https://doi.org/10.1038/s41550-022-01848-z

Hearing is believing

For blind and visually impaired astronomers, sonification of data creates opportunities for research and outreach. But for everyone, this Focus issue lays out the benefits of complementing vision-based data analysis tools with data sonification.

Anyone staring in awe at the images from JWST will appreciate that astronomy is a highly visual discipline. But distant messages from the cosmos can also be heard, as when Arno Penzias and Robert Wilson detected a faint noise using a horn antenna built for sensing radio waves. The hiss turned out to be radiation from the Big Bang. The use of sound can be generalized: sonification converts any kind of data into an audio display to convey information. It could be a change of pitch, loudness, timbre or rhythm representing a change in number, brightness or frequency, for anything from share price to particle count (Geiger counter). Using stereo effects can convey spatial dynamics.

In research, sonification of data can also provide a complementary method for analysing observations and avoiding biases. This month we present a Focus on sonification. The collection of articles sprung from the Audible Universe workshop in 2021, which convened astronomers and sound engineers — until then two disparate communities with a shared passion. A Meeting Report by Chris Harrison and colleagues discusses sonification tools for enhancing scientific discovery and accessibility to astronomy research and education. The authors describe a nascent multidisciplinary approach to designing and assessing various tools developed by different communities. One particular topic of interest concerns how to provide an audience with an overview as well as the finer details of the data. The sound community were familiar with this issue and explained to the astronomers about offering layers, some of which could be customized by the listener. Thus, having standardized yet customizable choices improves the experience and can account for differences in perception.

Sonification is also a powerful tool for improving diversity, equity, inclusion and accessibility. In their Q&A, Jake Noel-Storr and Michelle Willebrands interview four blind or visually impaired researchers working in astronomy research, education and outreach: Nicolas Bonne, Cheryl Fogle-Hatch, Garry Foran and Enrique Perez Montero. These days very few astronomers travel to observatories, yet the image of an astronomer as someone gazing into a telescope persists. This kind of bias and the focus on images create a barrier for the visually impaired to studying astronomy, or science more generally, which the interviewees have been breaking down. In addition to sonifying astronomical data, it is also possible to convey information through touch, such as tactile models of the sky. The researchers identify figures and plots as one of the biggest hurdles; including a clear and specific audio description of a graph can benefit everyone.

The Perspective by Anita Zanella and co-workers then discusses in greater detail the benefits of sound, including nearly 100 sound-based astronomy projects, in context. They point out the limitations and challenges. For instance, datasets are growing increasingly larger and more complex. Visualization requires filtering and cleaning, which makes it less than optimal for live monitoring, especially of transients. Our ears, however, can pick out weak signals against a noisy background and are sensitive to perceiving time-based changes and patterns, but unaffected by the direction of sound. As an example, for gravitational waves, the increasing pitch of the signal (the characteristic 'chirp') against a steady low-pitch noise is easier to detect by ear. Their figure 1 illustrates the difference, with the bare simulated chirp on top and embedded in LIGO noise on the bottom. Incidentally, the figure is actually a video — the inaugural video figure in *Nature Astronomy* — with a still image accompanied by audio. Clicking on the figure plays the video on our website. For the PDF version, clicking anywhere on the figure or caption will lead back to the website that plays the video.

In the second Perspective, Nicolas Misdariis leads a team of sound experts in sound perception/cognition, sound design, psychoacoustics and experimental psychology in setting out the basic elements of sonification, with its diversity of tools, applications and users, from perception to experience. The authors consider the main motivations for their community: what can be learned from the sound experience; where are they heading in terms of improved or new tools; and how to evaluate the usefulness, usability and desirability? Within this broader context, astronomers can develop accessible, well-designed and multi-purpose tools that can be assessed and improved over time. They also acknowledge the presence of a 'scepticism barrier' whereby the scientific value of sonification is questioned. As a young field, it is important to increase awareness, but also establish the basics of universality, standardization, multimodality (by incorporating the sense of touch and added spatial dimensions), analogy (Universe as a complex sound scene) and prototypicality (sonification as a 'quick and dirty' process for data monitoring).

During the Audible Universe workshop, it became clear that more gatherings are needed. Concepts such as emotion, multiculturality or artificial intelligence were not addressed. But the connections have been forged between astronomers and sound experts. It means that researchers wishing to use sonification, such as the pioneering Fiorella Terenzi and Wanda Diaz Merced, will not have to invent their own tools, necessarily, to make progress. And given that many have so far worked in silos means that a lot of the material is hard to find, unpublished or not published in mainstream journals. Thus, there is a push for the community to upload their sonifications on the Data Sonification Archive (https://sonification.design/), so that there will be a reference repository going forward.

Later this month, on 17 November, UNOOSA, as part of their Space for Persons with Disabilities programme for advancing inclusive, equitable and sustainable development in space, will host an online event on sonification. The timing could not be more fortuitous. Given the important role of sonification in the accessibility of data for differently abled researchers, we hope this Focus issue will bring greater awareness and foster stronger ties between various communities that benefit from sonification in their research, teaching and outreach efforts.

Published online: 11 November 2022