sonification as purely scientific runs the risk of further polarizing C. P. Snow’s [90] Two Cultures debate.⁶

⁶The Two Cultures is a reference to the existence of two separate cultures with little contact between them — one is based on the humanities and the other on the sciences [97, p. 2] a divide which James [46] described as a “psychotic bifurcation” [p. xiv]. James summarized the situation thus:

In the modern age it is a basic assumption that music appeals directly to the soul and bypasses the brain altogether, while science operates in just the reverse fashion, confining itself to the realm of pure ratiocination and having no contact at all with the soul. Another way of stating this duality is to marshal on the side of music Oscar Wilde’s dictum that ‘All art is quite useless,’ while postulating

7.2.2 What mapping?

The other motivation behind Hermann's recasting of the definition of sonification was the mapping question. Several definitions of sonification have been proposed over the past twenty years or so. For example, Scaletti [81], who gave one of the earliest, saw sonification as having two parts, one to do with information requirements and the other with information representations [8]. Scaletti provided the following definition:

... a mapping of numerically represented relations in some domain under study to relations in an acoustic domain for the purpose of interpreting, understanding, or communicating relations in the domain under study. [81, p. 224]

Barrass reconsidered Scaletti's definition of sonification from a design perspective by substituting the concept of 'usefulness' in place of 'interpretation' [8]. The resulting design-centric definition that sonification is the use of nonverbal sounds to convey useful information embraces both functionality and aesthetics, while sidestepping the thorny issues of veridical interpretation and objective communication. Usefulness allows for multiple sonifications of the same data for different purposes, and provides a basis for evaluation, iterative development, and theory building. This idea was taken up in the NSF Sonification Report of 1999, along with a fallback to a more succinct version of Scaletti's definition of sonification to give the current generally accepted definition:

Sonification is the use of nonspeech audio to convey information. More specifically, sonification is the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation. [51]

Whilst this definition works very well for describing parameter mapping sonifications (where data drive (or 'play') the sound generating hardware; see Chapter 15) Hermann argued that it did not allow for model-based sonification (see Chapter 16) or other techniques not yet developed. In model-based sonification the data itself becomes the sound model and interaction tools are provided to allow the user to excite the model and thus generate sound which is thus itself a representation of the data. In this type of sonification it is the user that plays the data. Hermann states that model-based sonification allows us to "explore data by using sound in a way that is very different from a mapping" and that "structural information is holistically encoded into the sound signal, and is no longer a mere mapping of data to sound". However, even though the rendering of the data into sound takes a different form, there is still a mapping. Any time something is represented in a form external to itself, a mapping takes place; an object from a source domain is mapped to a corresponding object in the co-domain (or target domain). Sometimes the mappings are very obvious and transparent, as in parameter-mapped sonifications, but even model-based sonification involves mappings in this general sense as there are still transformation rules that determine how the data set and the interactions combine to produce sound which represents some state of the system. The mappings may not be simple, but mapping is still taking place.

Recognizing that all perceptualization (e.g., visualization and sonification) involves mapping in some form admits any possible number of mapping strategies whilst retaining the more

that science is the apotheosis of earthly usefulness, having no connection with anything that is not tangibly of this world. [p. xiii]

catholic definitions of Scaletti [81], Barrass [8], and the NSF report [51] and recognizing the potentially interdisciplinary nature of sonification design. Whilst sonification is undoubtedly used *within* scientific method the *design* of sonifications themselves must, we argue, remain an interdisciplinary endeavor as the Auditory Display community originally envisaged.

7.3 Aesthetics: sensuous perception

If sonification allows for (or even requires) interdisciplinary contributions we must consider the question of the role of artistic practice and wider aesthetic issues in sonification design. Sonification is a visualization activity in which sound is used to convey information about data sets.⁷ Perhaps because of the novelty value in the early days of being able to make data go ‘ping’, many sonifications (including recent ones) have been created that are not particularly useful, useable, or meaningful. In the graphical visualization community a debate has been taking place in recent years over the role of function and its relationship with data art. Lima [58] set out the case against data-art-as-visualization thus:

The criticism is slightly different from person to person, but it usually goes along these lines: “It’s just visualization for the sake of visualization”, “It’s just eye-candy”, “They all look the same”.

