Multi-sensory Approaches for Accessible Astronomy

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www.audiouniverse.org

With: James Trayford (Portsmouth), Anita Zanella (INAF), Nic Bonne (Portsmouth),
Sean Dougherty (Newcastle), Rose Hinz (Newcastle),
Jack Tucker-Brown (Newcastle), Patrick O'Neill (Newcastle); Enrique Perez-Montero (IAA-CSIC);
Aish Girdhar (ESO/Newcastle) & Audio Universe team

Why am I interested in multi-sensory Astronomy?

1. Accessible and inclusive science

2. Immersive, engaging communication & education

3. Innovate methods for scientific discovery

For research & communication almost exclusively visualisations used

Accessibility

Accessibility for sight impaired and others preferring non-visuals

Dr. Wanda Diaz Merced,
South Africa/Puerto Rico

Credit: TED

Accessibility

1 in ~200 registered blind (35-40 million people)

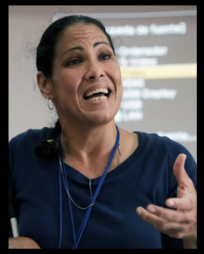
Many more with some vision impairment

(~2.2 billion, depending on exact definition)

Ref: World Health Organization

Dr Garry Foran, *Australia/Japan*

Dr. Nic Bonne, *UK/Australia*



Dr. Wanda Diaz Merced, *South Africa/Puerto Rico*

Dr. Enrique Pérez Montero, *Spain*

Agiris Koumtzis, *Greece/Germany*

Each finding own ways to research, including specialised software from scratch, heavily reliant on sighted support

See interviews in Noel-Storr & Willebrands (Nat. Ast., 2022)

Engagement

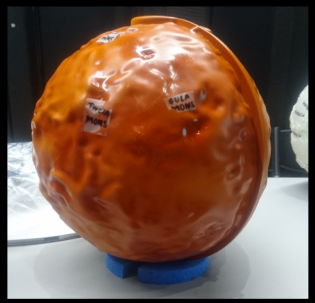
Multi-sensory immersive and engaging outreach/education
*(which naturally becomes more **fun and accessible**)*

Image credit: https://clearstepsplus.co.uk/learning-difficulties/

Tactile Astronomy Engagement Projects

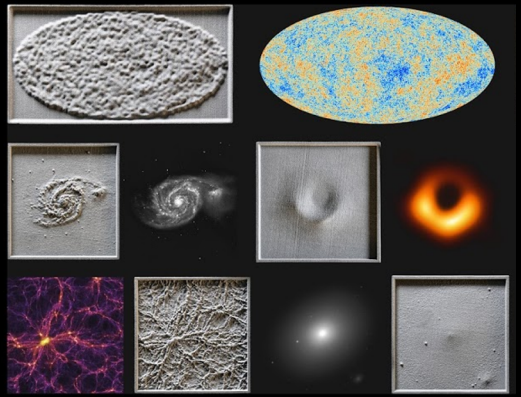
A Touch of the Universe (University of Valencia+)

https://www.uv.es/astrokit/



Tactile Universe (University of Portsmouth +)

www.tactileuniverse.org



Sound for Research

Sound is inherently multi-dimensional (pitch, volume, timbre, duration…)

Cocktail party effect (differentiate multiple data streams)

Strong potential to intuitively & comprehensively explore large, noisy, complex and/or multi-dimensional data with sound
(Hermann et al. 2011; Sawe et al. 2020)

