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Sonifying the world

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> We are so limited in the ways that we use our data. Basically we have a number of ways that are very statistical, certainly very mathematical and very useful, and then we represent the results of those statistics in graphs and tables. That's one way, and then we do have visualizations, for example an animation of how the warming, using colors from yellow to red to deep brown over the decades. But that's it it's really quite limited. So working on . . . sonification . . . you realize that when you hear something, you're able to understand the data in a new way, and that's what [has] been very fascinating.
>
> (Rosenzweig in Polli n.d.)

This chapter introduces data sonification and how it being used in the sciences and in the arts to communicate stories about the world and its surrounds. Sonification, the conversion of data into sound, has been of surfacing interest in cultural and political geography sitting alongside an interest in data visualization, and data and geography more generally (Ash 2015; Palmer and Jones 2013; Graham 2005; Kitchin 2013; Woodward et al. 2015). Sonification is defined as 'the use of non-speech audio to convey information' (Kramer et al. 1999) and is considered an equivalent or addition to visualization due to the finer ways in which auditory perception can discern changes in temporal, spatial, and amplitudinal clarity. It is predominantly used within the sciences (and increasingly the arts) to represent data composed into sound through algorithms. Simply put, sonification takes data in the form of numbers from a dataset or graph (the rise of sea levels over a century, the levels of CO_2 in the atmosphere since the industrial revolution, income disparity in a particular urban area over a period of gentrification) and converts it into sound. The different parameters of the numbers (date range, increase and decrease, intensity) are expressed through varying tones, pitches and durations – for instance increases are higher pitched notes, decreases lower, length of time is expressed in the length of the note held and so forth.

While sonification does not sit within non-representational theory – it can be argued that it is antithetical to the idea of non-representation in that it is a translation of data into audio – it indicates the overlaps between science and art, sound and affect, composer and audience. It brings to light the complexities associated with the transformation of data, and the subjective and affective processes through which numerical information is scored and arranged, whether by scientists for the purposes of clarification, or artists for creative communication. This chapter touches on a range of diverse practices, from classic notions of listening to the natural environment, to artistic sonifications of climate data, and the scientific approach of physicists and astronomers in their capture of vibrational waves. When taken together, these examples provide a provisional lens for exploring the potential in linking scientific knowing and sonic expression. Sonification, argue Michaela Palmer and Owain Jones, is a vital method for 'exploring processes in spacetime terrains such as bodies and landscapes' (2014, p. 222). Linking science and sound can indicate directions for thinking how data is communicated to activate different perceptions of, and relationships to, the world, to the here and now as much as to times and spaces far beyond the scope of human comprehension. It can help to reveal how data-based practices of sounding – capture, transmission, interpretation, manipulation, representation – can bridge places, times and bodies in meaningful ways.

'Finally, astronomy grew ears. We never had ears before' (Overbye 2016). These were the excited words of Columbia University professor Szabolcs Marka, a member of the Laser Interferometer Gravitational-Wave Observatory (LIGO) team as he described how, in February 2016, they had proved the existence of gravitational waves for the first time in human history. This was not an insubstantial feat. LIGO's researchers had done what scientists had been striving to do for the past century – confirm the final prediction of Einstein's general theory of relativity by detecting very weak gravitational wave forms – and they'd done so using sound. The group had managed to record the vibrations from two black holes colliding and collapsing into one another a billion light years away. These were captured by an exquisitely sensitive custom-built long string instrument and translated into a faint, very brief rising tone, 'like sweeping a hand across a piano up to middle C' (Overbye 2016). 'It's the first time the universe has spoken to us with gravitational waves', explained David Reitze, a physicist at the California Institute of Technology, on the significance of the sound (in Overbye 2016). 'It's mindboggling . . . We have been deaf, but now we can hear them. We now expect to hear things we never expected as we open a new window of astronomy. This was a scientific Moon shot, and we did it, we landed on the Moon' (Commissariat 2016).