It is instructive to consider the existing relationships between graphical visualization and art as the sonification field is experiencing similar tensions. The overall purpose of visualization is to shed light on the data being represented in order to allow meaning to be inferred. Information is data that has been given meaning and so without the meaning it remains only data. The process of meaning making can, of course, take place without the agency of a representation (we could begin examining the raw data looking for patterns) but sonification and visualization are concerned with the creation of representations of data that facilitate inference and meaning making. Often the forms of the representations are derived from the form of the underlying data [58] (indeed, de Campo’s Data Sonification Design Space Map [28] was specifically devised to enable sonifications to be constructed in which hidden structures and patterns in the data emerge as perceptible sonic entities) but a foundational premise of design practice is that that form should follow function. Consider, for example, a beautiful piece like Radiohead’s “House of Cards” video [73]. In Lima’s view it ought not strictly to be considered information visualization as it provides no insight, it is pure spectacle. The value of the piece lies solely in its artistic properties as it does not fulfill the criterion of usefulness that visualizations must, it is argued, possess. We could marshal to Lima’s side Redström who identifies a basic issue in interaction design aesthetics which is the question “of how through a certain design we aim to make a computational thing express what it can do through the way it presents itself to us through use over time” [75, p. 1]. Because the “purpose of visualization is insight, not pictures” [21, p. 6] so Redström puts the focus of aesthetics onto “expressions and expressiveness of things” [75, p. 2] and leads us to look at how material builds form through the logic underpinning those expressions. For example, on the subject of tangible interfaces Redström says:

⁷The classical definition of visualization is “the process of forming a mental image of some scene as described” [71, p. 320]. So, by visualization we mean the process by which mental images and cognitions (what we call *visualizations*) are formed from the reading of external representations of data. Those representations may be visual, auditory, or even haptic. Data sets can be repositories of data, such as files, tables, etc. or real-time streams of data events such as would occur in a process monitoring application.

... it is not the fact that they are tangible that is the most crucial part of tangible user interfaces considered to comprise an interface design strategy, but how they aim to deal with the relation between appearance and functionality. [75, p. 15]

Wright et al. [108] suggest aesthetic experience should lie at the heart of how we think about human-computer interaction. This aesthetic-oriented view, they say, takes us beyond studying the way people interact with the technology we have designed and ends up influencing the way we design and build that technology.

7.3.1 Two *aesthetic turns*

Lima is in good and well-established company. William Morris [64] adjured us to have “nothing in your houses that you do not know to be useful, or believe to be beautiful”. When Oscar Wilde proclaimed that all art is quite useless [106] this was not a dismissal of art as an irrelevance but an assertion that the utility of art lies not in terms of work to which it can be put but to its intrinsic aesthetic qualities and value; art *is*, tools *do* — this looks remarkably like another expression of the Two Cultures divide. And yet, product designers increasingly try to make tools that are also beautiful. This view would see the danger for visualization design being when the drive to instill beauty takes gets in the way of utility. Lima [58] argues strongly that “simply conveying data in a visual form, without shedding light on the portrayed subject, or even making it more complex, can only be considered a failure”. If what we are building is neither very beautiful nor very useful, then we have, it would seem, failed altogether. What place, then, should aesthetics have in the work of sonification designers?

Aesthetics is commonly understood today to be the “philosophical study of art and the values, concepts, and kinds of experience associated with art such as taste, beauty, and the sublime” [45]. The word aesthetics stems from a broader Greek root having to do with perception and sense and, prior to the mid-eighteenth century aesthetics was a branch of philosophy concerned with perception by the senses.⁸ Indeed, the word *anaesthetic* literally means the removal of feeling. Synaesthesia (same root) is the bringing together of the senses in perception (e.g. color-hearing). In the mid-eighteenth century a move began amongst German philosophers to consider these issues of taste, beauty, and the sublime. In 1750 Baumgarten defined aesthetics in terms of judging through or by sense. Through the work of Baumgarten’s successors, Kant, Schiller, Schelling, and Hegel, by the end of the nineteenth century an *aesthetic turn* had taken place giving rise to our modern understanding of aesthetics which, according to Nake and Grabowski [65, p. 54], has beauty as a major focus.

The first
turn

Rose-Coutre defines art as “purely and simply an aesthetic object that appeals to the senses in a certain way” [78, p. 5]. In Kantian philosophy, although the central questions are concerned with how we are able to make judgments of beauty, aesthetics occupies the realm of sensibility and aesthetic experience is “inexplicable without both an intuitive and a conceptual dimension” [20]. For Kant, perception and understanding are intertwined, even inseparable. Hegel, building upon Kant’s work, defined art as a sensuous presentation of ideas, something that communicates concepts through our senses and our reason [26]. In Hegel’s world, and somewhat in opposition to Wilde, art for art’s sake is anathema; for him

⁸The etymological root of aesthetics is the Greek word αἰσθάνομαι meaning “I perceive, feel, sense” [38].

art was for beauty's sake as a sensuous (aesthetic) form of expressing truth; art's task "is the presentation of beauty and that beauty is a matter of content as well as form" [43].

