LISTENER-CENTRED SONIFICATION PRACTICE AS TRANSDISCIPLINARY EXPERIMENTAL ARTISTIC ENGAGEMENT

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ABSTRACT: Project RADICAL presents sonification research and practice as a listener-centred, transdisciplinary activity. In this chapter, authors discuss sonification from perspectives of artistic and musical practice. Particular emphasis is placed on spatial listening, embodied experience, environmental interaction, and communication, resulting in an interrogation of methodology, objects and foundations often assumed for sonification. The reader is invited to apply an ethnographic ear to a roundtable presentation investigating new sonic and musical practices that converge upon a reframing of sonification as engaged aesthetic activity productive of and carrying new technical and epistemic knowledge.

KEYWORDS: Ethnography; embodied listening; phenomenology; aesthetics; space.

INTRODUCTION

Project RADICAL is a group of artists, composers and creative programmers exploring new ways of making and listening to sonification.[1] Our research places the position of the listener as a central concern which inspires us to design intersections between sound and information by which we can investigate how meaning is constructed through listening experiences.

Working in a variety of media, we approach sonification transdisciplinarily, necessitating an expanded notion of aesthetics in both our sonifications and our artworks. For sonification, this means locating this body of practices outside any particular disciplinary purview, making it available to any whom it might be useful for any purpose. Meanwhile, we allow the meaning of terms like sound art, fine art, or music, to remain open to being defined by the listener. This facilitates the exploration of new sound experiences that aim to provoke questions of how sound and meaning are co-constitutive.

This chapter outlines aesthetic and conceptual frameworks and provides practical examples of the working practices and ongoing research of

1] Project RADICAL is funded by a Leverhulme Trust Research Project Grant (RPG-2020-113). See https://projectradical.github.io/

the group's members. Our work can be heard to resonate in a landscape in which information sharing takes place in a performed, participatory environment that accommodates feedback. We re-examinate aesthetics as grounded in practice, actively investigating phenomenological methodologies for spatial audio and temporal listening. We seek to create sonification work transdisciplinary in both approach and impact: an open family of practices that will be further developed within many disciplines.

We offer the reader an opportunity to apply an ethnographic ear to our work. Below, each of us in turn narrates his individual engagement with sonification through brief discussions of the new sonic and musical practices and how they intersect with technical and epistemic approaches in our creative work. The reader thus has the opportunity to join our discussion as a questioning participant rather than a passive receiver of information.

Our approach mirrors a key concern of our project, which is to reconsider foundational notions of aesthetics, transforming them into productive and performative tools. To this end, we take embodied listeners and information as data systems that encounter one another co-productively within sound environments. In such encounters, speculative objects enter the world through aesthetic processes of perception. By placing the listener at the centre of the experience for sonification, and considering aspects of the sounding environment to include multi-perspectival spaces and temporalities, we resonate with formative notions of 'aesthetics' alongside the formation of knowledge itself.

The turbulence at this intersection reminds us of Gaston Bachelard's writing on the emergence of scientific knowledge as the realm of tangled confusion, of trying out, and the resistance of the inertia of preconceived opinions. Knowledge is repeatedly in need of those "epistemological acts... that bring unexpected impulses into the scientific development" (Bachelard, 2002, p. 136). Another resonance we consider fundamental is one which allows aesthetics to be defined as experience itself, which comes from the Greek words on which the English usage of 'aesthetics' is based: *aisthetikos*, meaning, among other meanings, 'of or for perception by the senses, perceptive', and *aisthanesthai* 'to perceive (by the senses or by the mind)'. It is with these fundamental aesthetic notions that we hope to render information perceptible, and viscerally.

DATA: THE VERY IDEA, AND THE PURPOSES OF SONIFICATION

John Bowers

Let us take a moment to reflect on something so obvious that it is often passed over. Just what is data? As a first critical observation, perhaps we should refer more to capta (things taken) than data (things given). Many philosophers of science, at least since Popper (1935), have emphasised the theory-laden character of data. Data already reflect the purposes and practices of those who 'gather' or 'capture' them. This is most spectacularly clear in quantum physics where, for around a century, it is known that how matter appears, as a wave or as a particle, amongst many other issues, depends on the arrangements of apparatus and the kinds of measurements taken. For a writer like Karen Barad (2007), who critically extends the perspectives of Niels Bohr, this suggests that the apparatus co-constitutes the phenomena observed. Any framing that we assert on the world, between what is inside the experiment and what is regarded as background context, in part creates the phenomena we observe. While Barad is writing about quantum physics, she intends these points more generally. Indeed, it should be obvious to any psychologist, social scientist or, for that matter, opinion pollster that what instructions are given to participants, how a question is articulated, what range of possible answers are given or what coding methods are adopted, are careful matters of design. Measurement technologies and related apparatuses, from webforms to heart monitors, all involve exclusions (of backgrounds from foregrounds), alignments (of the subject-objects of investigation with some scale and some agency, human or otherwise, taking readings), in line with some (tacit or otherwise) purpose. In a sense, data arrives late on the scene, not at the very beginning.

Perhaps we can summarise these points in a slogan: No datum is innocent. Taking this seriously might suggest some reorientations for sonification's research agenda. Rather than taking a given data set for granted, as a 'gift' from the application domain, can we situate sonification in the extended field of capta, where the 'cuts' between what is studied and what is excluded, and the choices of framing, alignment, and purpose that make capture and gathering possible, are also our concern?