Even beyond its scientific importance there's something intuitively appealing about the LIGO story, with its almost comical mismatch between this tiny, innocuous-sounding chirp and the global excitement that it triggered. Here, sound becomes a tool not only for communication but also for exploration, offering a means of tapping into phenomena that exist at scales well beyond the ordinary limits of human perception. Humans' ears are often better than our eyes at detecting subtle changes over time, so sonification, the turning of data into audible sound, has become an increasingly popular tool in science in recent years. The interest of sonification in the cultural geographies echoes its use in the physical sciences in the areas of oil exploration, glacial processes (Tegowski et al. 2011), bathymetry (underwater depth study) (Chakraborty and Fernandes 2012), the surveying of ocean currents, the measurement of underwater noise from shipping (Merchant et al. 2012), and the migration and health of marine populations. Sonification is used here explicitly *for the purpose of understanding or to communicate information*. From mapping solar flares to making particle collisions discernable, sonification is a means for scientists to communicate biospheric and atmospheric changes in novel ways. Whether used for practical purposes in data analysis – for identifying patterns in high-dimensional data in much the same way you might plot a graph – or for communication of findings, the results often end up shared online. Sonification has been adopted by NASA and astrophysicists as a novel means for outreach and publicity. A swift search throws up a suite of curious sonic artefacts created using environmental, cosmological or demographic data, some on sites like YouTube or Soundcloud, many others available directly from researchers' websites. Although some are made by interested amateurs, more are created by academic groups, and the range of subjects they cover is striking in itself, from explorations at the edge of astrophysics such as LIGO, to kitschy orchestral transcriptions of global temperature data to illustrate climate change, to rhythms much closer to home such as sonifications of River Severn tides by geographers Michaela Palmer and Owain Jones (2014).

What most of these practices share is a desire to take phenomena that are very slow, very complex or otherwise intangible, and transform them into compositions-of-sorts whose underlying significance is clear to a listener. This is often achieved by mapping particular parameters within existing data, for example temperature or pressure, to specific sound parameters, such as timbre, pitch or volume. Taken as standalone sonic artefacts the results often tend towards the novel: more odd curios than musical objects with any lingering resonance. Some leave the disconcerting sensation that the supposed objectivity of scientific data is being celebrated for its own sake, while others simply suggest researchers are finding new ways to play with the massive volumes of information their instruments are gathering. NASA's CRaTER Live Radio does both, transforming a real-time stream of cosmic ray telescope data into an unending generative broadcast of soft-focus clockwork plinks and synthetic string drones that evoke the nightmarish consumerist mood-muzak beloved of vaporwave producers.

Equally, however, their explicit connection to their source material is what lends some sonifications their peculiar emotional impact. In 2015 scientists released recordings of Comet 67/P, aka the Rosetta Comet, 'singing' – technically untrue since sound cannot travel through the vacuum of space. Its voice was in fact comprised of magnetic field sound waves or vibrations stimulated by charged particles (plasma) shooting off its surface; these were captured by the Rosetta Plasma Consortium's magnetometer at 40–50 millihertz, and increased by a factor of 10,000 to bring them into audible hearing range.[1] To sonify these data, the researchers mapped out parameters marked by pitch and tempo into which the vibrations were transduced. These were mapped to sounds amusingly akin to the output of an old analogue oscillator. This created its distinctive voice, an eerie, scuttling, speechlike spattering of clicks and pops, falling somewhere between the stereotypical sound of interstellar alien transmissions in science fiction and hydrophone-recorded calls of dolphins and whales.

While obviously nowhere near the scale of the humpback recordings of the 1960s and 1970s, which sold in the millions and helped trigger environmental movements calling for the banning of whaling, this very deliberately designed sounding of the comet sparked a not dissimilar collective imagination. The lonely voice of 'the singing comet' tugged at the heartstrings, hinting towards some unknown consciousness floating out there in space, and bringing something as far away as possible from human life into a frame of anthropomorphic comprehension. Swathes of YouTube clips were uploaded to celebrate the rock hurtling through space, featuring segments of the comet song, remixes and musical compositions, alongside articles describing it as 'humming', 'belting out' and 'crooning'. The translation of magnetic field oscillations into audible sound seemed to give the comet, a lump of interstellar rock and ice, a consciousness, a character – a life.