Sound for Research

Ear good at perceiving time-based information and non-focussed data monitoring

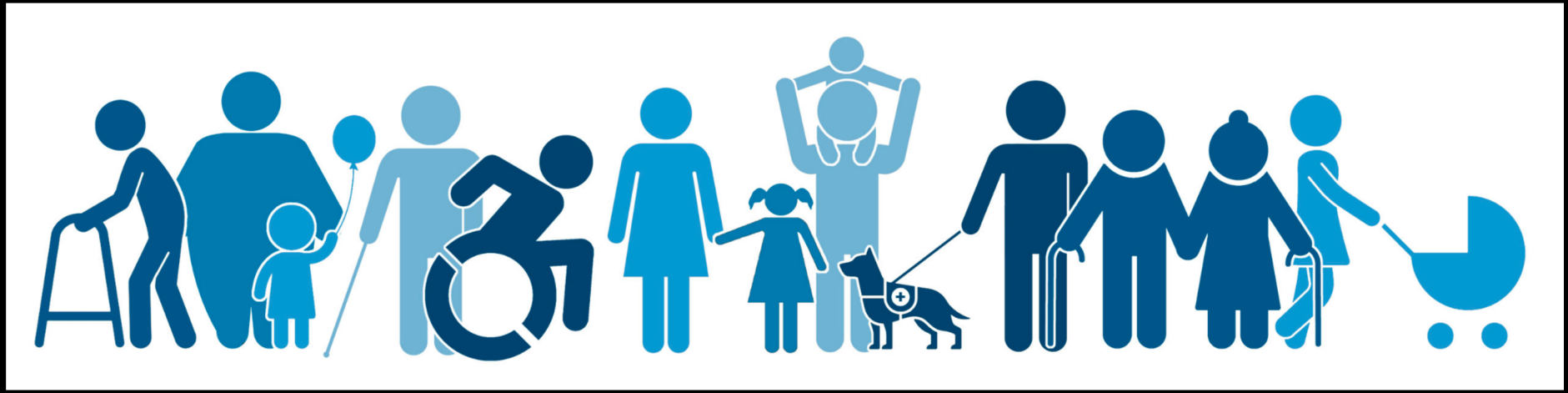
Geiger counter, alarms in hospital / control room, pattern recognition…

(e.g., Guttmann et al. 2005; Walker, B. N. and Nees, 2011)

Strong potential for exploring time-series data and live monitoring of transient events

(e.g., Cooke et al. 2019)

Universal Design



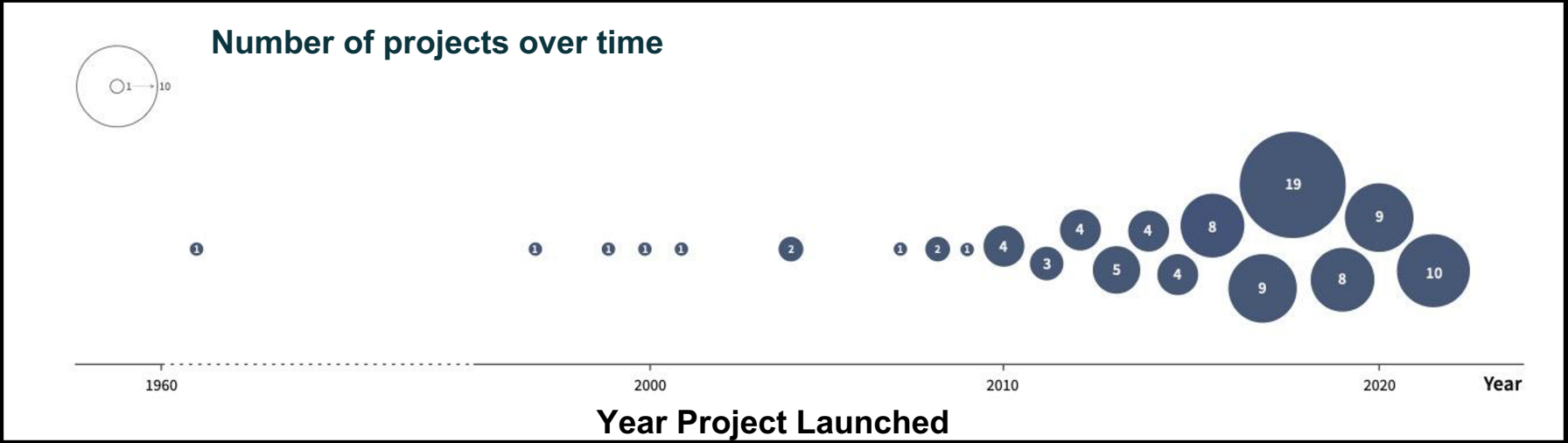
Accessible options should not be an ‘add on’ or ‘extra’ because:

1. Not truly inclusive
2. If not ‘mainstream’ very difficult to be taken seriously, funded etc.

Universal (accessible) Design and demonstrate *everyone* benefits

Sound Design and Sonification

98 astro-sound projects discovered (as of December 2021)
Rapid popularity growth over last ~10 years



Zanella, Harrison et al., Nat. Ast., (2022)