Relatedly, let us follow some observations in anthropologically and sociologically inspired studies of scientific practice and observe that data is taken in specific places: in the hospital, in the experimental cubicle, on the street, through the webform. Data is recorded using particular material

technologies, the kinds of things Bruno Latour (1987) calls "immutable mobiles", that enable transportation from one place to another without what is moved being destroyed in the process. Copernicus employed reliable scribes so that astronomical observations from throughout Europe and the Arabic world could be brought to him. In the US 1890 Census, punch cards were more durable and practical than the census taker's hand-written transcriptions of what they were told. Data is taken to and accumulated at centres, particular places, it does not lie around just anywhere. It is in laboratories or the Census Tabulating Offices. In an environment of domestic computing, data is on the hard drive, not behind the sofa. Data accumulates in places which Latour calls "centres of calculation" — centres which connect to, and indeed help to constitute, their peripheries by '(re-)representation paths'. It is at such centres that comparisons and juxtapositions are made.

What should a centre of calculation containing sonification(s) be like? Where would it be? How would its sonic displays relate to the other displays, charts, tabulations, graphs, inscriptions, visualisations that are in play in such places? Whether that place is as big as an observatory or as small as a smart watch, there is a value in thinking ecologically to ask not (just) what is in the sonification but what the sonification is in.

Very commonly sonification research concerns itself, much like classical experimental psychology, with subjects which are making judgments, finding regularities, being sensitive to similarities and differences, making responses that can be evaluated for their truth or accuracy. Clearly, there are many other activities that listeners can engage in and that auditory displays can be designed for. We can design to incite interest, perhaps to draw someone over to examine something with us. We can facilitate curiosity, perhaps for something that might otherwise be neglected. We can enable imagination, perhaps for circumstances where we have become blocked. We may wish to foster intuition somehow, where the path of reason is getting us nowhere. We may wish to create the circumstances for conjecture, for guesswork and wild hypotheses, to get a new perspective on an old concern. Perhaps, we may wish to experience something aesthetically beautiful or challenging because why on earth would we want to not do that? The point is that all these possibilities involve an orientation other than the kind of judgmental truth that goes on in the classical experimental paradigms of sonification and psychologically-informed user research. This is not to say that interest, curiosity, imagination, intuition, conjecture, aesthetic appreciation and the rest are opposed to judgments of rationality

or truth. Indeed, it seems preferable to explore epistemologies where all are equally forms of thought-practice that variably entwine in the different activities that engage us.

Again, some new framings for sonification suggest themselves. Ask not (just) what the sonification represents but what it does. How do we design sonifications that do things (in addition to or) other than represent or 'perceptualise' phenomena? Things like incite curiosity, enhance appreciation, facilitate imagination, give joy, thrill?

RE-ENGINEERING AESTHETIC ASSUMPTIONS FOR RE-PRESENTING DATA

Paul Vickers

My whole research career has been centred on sonification. I started out wishing to combine interests in music and computing and landed upon the idea of using musical motifs to signal the execution paths through running programs to assist with debugging. Along the way I found that as a technologist I was increasingly grappling with creative pursuits. Coming at sonification from utilitarian and engineering perspectives, the intended goal of my labours is not to create an aesthetic experience. The creative pursuit here was exploring how to get my technology to do what I wanted. Aesthetic considerations were bracketed and treated as side products with the main focus being on how to ensure that the sound allowed the listener to construct precise and reliable information from the data that had been transcoded and transduced into audio.

When I began my endeavours in the mid '90s, sonification was an emerging niche discipline fuelled by the recent availability of affordable computer sound cards. My computer scientist mindset held that every problem and phenomenon could be neatly categorised and placed on a taxonomical chart (I am a programmer, after all). My limited formal musical education lacked an appreciation of the discourses around composition, aesthetics, sonic art, electroacoustic music, modes of listening, and so on. Aesthetic judgements were more concerned with how to make an auditory display that sounded 'nice' and which could be easily rendered diatonically using only a General MIDI sound set and the SoundBlaster SDK. The sublime, for me, was to be found in programming the technology

to turn data into sound; 12,000 lines of well-written source code was my aesthetic experience.

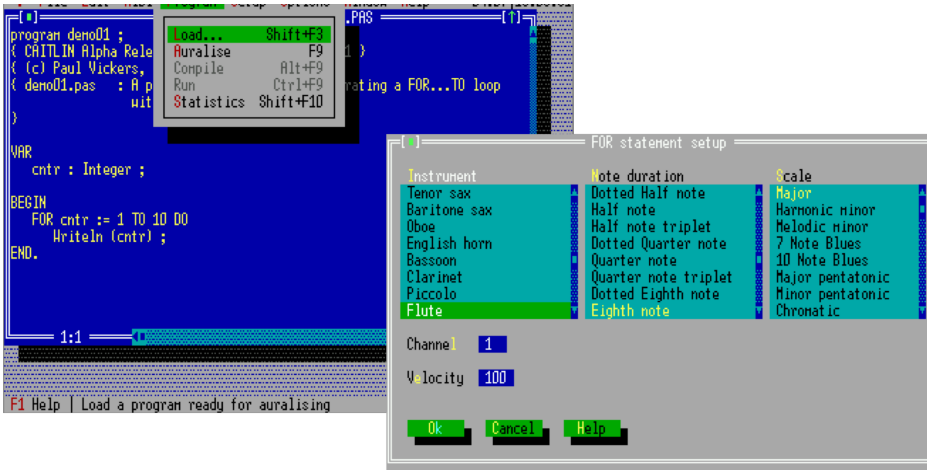

Figure 1: *The result of 12,000 lines of beautiful code! (Author's own work)*

When I began to discuss sonifications with composers and other practitioners of the mysterious 'sonic arts' I was confronted with new worldviews that challenged my narrow black-and-white taxonomical thinking. As I interrogated current sonification practice I saw that the aesthetic plays a vital role and, if not understood well and addressed properly, the result is impoverished auditory displays, both in terms of aesthetic experience and the ability to communicate data.