Bearing in mind that flush of empathy for something as distant as a comet, it's telling that many of the most affecting sonification-based projects are those that relate to climate and the environment. The questions they touch on are increasingly urgent; following 2015's COP21 climate summit in Paris, global temperature records had been broken month-on-month at the time of writing this chapter in 2016. So if many scientific sonifications tend to feel more decorative than functional – researchers finding ways to have fun with ever-accumulating volumes of data – it's in listening to the accelerating pace of global environmental change that the approach itself seems to have the greatest potential. People now collect staggering quantities of information about Earth's function from satellites and sensors on the ground, as well as from the massive predictive computer models that underpin climate change projections. Even for researchers the sheer scales involved in tracking and predicting the state of the environment can seem so vast as to be abstract, and climate change, for example, remains a notoriously difficult topic to capture and maintain public interest in. Sonification methods enable these complex, multidimensional processes to be compressed into timescales that are viscerally comprehensible to people.

For example, in her 2004 work *Heat and the Heartbeat of the City*, US artist Andrea Polli (2006) used both historical and projected future data from climate models produced by researchers at the NASA Goddard Institute for Space Studies and Columbia University, to illustrate the relationship between rising temperatures in urban spaces and increases in hospital emergency visits. In it, she manipulates pitch and volume to signal temperature increases and the intensity of their effects, seeking to create a sonic discomfort that conveys the discomfort associated with heat surges. For Polli, 'the work uses sonification as a way to construct a kind of narrative, emphasizing a climate phenomenon that affects human life negatively and compressing a 90-year time scale involving millions of people into an individual experience of minutes' (2006, p. 44). The piece does not make for easy listening. Modulating like ghostly, half tuned radio transmissions, interspersed with sharp blown out buzzes and underlain with occasional muted rhythmic hums, the tones composed by Polli build an atmosphere of apprehension, of a tense waiting for some kind of imminent revelation. This is emphasized over time: as the tones unfold from seconds into minutes, their density and volumes accumulate to deeply unsettling registers. Rising temperature levels translate into pitches and frequencies that agitate the ears and the imagination, to invoke anxiety and trepidation. And why should it not? The story Polli tells is one of danger, of urban and human sickness and harm associated with anthropogenic environmental change. As she puts it, 'I think that sound is a very visceral thing and I think that if people can really feel the potential difficulties, the potential discomfort, but more than just uncomfortable, actual problems that will result from global warming, maybe in some way they will be convinced to think more seriously about the issue' (Polli n.d.). Another work at the interface between data science and sound art, but focused on the experience of climate in the here and now, is outdoor immersive music installation *Variable 4* by London's Daniel Jones and James Bulley. The pair use an array of sensors to track local weather conditions which then modify a generative musical score, heightening listeners' physical awareness of small fluctuations in temperature, wind and humidity that might otherwise go unnoticed.

There are intriguing parallels in this kind of work with other practices in soundscape ecology and field recording that similarly translate very subtle or long-term phenomena into recordings that make their underlying ecological processes shockingly obvious. Recordings of melting glaciers (often time-compressed) are often used as audio signifiers of climate change – most famously Chris Watson's 'Vatnajökull' from his 2003 album *Weather Report* but lots of others too. More starkly affecting are the long-term soundscape projects of Bernie Krause (in part documented in his 2012 book), who has been returning to record the same ecosystems regularly for several decades; played back-to-back, his recordings reveal a gradual decay in acoustic diversity that signals massive declines in wildlife populations as a result of increasing human activity.

In geophysics sonification is often used to understand similarly long-range and large-scale seismic events, such as earthquakes and volcanoes (Peng et al. 2012). By modifying infrasonic vibrational phenomena these processes become audible, their frequencies are transposed into the ranges of human hearing, while the long cycle durations of events are condensed via pitch shifting and space–time compression. Over the last decade hydraulic fracking activities for ground oil collection in Oklahoma have sharply increased, as has seismic activity (by 4,000 per cent between 2008 and 2013). To highlight the growing frequency and severity of these earth movements, in 2015 the Center for Investigative Reporting created an audio timeline of Oklahoma's earthquake patterns using data from the Northern California Earthquake Data Center. As creator Michael Corey explained, 'each "plink" you hear in the recording is a single earthquake in Oklahoma. The lower the pitch and the louder the note, the bigger the earthquake' (2015). Beginning as a series of disparate synth notes, the piece gradually escalates to itchy, SND-style strobing clicks and struck melodies,[2] finally evolving into a full-on barrage as earthquake activity hits its present-day peak.