The second turn

In recent years a second aesthetic turn has taken place in the fields of data visualization, data aesthetics, and Creative Commons. In the past five years or so there has been a popular uptake of computational tools, technologies, and processes that were previously only available to specialists, scientists, and engineers in centralized institutional labs such as those at NCSA, Nasa, CSIRO, etc. The development of open source or free access platforms such as Processing⁹ and Many Eyes¹⁰ has led to a much broader conceptualization and application of visualization in artistic media, advertising, DIY online culture, and communities that have a wide range of different goals, languages, and evaluative dimensions (e.g., affect, social significance, narrative, production quality, etc.) that are often grouped together under the umbrella term "aesthetics". The different sensibilities of the new designers and audiences in this "second wave" has led to a reassessment of visualization and debates about the differing principles used by first and second wave practitioners. For example, Lima's manifesto [58] is a clear example of the first wave in which functionality is of prime importance. Lima went as far as to describe himself as "a functionalist troubled by aesthetics."¹¹ For the first wave the inherent danger in visualization is summed up well by Carroll [22]:

To some extent however this elegance, which makes data visualisation so immediately compelling, also represents a challenge. It's possible that the translation of data, networks and relationships into visual beauty becomes an end in itself and the field becomes a category of fine art. No harm in that perhaps. But as a strategist one wants not just to see data, but to hear its story. And it can seem that for some visualisations the aesthetic overpowers the story.¹²

"Second wavers", such as Vande Moere, on the other hand, have embraced aesthetics as a tool for visualization work and talk of "information aesthetics", "information aesthetic visualization", and "artistic data visualization" [96, 53]. For them, the second aesthetic turn provides the link between information visualization and data art and requires interdisciplinary practice. Very much in tune with Hegel and the first aesthetic turn, Lau and Vande Moere say that information aesthetics "adopts more interpretive mapping techniques to augment information visualization with extrinsic meaning, or considers functional aspects in visualization art to more effectively convey meanings underlying datasets" [53]. As an example of such interdisciplinary work in practice consider Keefe et al. [48] who described two interdisciplinary visualization projects in which computer scientists and artists worked together to build good representations. They propose a spectrum of representation (see Figure 7.2) at the left end of which lie those visualizations that we would normally label information art with more traditional information visualizations residing at the right hand end. The purpose of this spectrum is not to divide and categorize to help keep art and science and engineering apart but to show that both ends (and all points in between) are valid and meaningful expressions, and that the artist and the researcher should collaborate to develop new techniques and representations.

Figure 7.2 shows that systems with a tight connection to underlying data are highly indexical.

⁹<http://www.processing.org>

¹⁰<http://www.many-eyes.com>

¹¹See Justin McMurray's blog of 3 September, 2009 at madebymany.com: <http://tinyurl.com/5uqlwg6>.

¹²Jim Carroll made this statement in response to a talk by Manuel Lima at BBH Labs in 2009.



Figure 7.2: Indexicality in visualization (adapted from Keefe et al. [48]). The black and white bars indicate visualization tools operating at different ends of the representational continuum. The white bar is a system that is informed by underlying data but in which artistic freedom is the main driver. The black bar would be the position of a system in which artistic expression is much more tightly constrained with the focus being clear representation of a data set.

Vickers and Hogg [100] introduced to sonification discourse the concept of *indexicality*.¹³ Something (a gesture, an utterance, a sign, etc.) that is indexical points to (indicates) some other thing that is external (an entity, an idea, etc.). In sonification practice indexicality becomes a measure of the arbitrariness of a mapping (in semiotic terms an indexical signifier is non-arbitrary and has a direct connection (physically or causally) to that which it is signifying [23]). In sonification it is the data that makes the sound (parameter-based sonification) or user interactions with the data that make the sound (model-based sonification). A sonification system exhibiting high indexicality is one in which the sound is derived directly from the data (for example, through the use of direct data-to-sound mappings). Low indexicality arises from more symbolic or interpretative mappings.

Keefe et al. [48] discovered that getting artists and visual designers to help with a visualization project at the design level from the outset is key and bears much more fruit than using them for “turning the knobs of existing visualization techniques” [p. 23]. Artists, they say, routinely “provide a unique source of visual insight and creativity for tackling difficult visual problems”; they do more than “merely making a picture pretty or clear for publication”. For Keefe et al. the integration of function and aesthetics is a desirable challenge. It is the artist working within the tight constraints of programmatic data mappings and the computer scientist facing the issues of visual design that creates the opportunity for them to work together “to design novel visual techniques for exploring data and retesting hypotheses”. For an example of this at work in sonification design, see Stallman et al. [92] who used a composer to help in the design of an auditory display for an automated telephone queue management application.

7.3.2 Aesthetics as a guide

Aesthetics or, specifically, aesthetic perception then, is a framework we use for making judgments about artistic works. Thanks to the aesthetic turns, when the word *aesthetic* is used in the same breath as sonification or auditory display it is often automatically assumed that one is talking about artistic qualities or properties. Just like the first-wavers would claim for visualization, sonification, the argument goes, belongs to science and engineering

¹³Indexicality is a concept from philosophy which is often used interchangeably with the linguistics term *deixis* and is also used in semiotic explanations of *sign*.

and we should not be discussing it as if it were art. The problem here though is that this is something of a false dichotomy predicated upon the assumption that art and science are somehow incompatible bedfellows. The issue here is that aesthetics is not synonymous with art. Aesthetics is about more than art, at its core it is about sensuous perception— we make aesthetic judgments every day about the products we buy (or don't buy), the clothes we wear, and the tools we use.