The simple definition of sonification is the use of non-speech audio to represent data or data relations. However, lurking beneath the surface of the seemingly innocuous word 'represent' is a world of unexplored problems and challenges. Data possess no sound of their own, so any sonic indices we attach to them are (with the possible exception of the edge case of data audification) purely conventional (in the semiotic sense) and come laden with a host of philosophical, experiential, aesthetic, and phenomenological challenges — sonifications sometimes behave so strangely (Vickers, 2020). What, exactly, do we mean when we say that this sound represents that data? Do we mean the sound stands in for the data? Or are we in some ontological way saying that this sound is re-*presenting* the data to us now in this time and place? Or both? Or neither? Would the word 'reveal' (an unveiling or apocalypse) be a better fit here than 'represent'?

In 2006 Bennett Hogg and I began a programme of work to build a more theoretically-grounded framework for talking about and understanding sonification aesthetics (Vickers and Hogg, 2006). I am now firmly of the view that any work that seeks to seriously understand sonification design needs to account for embodied perceptual experience including an account of the aesthetic and phenomenological issues raised by the auditory presentation/representation/re-presentation of data. This necessitates going beyond understanding the psychoacoustics and psychophysics of sound and to embrace the messiness of sound being experienced and perceived by whole living organisms (people as mind, body, and soul) in complex situations and listening environments.

I have needed to learn to approach aesthetics from a new perspective. For much in the world of computer science aesthetics is limited to what sounds 'pleasant' (whatever that means). There is something of a phenomenological turn that needs to be taken in sonification: we must learn to appreciate the role of the senses in listening to sonifications and all that this entails and implies. This goes beyond mere judgments of pleasantness and raises issues of sense, perception, feeling (both physical and emotional), and so forth. To think about sonification design purely in technological and utilitarian terms is to ignore the messiness of the embodied listener who possesses sets of experiential and enculturated understandings that affect the way they will experience, listen to, and comprehend what the technology is attempting to reveal to them. To do this well we need to understand both the technology and the language(s) employed in both the revealing and the perception.

DATA WAYFARING: SOUNDWALKING THROUGH SONIFICATION

Tim Shaw

Both soundwalking and sonification are possible methods for revealing and attending to aspects of shared perceptual environments. Soundwalking is a method for increased awareness of an environment through movement and listening. Developed through the research of the World Soundscape Project, the practice of soundwalking was through an acknowledgment of the changing soundscape of Western Canada in the 1970s (Westerkamp, 1974).

Figure 2. *Listening to an escalator through a contact microphone during an Ambulation soundwalk. (Credit: Vincent Ducard and Sonic Protest, Paris).*

Sonification is the practice of turning data into sound, a way of being able to understand complex data streams through listening. Sometimes used as an alternative to visualisation, it is a method commonly employed by scientists, designers, artists and musicians in an attempt to understand and render data in new ways (Hermann et al, 2011).

Data Wayfaring proposes a combination of these two practices, a listening walk engaging with environmental signals, investigating an unorthodox way of approaching the sonification of data through physical movement. This piece extends two of my previous projects, Ambulation and Netwalk. Ambulation (Shaw, 2020) is a soundwalk which uses field recording techniques and listening technologies to create a walking performance using environmental sound. Netwalk is an augmented soundwalk which broadcasts altered soundscapes and processed video to an online audience using internet streaming technologies. Developed during the lockdowns of 2020 it has become a method for sharing an embodied soundwalking experience to remote audiences. The research around the development and presentation of these sound walks contributes to the idea of field recording and sound walking as a live, procedural practice.

This represents movement away from the notion that recording is only the movement of documentary material from one place to another or the playback of fixed audio files.

I have been conducting augmented sound walks since 2014. In these pieces I walk with an audience through a given environment equipped with various listening technologies. I tune into live signals from the immediate space, sometimes processed through the microcomputer, using them as raw material for improvised performance. I propose, through soundwalking, a flattening of composition and performance, of audience and performer, of process and product. Through my Ambulation sound walk (Shaw, 2020) the act of field recording is not only the process of moving material from one place to another but a live, performative act with the immediate soundscape. I investigate how listening technologies are not only for recording but also a method of perceiving various aspects of space in the moment. Though I do use technologies associated with sound recording practices, no permanent recordings are actually made, the recording device becomes a device for listening through. Mediated sound becomes creative material, or raw data, for compositional purposes.

Data Wayfaring creatively investigates the complex relationship between human perception, technology and the many species which share our soundscapes. By listening through multiple sensing technologies I explore the presentation environment as a giant sensor, using various techniques to sense its nuances and unearth its changes. I regard this activity as a reciprocal, dialogical interchange between humans and non-humans, infrastructures and ecosystems.

Through *Data Wayfaring* I am combining soundscape listening with sonified, non-acoustic data. Here I am working with data as a live, ever changing signal which responds and depends upon the direct environmental conditions of its collection. I explore how live data streams can be navigated through walking and movement. In any given environment there are a whole set of possible data streams one can listen into. Through a listening practice we can simultaneously hear, for example, the world moving, animals interacting, fall out electromagnetic signals, pollution levels, telluric currents and cosmic weather. Listening, supported by technology, can encourage us to think and act differently about our shared spaces and create a sense of commonality other than through visual culture.

The purpose of this exploration is not only to reveal nuances and patterns in geo-located data but also to explore the way that data can be

specific, responsive and situated (see Electromagnetic Situationism by Savičić (2019)). Live data streams are converted into sound using different sonification methods developed by myself and the other members of the RADICAL team. I then compose with this data in the same way I would treat acoustic streams through my various microphones.

With this project I demonstrate how having an open, improvisational approach to technologically supported soundwalking enables rich and unexpected results to occur and how this way of working can contribute to contemporary notions of soundwalking and sonification. I hope to investigate the practices surrounding data collection rather than just the data itself. Approaching data as a procedural process, not moving or recording data from one place and presenting it in another but working with it from within the environment it is related to.