Exploring a less-discussed consequence of large-scale fracking, it's a great example of how a well-conceived sonification can illustrate in a few seconds, and in an emotionally engaging way, a complex trend that would be much less obvious if displayed visually. Yet at the same time it also throws up a broader question: why did the creators choose this particular set of sonic characteristics to represent the Oklahoma data? This highlights some of the knottier issues with data sonification as a communicational practice. Although often presented as direct sonic representation, only part of the composition process is actually ceded to the input data; any sonification is still the product of a host of subjective decisions made by people, from the methods used to collect the original data, to deciding what sections of the data are included (and why), to choosing the actual sounds or sonic parameters. One risk of obscuring these phases of the composition process is that sonifications can easily seem to fetishize the supposed objectivity or authenticity of the data they describe.

On the other hand, it's this tension that makes many of them so fascinating from an aesthetic perspective. The Large Hadron Collider's LH Chamber Music group (comprised of physicists and engineers working at CERN) perform instrumental scores based on sonified data from particle collisions, but harmonic and rhythmic structures of the resulting pieces exist so clearly within a Western classical tradition that it's difficult to interpret how they relate to their origins in the LHC's experiments (Hetherton 2014). Similarly, pieces that translate rising global temperatures into pitch and volume on acoustic string instruments illustrate the process of climate change in such an obvious, almost whimsical way, that they erode some of the gravity of their subject matter. At the most bizarre end of the continuum, meanwhile, one sonification by Georgia Tech Labs represents a stock market index as an evolving forest soundscape populated by insects and birds, generating an artificial ecosystem that blossoms with life as the index rises – a sonic analogy that couldn't be more counterintuitive bearing in mind the mostly antagonistic relationship between economic growth and the environment (School of Psychology, Georgia Institute of Technology n.d.).

These weird or surprisingly prosaic aesthetic choices highlight a common tendency across many sonifications – to bring otherwise imperceptible processes or timescales into the realms of the immediately familiar or the everyday, to make them comprehensible for listeners beyond the lab. That they focus on science as a process of exploration and play is refreshingly different from either corny musical responses to recordings of wildlife or the cosmos, or the vast and unknowable data sublime invoked by artists like Ryoji Ikeda. But if simplified too far they can also mask that these real-world processes are in fact messy; compared to the noisy nature of climate or ecological data, many feel strikingly clean, as if carefully curated for listening ears. Sonifications with an emotional impact beyond initial curiosity are those that find ways to maintain that complexity, while drawing out subtle nuances in data whose significance would be overlooked if communicated by any other medium. The ongoing stream of abstract bad news relating to climate and the environment can easily lead to fatigue. In contrast, as with vivid field recording projects such as Krause's, the visceral futures described by Andrea Polli, or translations of seismic data into audible noise shockwaves, invite different ways of thinking about – and feeling – aspects of the world that are otherwise kept at a distance.

The examples discussed here are just a few of the ways that sound influences the way we know the world. Whether intended or not, affect and emotion intervene when sound is used in novel ways to become a communicative medium beyond speech and voice. Sonifications can produce excitement and joy at, for example, the 'chirping' of gravitational waves that permeate the universe, or feelings of empathy with inanimate objects that 'sing' while they hurtle through space. Sound can elicit care and concern for the environment in the way that Schaeffer's or Krause's acoustic environments do, as they provide narratives of species and ecosystemic decline. Sound can evoke fear and apprehension through the use of pitch and tempo as illustrated in the works of Andrea Polli. The emotions and affects that are woven through these diverse practices do not neatly fit with any particular theoretical approach, but rather make space for, and invite further experimentation and investigation on, in, around and through sound.

Notes

1. Accessed 11 March 2019 at https://soundcloud.com/esaops/a-singing-comet.
2. SND is a musical duo formed in 1998 by Mark Fell and Mat Steel, known for their new digital minimalism.

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