In recent times, as computer graphical user interfaces and interactive systems have become functionally richer and more impacted by graphic design, we are increasingly employing our aesthetic sense-making faculties in our engagement with them. Although aesthetics clearly plays a role in how we respond to the visual presentation of an interactive system, Graves Petersen et al. [37, p. 269] claim that it is a mistake to assume that aesthetics is restricted to visual impressions. Whitehead's claim that art "is the imposing of a pattern on experience, and our aesthetic enjoyment is recognition of the pattern" [105] suggests that whilst aesthetic judgment is required for enjoyment of art, the fact that patterns are involved means that there is potential for leveraging aesthetics in the design and use of visualization systems whose primary purpose is about gaining insight into data. Nake and Grabowski [65, p. 62] go as far as to say that because aesthetics is concerned with sensuous perception, questions of beauty are secondary. Graves Petersen et al. [37, p. 270] support this view by saying that those "who view the potential of aesthetics as the possibility to provide users with a pleasing visual appearance of products are leaving out much of the potential of aesthetics". They boldly claim that far from being an "added value" or even "an adhesive making things attractive" aesthetics is "an integral part of the understanding of an interactive system and its potential use" [p. 271].

In mathematics aesthetics has long been understood to play a vital role. Mathematicians strive to find simpler ways of describing an object or phenomenon. Sometimes this is for simplicity's sake, other times because the application of the simpler representation to a real-world problem makes the calculation easier or faster. Einstein's guiding principle was to seek mathematical beauty or simplicity. The physicist Paul Dirac took this idea even further in his "Principle of Mathematical Beauty". For Dirac, the more theories revealed about nature the more beautiful they would be; ugly theories could not be right. So, for mathematicians, truth and beauty are intertwined: beauty reveals truth and the truth is beautiful. But the point is not that mathematicians are seeking beauty for its own sake, but that the simple, that is, the beautiful, brings understanding more readily. To give a very practical example, metrics for aesthetics in graph drawing include the number of edge crossings (the fewer the better) and the amount of symmetry exhibited by the graph (the greater the better) [53]; both of these measures are associated with a graph's readability. So, aesthetics deals with judgment using the senses, and the easier the representation makes such judgments, the better the representation is. However, we must be careful not to assume that just because something is beautiful it is, therefore, interesting. In a discussion of his work on algorithms for generating low-complexity ('simple') art, Schmidhuber [86] says:

Interest has to do with the unexpected. But not everything that is unexpected is interesting — just think of white noise. One reason for the interestingness (for some observers) of some of the pictures shown here may be that they exhibit unexpected structure. Certain aspects of these pictures are not only unexpected (for a typical observer), but unexpected in a regular, non-random way. [p. 102]

Just as Keefe et al. [48] recognized for visualization design, there is a tension in the design of auditory representations that requires aesthetic and artistic expression constrained by computational issues of data mapping. With regard to sonification design, Vickers [99] asserted:

The larger questions of sonification design are concerned with issues of intrusiveness, distraction, listener fatigue, annoyance, display resolution and precision, comprehensibility of the sonification, and, perhaps *binding all these together, sonification aesthetics*. [emphasis added] [p. 57]

Indeed, Pedersen and Sokola [68] cited an impoverished aesthetic as being partly responsible for people growing quickly tired of the sonifications used in their Aroma system [99]. Kramer [49] was particularly frank:

Gaver relates that SonicFinder was frequently disabled, Mynatt reports that poorly designed sounds degraded Mercator, and Kramer considers some of his sonification experiments downright ugly. [p. 52]

7.3.3 A pragmatist solution

If we can accept that aesthetics is not *only* about the art, when we consider sonification (and visualization more generally) we might go as far as saying that aesthetics isn't about the art at all.¹⁴ By that we mean that thinking of aesthetics as being the framework for making decisions about artistic value and taste is unhelpful in this context because it limits what we can do and even diverts our thinking, thereby distracting us from considering what aesthetics can be used for: the design of effective sonifications that promote sense-making, understanding, and pattern recognition. Far from being the pinnacle of artistic expression, in sonification good aesthetic practice helps us to achieve ease of use which Manovich [61] describes as “anti-sublime”. Being products of the first aesthetic turn the Romantics, Manovich points out, were concerned in their art with the sublime, with those phenomena and effects that go “beyond the limits of human senses and reason”. Therefore, visualization systems are necessarily anti-sublime for their aim is to make representable the data sets underlying them.