RESEARCH METHODOLOGY MANIFESTS PHENOMENA RESEARCHED

Jorge Boehringer

Sonification, the phenomenological encounter of sound and meaning, resonates through all structural levels of my sonic environments and musical works.

As a generator of research questions, sonification allows for the modelling and exploration of phenomena, of data about phenomena, and of processes of gathering data about phenomena. Finished works materially embody sonification when data is created or apprehended within performance methodology or the apparatus of the piece. Most often sonification functions in a mid-field, between my research questions and finished works, in which situations of sound, information, and materiality intersect as three sides of the same coin. Such tripartite intersectionality manifests in circumstances when:

1. what is inaudible is rendered audible; sounding what, from a human perspective, is not considered to be sounding (spatial forms, mathematical propositions),

2. processes of sonification are sonified,

3. sources of indeterminacy are created from deterministic data, often one of two forms: re-mapping or cross-modulation between data signals: the "irrelevant processes" described by George Brecht (Brecht, 1966), or the exceeding of thresholds for predictability or structural apprehension, i.e., real-time atmospheric data used as source for the generation of random phenomena (Haarh, 1998).

The electro-magnetic process of *transduction* is both a technical explicative and a metaphorical analogue for the treatment of information in my work. Transduction involves movement of a signal between material forms. In sound production, transduction refers to the transmission of pressure wave energy to or from magnetic systems (microphones or loudspeakers) creating an electrical signal that can be processed further (i.e., digitalised d). Extension of this process to human listening can be undertaken literally in explaining some processes within the ear, such as the vibration of inner ear membranes in response to sound pressure changes. This process can also be extended beyond anatomical and acoustic notions of transduction, to include what happens within the minds of listeners.

Metaphorically, transduction functions to illustrate the movement of not only electro-magnetic energies, but also conceptual and/or linguistic phenomena produced by listeners. Linkage between embodied listening and environmental sound grounds individual data from ambient sound sources with hermeneutical and skilful applications of listening. Sound perception becomes transpersonal when signal information can be transduced in a social sense through shared embodied or linguistic experience. Such considerations reach far beyond the ontological nature of signals and enter the regions for socio-epistemological inquiry. Examples to follow illustrate how the three methodologies above are enacted through processes of literal and metaphoric transduction in my work.

Transducing inaudible information into audibility has been of material concern in my work beginning in my installation *Standing Waves for Darius Milhaud* (2000) and the subsequent chamber orchestra piece *Standing Waves for Liberty* (2001). Both pieces excite room resonances whose partials are modified by movement in the same space. These approaches are extended through recent work, such as *Meanwhile* (Boehringer, 2020). In *Meanwhile,* pure tones tuned to a peculiarly-shaped attic space (*Figure 1*) are recorded along with ambient environmental conditions and traces of the process of performance. Played back over loudspeakers the material of the recording will excite room resonances in a listening space, and these

will be modified by the position and movements of listeners. Thus, a navigation aid to one's own listening space is provided from a recording of a removed and distant space. The listening experience is private, specific to each listener, as perhaps the listening space itself is. Certainly, the attic in which the original recording took place was private, and yet now this space is re-enacted within a potentially infinite and public collection of new spaces.

Figure 3. *View from the centre of the attic where Meanwhile (2020) was recorded (author's own work).*

Cartesian Birds (2018) is an environmental installation that renders glimpses of a species of bird created through a process of sonification, sonifying itself. A text-to-sound recording of a translation of works by Rene Descartes is subject to analysis. The results are displayed in real-time using a software oscilloscope of my own design. Discovery that the visual analysis produced bird-like forms (*Figs. 2 and 3*) suggested sonification of the data using generative bird-like sounds convolved with excerpts of the text-to-sound reading. The piece thus encounters itself through a transduction from text to image to audio and into the experiences of visitors. Metaphorically, this could be likened to placing the Cartesian Birds before a curved mirror in which they appear as cosmic eggs that produce further Cartesian Birds.

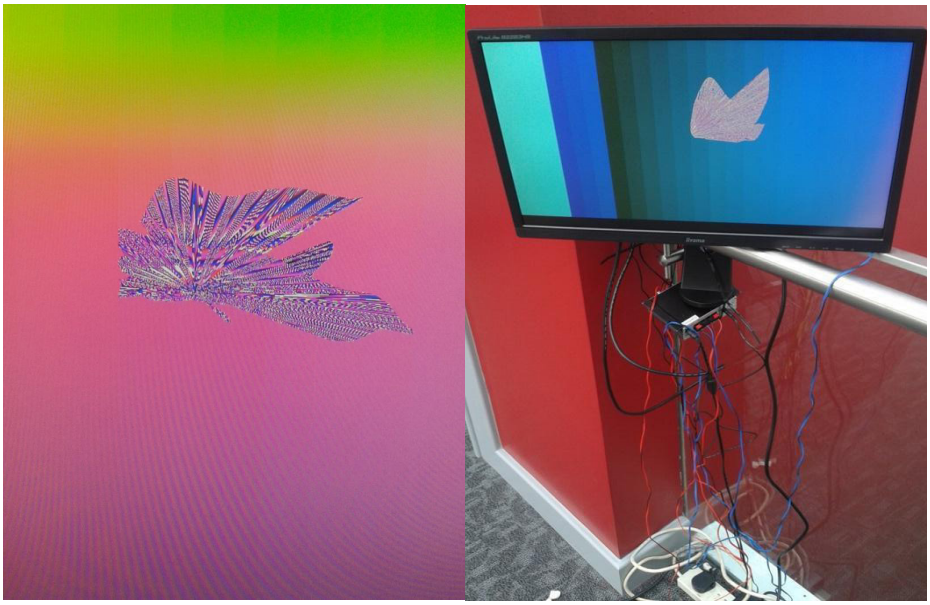

Figure 4. *Screengrab and a node from* Cartesian Birds *(2018) installation (author's own work).*

How visitors encounter themselves and one another in the circumstances of the project is of key phenomenological interest. Transduction of information to sound, literal and metaphorical, is rendered implicitly, rather than explicitly in my works. I withhold information, inviting visitors to participate in the (re)constitution of meaning. As such, listening becomes a performative gesture of intersubjective transduction enacted through absences that cannot be filled, phenomenological lacunae (Merleau-Ponty, 1968).