Harrison, Zanella et al., Nat. Ast., (2022)

Sound Design and Sonification in Astronomy

Primary Goal

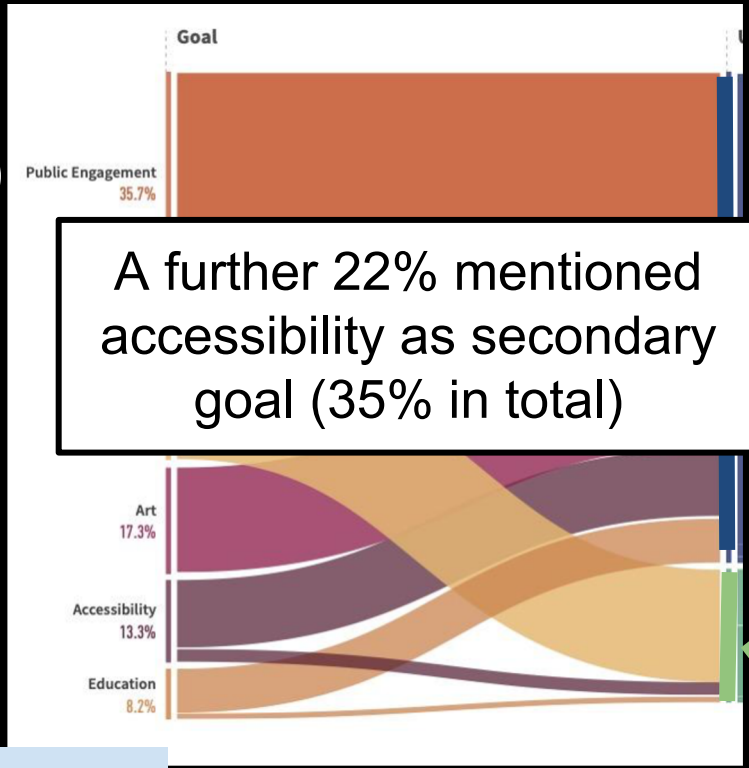
Public Engagement (36%)

Research (25%)

Art (17%)

Accessibility (13%)

Education (8%)



A further 22% mentioned accessibility as secondary goal (35% in total)

Primary User

General Public
79%

Researchers
21%

Zanella, Harrison et al., Nat. Ast., (2022)

Challenges for Sound Projects in Astronomy

Harrison, Zanella et al., Nat. Ast. (2022)

Zanella, Harrison et al., Nat. Ast. (2022)

Lack of efficacy testing and evaluation

Lack of 'proof' it is useful

Limited method development & standardisation

Like we have standards for producing figures

Lack of publications / dissemination

Examples of 'reinventing the wheel'