The question, then, becomes how may aesthetics be applied or leveraged in the design of sonifications? For the mathematician aesthetics “involves concepts such as invariance, symmetry, parsimony, proportion, and harmony” [33, p. 9] and mathematics can be interrogated in the light of these factors. In physics aesthetics “is often linked to the use of symmetries to represent past generative states” [56, p. 307]. In sonification design we are presented with many of the same challenges that face designers of interactive computer systems who are trying to ensure a positive user experience. The problem is that one cannot design *a* user experience one can only design *for* user experience [87, p. 15]. In aesthetic terms this is the difference between analytic and pragmatist aesthetics. In Moore's [63] analytic view aesthetics exist as objects in their own right and are intuitively apprehended by a viewer [37]. In this paradigm the aesthetic properties arise when the artist or designer creates an artifact and they await being found by the viewer/user with the resultant implication that they

¹⁴Aesthetics is not about art any more than a painting is about the technology and chemistry of pigment design and manufacture, except that they are interdependent. Without the technology there is no art; without aesthetic input there is no meaningful or usable visualization.

have some objective reality. This parallels the view that a software designer can intend for a product to have a particular universally shared user experience. What the analytic view does not take into account are the socio-cultural factors that affect how an artifact is perceived [37], or *experienced* to use Dewey's [31] terminology (see also Macdonald [60]). Graves Petersen et al. [37] observe:

Dewey insists that art and the aesthetic cannot be understood without full appreciation of their socio-historical dimensions ... that art is not an abstract, autonomously aesthetic notion, but something materially rooted in the real world and significantly structured by its socio economic and political factors. [p. 271]

Dewey's *pragmatist* stance recognizes that aesthetic experiences are the result of "the engagement of the whole embodied person in a situation" [108, p. 4]. This pragmatist aesthetics perspective reconciles us to the assertion that user experience may only be designed *for*, that we must do all we can to maximize the opportunities for meaningful dialogue with our sonifications, but recognizing that the experience will not be universal. Sonification engages the user in a sense-making process and as designers we need to remember that the user's interaction with the system "is based on not just the immediate sensational, but it builds upon earlier experiences as well as it draws upon the socio-cultural" [37, p. 272]. As Sharp et al. put it, "one cannot design a sensual experience, but only create the design features that can evoke it" [87, p. 15]. Wright et al. [108] suggest that because we cannot build the aesthetic experience (nor, in fact, significantly control the user's experience) our job as designers is to "provide resources through which users structure their experiences" [pp. 9–10].

In the pragmatist paradigm aesthetics is a kind of experience emerging from the interactions between the user and the context (including cultural and historical factors), and it is located in neither the artifact nor the viewer exclusively [108]. This pragmatist aesthetics takes into account that interaction is constructed as much by the user as by the designer and that the sense-making process involves not just cognitive skills but also "the sensual and emotional threads of experience situated in time and place" [108, p. 18]. In Kant's aesthetic worldview, the beauty of an object does not exist in the object itself but is a property that emerges as we respond to the object. For Kant, beauty was linked irrevocably to an object's form.¹⁵

In an application of pragmatist aesthetics to interaction design, Wright et al. [108] argued a need to place "felt life and human experience at the center of our theorizing and analysis". They observed:

But putting aesthetic experience at the center of our theorizing about human-computer interaction is not just about how we analyze and evaluate people's interaction with technology; it affects the way we approach the design and making of digital artifacts. Our ... work, which has brought together software developers, electronics engineers, and contemporary jewelers, has provided a fertile ground for reflection on the process of interaction design and the way digital artifacts are framed within traditional HCI practice. [pp. 18–19]

They conclude that "if the key to good usability engineering is evaluation, then the key to

¹⁵For Kant, beauty was universal (or rather that which one would perceive as beautiful one would assume is a universal response even though it might not be in reality) but the perception of beauty is arrived at through a disinterested inspection. By that Kant means that the judgment is made independent of any interest we might have in the object, independent of its content, its moral or financial value, etc. The judgment of beauty is made only in terms of the object's form (its shape, its composition, its texture, etc.).