The use of data in my work is tied to a fundamental indeterminacy present in all experience, from which frame of reference it is impossible not to withhold information. Historically, the meaning of data in both scientific and quotidian contexts is taken to be materially determinate and observer independent. This is changing as artistic work is directed towards methodical experiment with the being and the circumstance of the perceiver within the structure of experience (Irwin, 1977). Likewise, contemporary scientific practices address phenomena as dynamic entanglements of participating researchers, apparatus, and matter (Barad, 2007).

Signals are bodies transducing bodies, listening extends an intersubjective field beyond the human. That which is listening is also becoming, and becoming itself vibrates, be it flesh, mineral, or plasma.

INTERSUBJECTIVITY AS THE SPECTRUM OF PERCEPTIONS IN MEDIA-SPECIFIC SPACE

Gerriet Sharma

In electroacoustic sound composition we are dealing with spatial phenomena that not only come from a direction and head toward a vanishing point in the concert or studio space but also with sound phenomena that have sculptural spatial dimensions like proliferation, width, height, and so on. These form diverse sound masses that can penetrate, layer, move around one another and, through their properties, define space itself. However, given the contemporary proliferation of formats for spatial audio, projection techniques and devices, software tools, and spatial concepts, it remains an unresolved problem to determine what and where different listening groups hear in the created space, how plastic sound objects are experienced, and how these experiences would be described by listeners.

The aim of the research I propose is the conception of a common *space* of the perception of three-dimensional sound phenomena – a domain I have elsewhere called the Shared Perceptual Space (SPS) (Sharma, 2015).

For the composer and sound scenographer, the question arises today to what extent a communicable or self-explanatory composition of these phenomena is conceptually, theoretically and at all practically possible when faced with changing architectural space situations, different spatial descriptions, projection technologies, and perceptions.

> How composers conceive musical content and form – their aims, models, systems, techniques, and structural plans – is not the same as what listeners perceive in that same music. In electroacoustic music, the separation between the act of sound making and perception, combined with the specialised nature, proliferation and transience of methods and devices, indicate that technological knowledge cannot be part of any method founded on perceptual consensus. (Smalley, 1997, p. 107)

Is there within the field of space-sound composition, a space located within the music, where a composer's perception within the compositional process overlaps both the engineers' and audience's perception? How and from which sides (linguistic, technical, artistic, etc.) can this field be approached? Anyone who has spent a while working in a studio

has experienced the specialisation of their own perception that has very little in common with third parties' listening experiences and habits. This subjective experience can sometimes also take the form of acoustic illusions.

> My experience of teaching composers has often revealed to me that such distortions are frequent. (Smalley, 1997, p. 111)

To communicate this impression, approaches for a more stable perception by third parties must be found. Here I am not focused on "the description" or "the precise form" which appears to everyone or must appear to everyone the same way. That would be an unacceptable, regressive approach in the field of art/music. With the degree of freedom we reach for artistic creation and spatial sound designs, we are in a position to produce sculptural sound phenomena that are 'ghost like', ephemeral mirages whose perception is dependent on many prerequisites, not least the vantage point of the audience. So it is not about coordinating perception or the fixation of modes of perception. In this respect artistic research is often in a fruitful conflict with engineers demanding fixation of "auditory objects" in Cartesian space for their models (Zacharov & Koivuniemi, 2001; Rumsey, 2002; Berg & Rumsey, 2003). It is therefore about the layering of different perspectives and their descriptions of plastic sound objects and taking them into account during the compositional process.

Demarcating outlines of an SPS in the project Orchestrating Space by Icosahedral Loudspeaker (OSIL)[2] we repeatedly implemented a three-phase process: within the context of a series of progressively evolving electroacoustic compositions, the plastic qualities of these sound phenomena were explored. Parallel to the compositional process, an attempt had been made to find a catalogue of terms to establish generalisable descriptions of the objects produced. Research into existing terminologies and their application was employed to this end. Furthlaer to this, these terms were reviewed in an attempt to classify the researcher's own compositional process. Additionally, engineering sciences were used to simulate and explain the artistically produced spatial sound phenomenon in psychoacoustic terms with listening experiments, measurements and virtual modeling. The resultant interlocking descriptions and also collisions of perceptions gradually informed the ensuing compositional process and led to an expanded understanding and a different sonic practice of spatial designs with

2] Funded by Austrian PEEK/FWF programme at IEM Graz (2015-2018), www.iem.at/osil.

these phenomena.[3] However, we need many more and radically different approaches to understand our ability to perceive these phenomena. The current boom in sales, marketing and production of loudspeaker tools for the projection of "3D Audio" entirely focused on the reproduction of existing music and sound-environments, underlines the need for an alternative combined listener- and practice-based research strategy in the service of media-specific creations. Therefore, in searching for methods of investigation and throughout the research process we shall try to understand what we induce, i.e., which perception spectrum we provoke and which categories the audience, engineers and we have both for and in the listening experience. The aim is to better understand the variability and through research (constructing models, verbalisation, new compositions and sonifications) to get reacquainted differently with these plastic sound objects and their conception through an assumed SPS.