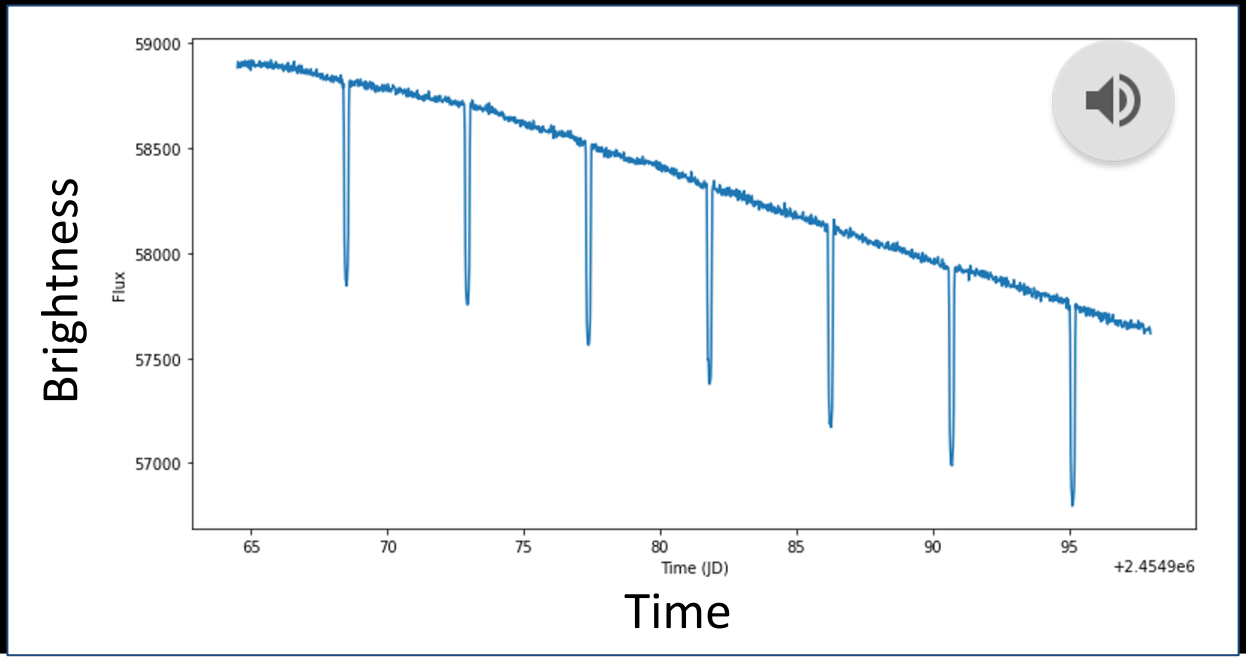
Not mainstream knowledge

Astronomy journals not used to sonification (topic or as media)

Research applications - STScI & MAST

https://astronify.readthedocs.io/

Astronify: Python package (currently)
Sonify “light curve” data e.g., *Kepler* Satellite database
Goal: integrate sonification into whole of MAST archive



Efficacy Testing of Astronify

Made mock light curves, Signal-to-noise ratios: 3-100

Online survey: count the transits (n=0,1,2)!

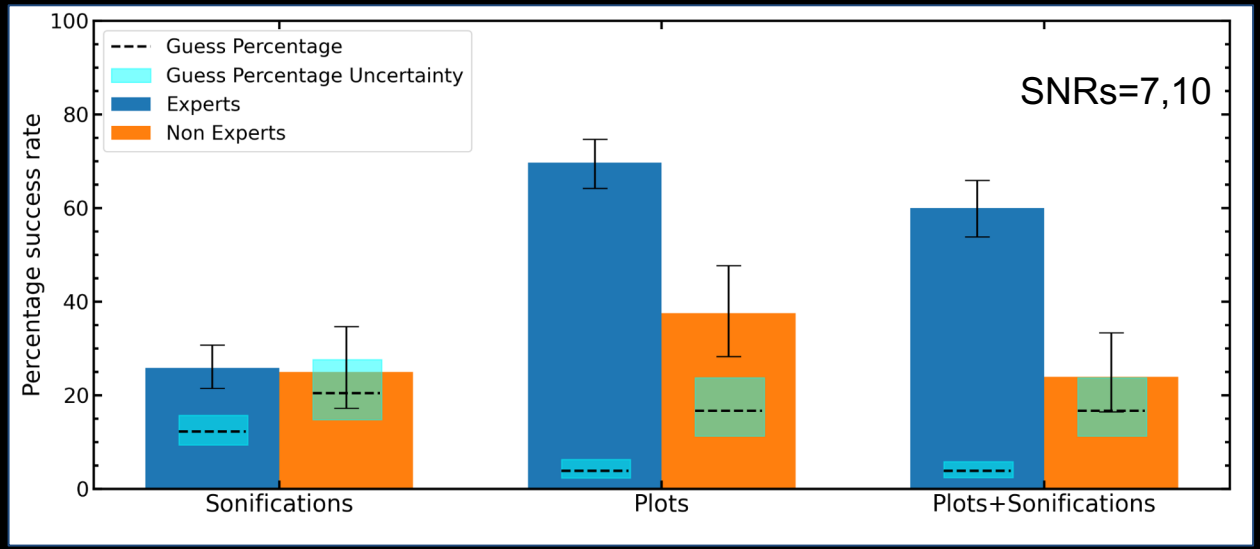
9 light curves per survey: plot only, audio only or both together

192 responses (split into data/astronomy experts/non experts)

Tucker-Brown, Harrison et al., MNRAS, (2022)