good aesthetic interaction design is understanding how the user makes sense of the artifact and his/her interactions with it at emotional, sensual, and intellectual levels”. It becomes unhelpful to think about the aesthetics of artifacts in their own right as aesthetic potential is only realized through interaction or use which is dependent on context [37]. The pragmatist outlook also breaks the close bond between aesthetics and art thus providing “the basis for focusing on the aesthetics of interaction related to our everyday experiential qualities when engaging in and designing interactive systems” [37, p. 271]. The focus now shifts to how an artifact is appropriated into someone’s life and how this is shaped by prior expectations, how the user’s activities change to accommodate the technology, and they change the technology to assimilate it into their own world. The emphasis is on meaning in use: how the user’s talk about technology changes, possibly even how the artifact ceases to become a topic of conversation, is a valuable source of data. One of the implications of this approach is that it takes place *in situ* and is oriented towards longer-term processes of change. Various forms of interpretive phenomenological analysis (IPA) are proving useful empirical techniques in this regard (for example, see Ní Chonchúir and McCarthy [66] and Light [57]). IPA is a psychologically-based qualitative research method that complements the more sociological grounded theory. Its aim is to gain insights into how a person experiences, or makes sense of, a phenomenon. Typically such phenomena would be of personal significance to the person being studied (e.g., changing job, moving house, starting a relationship, etc.) but IPA has also been used to study less personally-related phenomena such as using interactive computer systems or web sites. For instance, Ní Chonchúir and McCarthy [66] showed how IPA could get very personal insight into the user experience of Internet usage. Light [57] used IPA to study the experience of receiving phone calls to learn more about the issues that should be addressed in the design of mobile telephones. Traditional metric- and task-performance-based techniques have been used to measure sonification design factors such as accuracy, recall, precision, efficiency, etc. Whilst one could measure the improvement on performance of auditory displays that have been designed to maximize their aesthetics, aesthetic judgment itself remains primarily experiential and so we can envisage using qualitative tools like IPA not only to gain more understanding of how users experience sonifications, but to evaluate the aesthetic dimension more richly.

Raijmakers et al. [74] found that using a documentary film format to present personas of typical customers to product designers. They found that the films gave “access to incidental details that might or might not be important for design—the patients’ activities, homes, aesthetic tastes, ways of expression, etc.—since these things made the personas “come alive” for them as characters who might use future products.” If sonification is to move out of the lab and into the home, to become embedded in mainstream products, it is possible that radical techniques like this will enable us to get more understanding of the target user community.

7.4 Towards an aesthetic of sonification

If we admit the necessity of addressing aesthetic issues in sonification design and recognize that approaches such as pragmatist aesthetics offer useful frameworks for thinking about our aesthetic practice, the question still arises as to what *are* sonification aesthetics? What do they sound like? Are there some specific guidelines that, if codified, will guarantee (or at least offer the chance of) successful aesthetic expression? After all, areas such as graph theory and web design have established aesthetic metrics, sets of rules which, if followed,

promise an easy-to-read graph or a usable web site. However, it has been observed that often many codified aesthetics are contradictory and so cannot all be achieved in one piece of work [71]. Furthermore, sonification is not a discrete singular discipline, it occupies space in perceptual psychology, computer science, engineering, sound design, and sonic art drawing to varying extents upon skills in all those fields (and others besides, no doubt). Sonification comes in many different styles using different sonic techniques each of which may have its own set of specific aesthetics. Take the case of musical renderings. If we draw on music

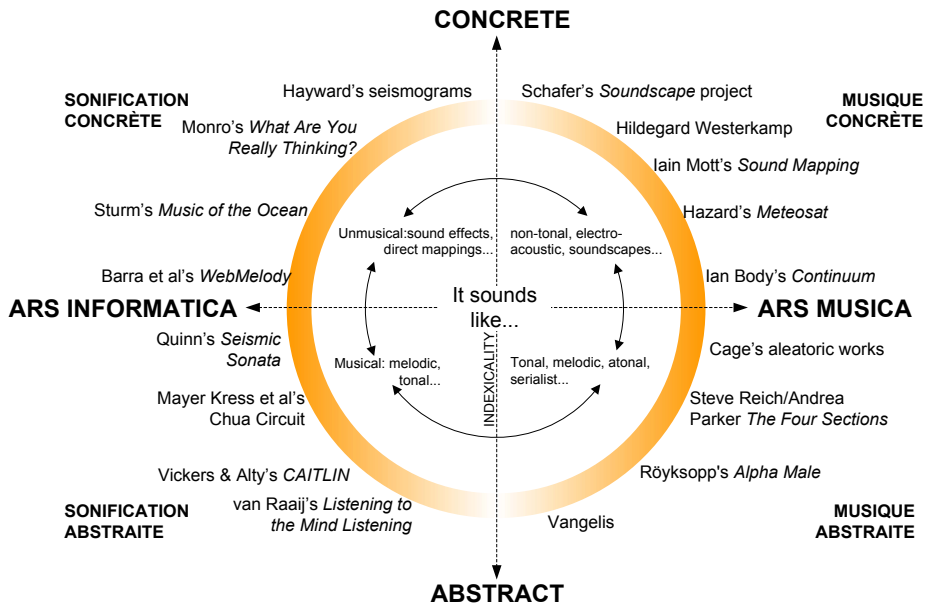


Figure 7.3: The Ars Musica — Ars Informatica Aesthetic Perspective Space (from Vickers and Hogg [100]).

practice for inspiration we see many different genres each with its own aesthetic rules. For example, Vickers and Hogg [100] suggested an aesthetic perspective space (see Figure 7.3) which associates sonifications with their closest analog in the musical world, the idea being that if a sonification is organized, say, along the lines of a piece of tonal music then it could draw upon the aesthetics of tonal musical composition (assuming an appropriate sub genre can be identified); likewise, a sonification that is organized like a piece of *musique concrète* could draw upon electroacoustic aesthetics. But each musical style has its own, quite distinct, aesthetic.