AN INTEGRATIVE OBJECT: EPISTEMIC TRANSFERS BETWEEN COMPUTER MUSIC COMPOSITION AND SONIFICATION

Marcin Pietruszewski

This section discusses a convergence of practices between computer music composition and sonification. Rather than focusing on respective polarities, I attempt to address epistemic contexts occurring in a transfer between practices of science and computer music composition. The composition with scientific data problematises both fields and gives rise to what can be called an "integrative object" (Schmid & Hatchuel, 2014), a speculative vantage point functioning in the non-disciplinary middle between respective domains. A reflection on these issues was foundational for my recent composition 'Synthetic Pulsar' (2021).[4]

3] The results can be reviewed in several places and publications. See https://www.researchcatalogue.net/view/385081/958807

4] See https://www.ctm-festival.de/festival-2021/programme/exhibition/ventrilogues/synthetic-pulsar-by-marcin-pietruszewski-alex-freiheit. A binaural rendering of the work can be streamed via Deutschlandradio Kultur: https://www.hoerspielundfeature.de/hoerstuecke-mit-kuenstlichen-stimmen-ventrilogues-1-100.html

Computer music composition based on scientific data depends on a fundamental understanding of data and phenomena that underlies it. Yet, what constitutes data and its objects is not unproblematic. Instead of taking a given data set for granted, domain-specific and instrumental contexts should be considered as a pre-condition of data's formatting, resolution and content. There is no such a thing as "raw data" — any data is deeply intertwined with a theoretical model of the world on which the measuring procedure is based. The praxis of composition with scientific data needs to first unpack the data and locate itself in the extended field of capta — the methodology of discovery — within the 'cuts' between what is studied and what is excluded, and the choices of framing, alignment, and purpose that make data capture and gathering possible (Lanigan, 1992, p. 215).

A key challenge for a composer working with scientific models is a representation of data as sound. A sound can be experienced as a change over time where its properties are perceived in its dynamic unfolding. Thus, representation of data as sound requires an invention of a temporal form: mapping between properties of data and sound. The formal problem cuts across both fields of practice, sonification and computer music composition, and points to a fundamental problem regarding the relationship between complex representations — series of numbers or sound streams — and an understanding of objects and their relationships.

Synthetic Pulsar (2021) was commissioned by CTM Festival in Berlin and was presented on specially built 64-channels Meyer Sound loudspeakers installation at Vollgutlager (Figure 1). The material point of departure for the work was the New Pulsar Generator (nuPG) program (Pietruszewski, 2020) in conjunction with physical modelling synthesis, both developed in SuperCollider 3.10 programming environment.[5] The work attempted to attain an epistemological exchange between practices of sound design, computer composition, contemporary thought and science through a series of speculative sonification models attributing physical properties to a well-established data set: rotational profiles of astrophysical pulsars (Bell, 1968).[6]

5] Also see: https://www.marcinpietruszewski.com/the-new-pulsar-generator and https://www.curtisroads.net/software/

6] The data sets were sourced from the European Pulsar Network (EPN): http://rian.kharkov.ua/decameter/EPN/browser.html

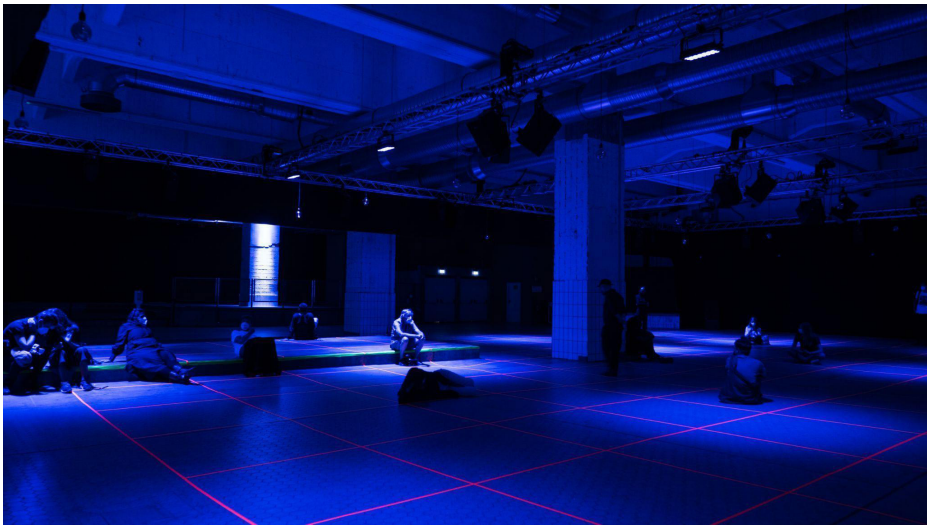

Figure 5. Synthetic Pulsar *(2021) at Vollgutlager, Berlin. Photo Copyrights: Eunice Maurice and CTM Festival*

While the practice of augmenting one data set or data feature by a secondary data source is an established method within sonification practice (Boverman *et al*., 2010), *Synthetic Pulsar* speculated physically impossible objects, attributing pulsars with forces of attraction and repulsion, and material qualities such as rigidity and elasticity. The process of attribution followed a systematic model of experimentation where existing sets of pulsar data properties (time vs intensity) were supplemented by a dynamic physical model emulating interaction of objects in a virtual environment. A classic sound of a pulsar consists of a radio-wave auditioned through a set of loudspeakers.[7] The speculative model of *Synthetic Pulsar*, intervening at the level of data, forces pulsars into physically impossible interactions: pulsars rotate around each other, attract and repel, collide and bounce around, slow down to almost stasis and spin around at extreme speed. These processes were dynamically mapped into various parameters within the pulsar synthesis model such as rate of emission, multiple sets of formant frequency, spatial position and amplitude. The audience was free to move around the venue and explore a variety of sound constellations in space.

In a broad perspective, the work attempted to capture an object of a pulsar as a synthetic entity no longer belonging to a singular discipline,

7] See https://www.youtube.com/watch?v=x5BQV3WX80E

but localised in the in-between zone of non-disciplinarity. Anne-Françoise Schmid has developed the concept of "integrative object" in order to capture exactly these types of objects. A reflection of these objects contributes to a more nuanced view on how sciences create something new and how innovation happens. According to Schmid, these objects "are not given, they are unknown, their dimensions are fragments of disciplines, but articulated in a heterogeneity such that milieu, a mid-site, is necessary to conceive and to receive them" (Schmid & Hatchuel, 2014 p. 136). Schmid proposes that we think of such an object as a multi-dimensional entity, each of whose dimensions is a different discipline or discourse. Since these dimensions can never be added to each other so as to synthesise a whole object, it is constituted ('made ready' for presentation) each time through the partial perspective and intentions of a given researcher. The richness of the model, and its application to contemporary objects, resides in this incomplete, problematic status that prevents integrative objects from ever being presented as a 'readymade'.

EXPECTATION IN SONIFICATION LISTENING: MOVEMENT SONIFICATION EXPECTATION MODEL (MOSEM) CASE STUDY

Joe Newbold

We can also see how musical elements of a sonification may impact not only one's experience of listening, but also an individual's behaviours. To examine how the use of musical structure within sonification impacts its use, the Movement Sonification Expectation Model (MoSEM) focused on musical expectation (Newbold, Gold, & Bianchi-Berthouze, 2020). MoSEM is used to examine how sonifications are experienced through the understanding of how real-time feedback can impact one's experience of one's own movement alongside people's implicit and embodied musical expectations. By basing these designs within the theory of embodied sonification cognition (Roddy & Furlong, 2015), sensory integration (Wolpert & Ghahramani, 2000) and musical expectation (Huron, 2008), an understanding of how one may interact with such sonifications can be gained. Exploring sonification in this way then extends our understanding of how musical structure within sonification can be used to impact people's interactions with it.

This programme of work used a simple implementation of expectation, altering the harmonic conclusion of a chord progression, to be complete or incomplete. This chord progression was then used as real-time feedback for a movement. When the individual reached the end of the movement they heard a final cadence. Either the music created by the sonification resolves (harmonically stable) at the end of the movement and they feel a sense of completeness and reward, or else the music created is incomplete (harmonically unstable) and hence they feel encouraged to continue their movement.

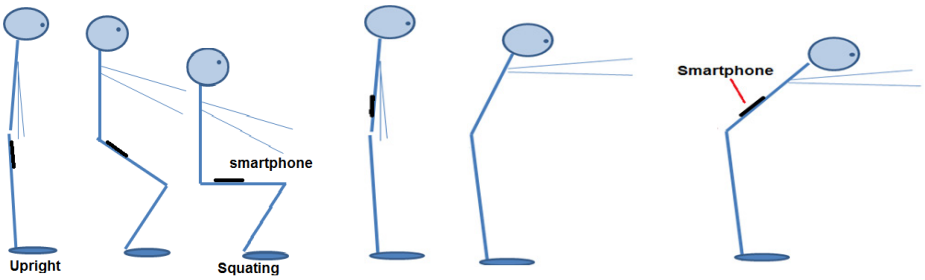

Figure 6: *The two movements first explored in the Movement Expectation Sonification Model (Adapted from Newbold (2019))*

This idea of expectation was first explored in two movements, the stretch forward and the squat down. In the first study, users moved more and for longer in musically unstable conditions, moreover users felt a greater sense of reward from the stable conditions. Length of sonification (i.e., how far into the movement the harmonic ending was heard), which was intended as a control parameter in the study to avoid learning effects, was shown to affect movement behaviour and perception of sound. The second study used the same design to investigate the squat down movement, a movement with more additional cues that the ending is coming and one that beginners commonly struggle with. It was expected that the same impacts would be seen, in terms of movement behaviour and perceptions. However, while participants did report feeling more motivated to continue their movement in unstable endings and felt they had achieved more in the stable ending, there were no significant effects on the movement behaviours, differing from the results of the first study. This again implies there are factors outside that of the musical expectation that impact the movement behaviours and perceptions.

This led to a study, presented in Newbold *et al*. (2020), examining the impact of different movement types was explored in depth. Based on the

previous studies , two movement types were defined as 1) open movements, where limited additional cues are indicating the end of the movement and 2) closed movement where strong additional cues are indicating the end of the movement. It was hypothesised that the presence of these cues would limit the impact of musical expectation on movement behaviour, as people are more reliant on the additional cues. These studies show the way the expectation of one's movements impact how musical expectation can be used to alter one's movement, either when it does not match the expected movement, or it disagrees with external cues to the end of the movement. From these observations, an extension of MoSEM was used to consider the impact of movement expectation.

From this understanding of the use of musical expectation within sonification and how it impacts one's perception of self, we can begin to unpack some of the potential benefits for using musical elements within sonification and how they are embodied by the individual. In Roddy's work for embodied sonification, this impact is further considered through the lens of embodied cognition (Roddy & Bridges, 2018). The Embodied Sonification Listening Model, (Roddy & Bridges, 2018), is used as a way to understand how people's embodied cognition of sound impacts how sonifications are perceived and the conceptual metaphors that are used when extracting meaning from them. By considering then some of the higher-level musical ideas that people may have embodied understandings of, we can start to explore how the experience of a sonification can be used to impact one's perception and behaviour.