Sound design, arguably the field of sonic practice most closely related to sonification, is filled with practitioners who develop their own personal aesthetic rather than adhering to some definitive ‘red book’ of sound design. Sonification aesthetics is still in its infancy as far as detailed research goes and so we are not yet at a point where we can offer a definitive set of aesthetic guidelines. It is not even known whether any such set of guidelines is possible or, for that matter, even desirable. In reference to their work on aesthetic interaction design, Wright, Wallace, and McCarthy [108] said “nor does it seem sensible to talk of principles or

guidelines for designing enchanting experiences”.¹⁶ Lavie and Tractinsky [54] observe that aesthetics is still marginalized within HCI, commenting that “readers of human-computer interaction textbooks can hardly find any reference to aesthetic considerations in design”. They did, however, begin studies to discover what factors might make good measures of aesthetic quality in interactive systems (specifically, web sites). What we can offer at this stage, then, are some indications of where the interesting ground may lie and what aspects of auditory information rendering appear worthy of systematic and detailed attention in future research explorations. Addressing the aesthetics of large-scale information visualization systems, Quigley [71] identifies four different problems affecting the visualization of data using large graphs:

1. Graph drawing aesthetics
2. Computation
3. Screen space aesthetics
4. Cognitive load

He further breaks graph drawing aesthetics down into two subcategories, *drawing aesthetics* and *abstract representation aesthetics* both of which contain a number of organizing principles (such as the need to maximize symmetries, the avoidance of overlapping groups of nodes, etc.). These aesthetic principles are fairly tightly defined but relate only to a single visualization task, that of representing large data sets with graphs. Other visualization techniques will have their own aesthetic ‘rules’. If we are to move towards such sets of rules for sonification we must first classify the different types of sonification practice. There are simple gross distinctions that can be made, for example between parameter-mapped sonifications and model-based sonifications, but even within these, as this volume attests, there are different representational techniques that can be used each of which is likely to have different aesthetics.

7.4.1 Aesthetic premises and oppositions

However, to see where the sonification aesthetics research focus might be placed, it is possible to offer some general areas which will affect aesthetic practice. In *Microsound* [77] Curtis Roads set out a collection of aesthetic premises and aesthetic oppositions that he found helpful to consider when composing in the granular synthesis domain. Some of the principles dealt with issues related to electronic music generally whilst others were concerned with the specific properties of the microsound domain. Whilst they do not especially inform sonification design practice, the very existence of an aesthetic philosophy for this relatively new area of music composition suggests that an undertaking to formulate an aesthetic philosophy for sonification might be fruitful. Perhaps more relevant to the subject at hand are the aesthetic oppositions which might serve as a basis for beginning the discussion about the aesthetic guidelines to which sonification designs might usefully adhere. Roads’ ten oppositions are as follows:

1. Formalism versus intuitionism.
2. Coherence versus invention.

¹⁶Enchantment is a particular branch of experience which deals with the feeling of being caught up in something.

3. Spontaneity versus reflection.
4. Intervals versus morphologies.
5. Smoothness versus roughness.
6. Attraction versus repulsion in the time domain.
7. Parameter variation versus strategy variation.
8. Simplicity versus complexity.
9. Code versus grammar.
10. Sensation versus communication.

By stating these aesthetic dimensions in terms of opposites requires us to consider what is meant by sounds at either pole. For instance, when would smooth sounds be more suitable than rough sounds, and vice versa? To these oppositions we may add Leplâtre and McGregor's [55] basic aesthetic principles for sonification design: homogeneity of the design, temporal envelope, and sonic density. Leplâtre and McGregor found that "functional and aesthetic properties of auditory cannot be dealt with independently" and so to their and Roads' categories we might add low-level functional measures such as usefulness, usability, pleasantness, functionality, ergonomics, intuitiveness, learnability, and enjoyability (or, perhaps, annoyance). Some of these terms have analogs in the HCI/interaction design fields, though it should be noted that the trend in HCI is away from pure metrics and towards designing for user experience (hence the rise in phenomenological methods). As Roads noted, an aesthetic philosophy "is nothing more than a collection of ideas and preferences that inform the artist's decision-making" [77, p. 326] and so we must be careful not to treat as sacred any list of aesthetic guidelines. Even if aesthetics could be codified, they still require talent and skill to implement them; the talent must be innate and the skill must be taught or otherwise acquired. Any skilled practitioner also needs to know how and when it is appropriate to break the rules.

7.5 Where do we go from here?

To improve the aesthetics of our sonifications, then, we argue that first and foremost the designers of sonifications either need to be skilled in aesthetic thinking and practice or they need to work with someone who possesses such skills. We are beginning to see higher level university courses that embrace art and technology and which educate people to be literate and capable in both, and they show that technologists can learn aesthetic skills just as artists can learn to write code. But such courses are few and require a concerted will to think and work in an interdisciplinary way (which cuts against many university departmental structures and funding models). Until such a time as the majority of sonification designers possess aesthetic design skills we repeat Kramer's initial call for interdisciplinary work. Where Kramer called for the community to work with composers, the net needs to be cast wider to include sound designers and other sonic artists, all the while keeping our eyes on the goal which is to produce auditory representations that give insight into the data or realities they represent to enable inference and meaning making to take place.

In sonification and auditory display, where hard evidence of insights produced by the

auditory representations is much less common than in graphical visualization, the integration of function and aesthetics is even more urgent and problematic, especially in the light of the strong affective and cultural aspects of sound that we have through musical education and experiences.

Sonification is becoming embedded in everyday objects and activities. This means that issues of desire, branding, emotion, and narrative will become increasingly important as they already have in graphical visualization. Where graphical visualization draws on graphic design these directions suggest that we can draw on sound design for commercial products (and toys) and film sound in the next era of ubiquitous everyday sonification where sonification becomes a commercial, domestic, consumer, mass medium. Whilst composers are not, of necessity, focused on functionality or accessibility to a broad audience, product designers and film sound designers are.¹⁷ How does one design affective and persuasive sonifications? The question of beauty and its relationship to utility has been raised for both sonifications and graphical visualizations. This is where design thinking and aesthetic practice could help. Figure 7.4 shows that aesthetics (sensuous perception) is the common thread in sonic art and sonification and we contend that the wall between sonic art and sonification has been put up unnecessarily and that treating sonification as a truly interdisciplinary design process offers much scope for informing the work of the auditory display community as it matures and develops.

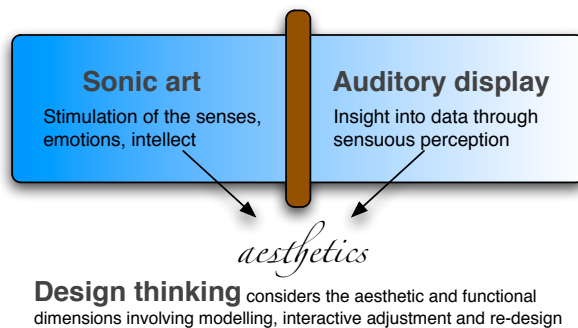


Figure 7.4: The wall between sonic art and sonification/auditory display is a false one. Aesthetics is a framework for working across the spectrum.

Despite the promise of sonification to provide new insights into data there is little to show in the way of scientific discoveries made through sonification in the past twenty years. A definition of sonification focusing on usefulness and enjoyment reconfigures sonification from an instrument solely for scientific enquiry into a mass medium for an audience with expectations of a functional and aesthetically satisfying experience. A design-centered approach also moves sonification on from engineering theories of information transmission to social theories of cultural communication. Developing this theme Schertenleib and Barrass [84] are developing the concept of sonification as a social medium through the Many Ears site for a community of practice in data sonification.¹⁸ This site is modeled on the Many Eyes

¹⁷Of course, the popular music industry is predicated precisely upon appealing to a broad audience. However, there is nothing about musical composition *per se* that demands this.

¹⁸<http://www.many-ears.com>

site for shared visualization and discovery that combines facilities of a social networking site with online tools for graphing data.¹⁹ Anyone can upload a data set, describe it, and make it available for others to visualize or download. The ease of use of the tools and the social features on Many Eyes have attracted a broad general audience who have produced unexpected political, recreational, cultural, and spiritual applications that differ markedly from conventional data analysis. The Many Ears project seeks to find out what will happen when data sonification is made more available as a mass medium. What new audiences will listen to sonifications? Who will create sonifications and for whom? What unexpected purposes will sonification be put to? [84]

Kramer's 1994 call (echoed a decade later by Vickers [98]) to include composers in the sonification design process [49] is as relevant today as it was then, and extends to sound artists, sound designers, film sound, and interactive product designers. At this stage it would appear that there is great potential for sonification to become a medium for communicating information about data sets to a broad music-listening audience who also have expectations of an aesthetically satisfying experience. A positive way forward is to adopt an approach that does not polarize art and science along some artificial simplistic dimension. Design thinking requires an approach that accepts that there are multiple constraints and multiple solutions in any problem domain. A good solution is one that addresses the requirements of the brief, which may involve qualitative and quantitative aspects, and proper attention to the context and the audience. Auditory display is an exciting field at the intersection of future developments in music, design, and science and we look forward to the hearing the progress in these directions.

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