BOWING THE RIVER/KNOWING THE RIVER

Bennett Hogg

The realisation that violins were once trees has been a conceptual stimulus for several projects for me over the past 30 years. As part of "Landscape Quartet"[8] I began by staging a number of encounters between violins and the natural environment. Dragging violins along paths, and listening — via microphones implanted in the instruments — to the resultant sounds, reveal paths less as fluid transitory spaces than as obstacle courses to be

8] An AHRC-funded environmental sound and music project 2012-14.

negotiated. The violin gets snagged on things, and comes into contact with a variety of materials, and monitoring the sounds produced on headphones sets up a complex relay of haptic and auditory experience remarkably akin to bowing. A direct connection between what I *feel*, in terms of tension in the strings and the textures of materials coming into contact with the violin and the sounds I *hear* coming from the violin through my headphones is quickly established in a manner akin to Michael Polanyi's example of the blind person's stick (Polanyi, 1966).

Soon after these experiments I brought violins into a river and developed an improvised musical practice where the water flows over the strings, effectively bowing them. The sound is closer to an ensemble of flutes than the expected sounds of a violin, and affords the player movement to or against the flow. This movement with different currents is an experience that is different to the dragging mentioned earlier, but which is also experienced as akin to bowing: the haptic "feel" and its resultant "sounding" seem to connect to the deeply incorporated knowledge of bowing for a violinist. In this situation the feedback between action and sound is augmented by a sense of "getting to know" the river itself: the different currents produce different sonic results depending on the actions of the "player". The net result is that the player, violin, and river act upon one another, the player acquiring knowledge about the river that would otherwise be inaccessible, a sonification of aspects of the river's behaviour in real time.

What this experience reveals for me is the inescapably tacit and embodied nature of sonic experience. According to Michael Polanyi tacit knowing is that which cannot be directly articulated in words and is often not even consciously "known". There are two interconnected states of tacit knowing, the proximal and the distal. Distal tacit knowledge is in play when I pick up a glass, proximal is in the series of unconscious muscular and haptic actions I enact to do so. Playing an instrument or singing depends, as do all actions, on a great deal of acquired and practised tacit knowing, and so it seems likely this might be transferable to novel situations. In one sense it's unsurprising that bowing should be associated with the sounding of a violin, yet the actions of dragging and submerging violins excludes the essential dimension of actual bowing, the movement and control of the right arm. As I see it, putting the familiar object (the violin) into an unfamiliar context brings this hidden tacit knowledge that underlies bowing into the open. It emerges as a tool through which to understand the river.

What is the nature of this "understanding", then? Polanyi exemplifies tacit knowing with the example of using a stick to explore a dark cave where "our awareness of [the stick's] impact on our hand is transformed into a sense of its point touching the objects we are exploring" so that meaning becomes "located at tip of the probe or stick to which we are attending" (Polanyi, 1966, p. 13). But Polanyi does not mention sound, despite his discussion of how people with visual disabilities use a similar tacit knowing to navigate the physical world. It is not only the haptic but also the auditory that is in play in the scanning and tapping of the stick, and something similar is in play with the violin on the forest path, or in the river. Quite specifically qualitative aspects of the environment are revealed through haptic and auditory experience, drawing on tacit knowing adapted and deployed without being consciously invoked: I became aware of the role played by my tacit knowledge of bowing in understanding the novel situation *when* I dragged it along a path, or immersed it into the river. Skills and knowledge otherwise concealed behind competencies emerge into conscious experience in the forest and river. Although this particular tacit knowledge results from my training as a violinist, all auditory and sonic experience is mediated like this.[9] This raises problems for sonification, but also opens a range of affordances and modes of engagement with sonification where we are actively exploring data, rather than representing it.

CONCLUSIONS

The creation and apprehension of meaningful sound is of key interest for those engaged with new musical practices, experimental interdisciplinary artwork, and sonification research. Above we have demonstrated points of entanglement and resistance within a trans-disciplinary research team who explore new sound experiences aiming to provoke co-constitution of sound and meaning. Rather than presenting a unified singular perspective, our work embodies theoretical considerations through diverse sonic practices. For sonification, this allows us to mobilise a more nuanced perspective that locates it as an activity outside the domain or purview of any specific disci-

9] Karin Bijsterveld distinguishes between these terms on the basis that not all sonic experiences are exclusively auditory. (Bijsterveld,2019).

plinary category: in the non-disciplinary middle. Meanwhile, terms such as sound art and computer music become necessary frameworks for capture and experience with the complex worldliness of data.

A central theme in our research is that sonification is a domain that needs to be redefined, a domain whose objects and methods are in the process of negotiation. Approaching these problems, creative practices offer an opportunity to ask not just what a sonification represents but what it does. How do we design sonifications that do things, in addition to, or other than, merely represent or directly 'perceptualise' data relations? The process of our work, of artwork, addresses quotidian needs: things like inciting curiosity, enhancing appreciation, facilitating imagination, giving joy, thrill, and creating the circumstances for conjecture, for guesswork and wild hypotheses. Sonification can become not merely a demonstration in sound, but an experience of or with sound, open to exploration, and critical reflection.

The set of practises and theoretical investigations proposed within this text forces us to question the role of data within the sonification process: *No datum is innocent*. In our practice, sonification examines data from a perspective *as experienced*, rather than assuming a non-existent ideal perspective and uncritically expecting that data broadcast at it will be received and understood. Listener-centred thinking thus informs the agential cuts we perform between what is studied and what is left unexamined. Further, such agential cuts guide our development of apparatuses, experimental systems for gathering and communication of information.

Sonification does not happen in a vacuum. Artistic practices with data sharpen our sensitivity to a broader ecology of display. Rather than asking *what is in the sonification*, we may ask w*hat the sonification is in*. Sound thus becomes entangled in not only the creation of meaning but also the creation of place. In our works, as discussed in this chapter, relations between place, periphery, and connections between them become compositional and material concerns that drive our research. New questions emerge: how can we design for juxtaposition, comparison, and manipulation? What materials and modalities will we develop to do so?

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