Efficacy Testing of Astronify

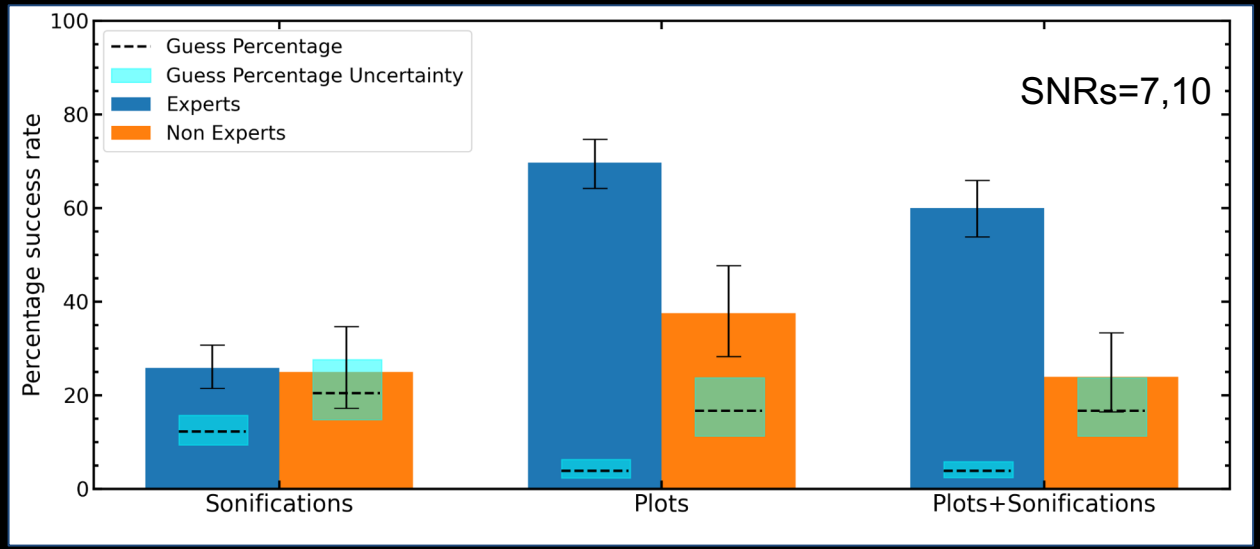
High SNRs = high success rates with sonification (85-100%)
Medium SNRs = high success for plots (**only experts**)
moderate success with sonifications (**experts and non experts)**



Tucker-Brown, Harrison et al., MNRAS, (2022)

Efficacy Testing of Astronify

Conclusion: sonification is viable but training/experience will be crucial for wider adoption (cf. visual analysis experience)



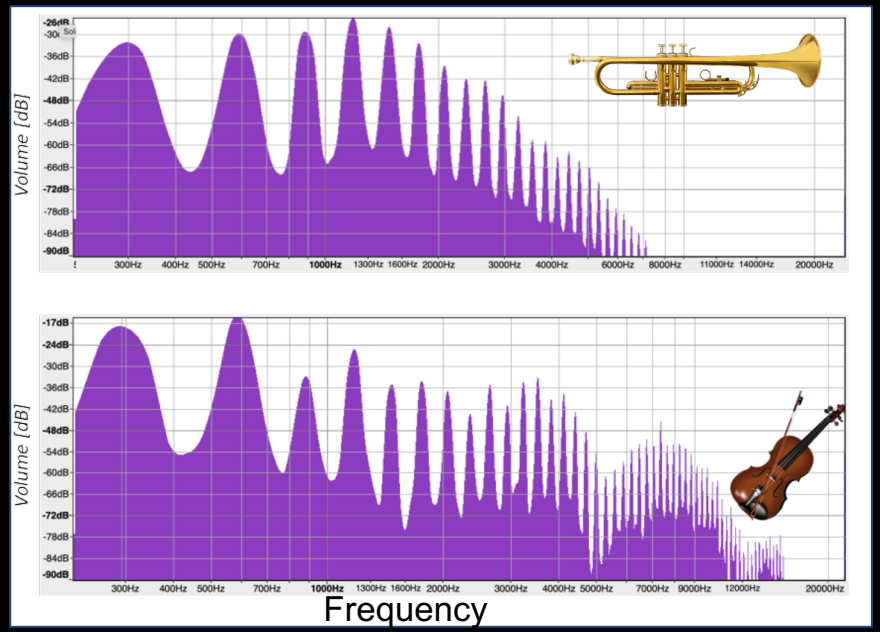
Tucker-Brown, Harrison et al., MNRAS, (2022)

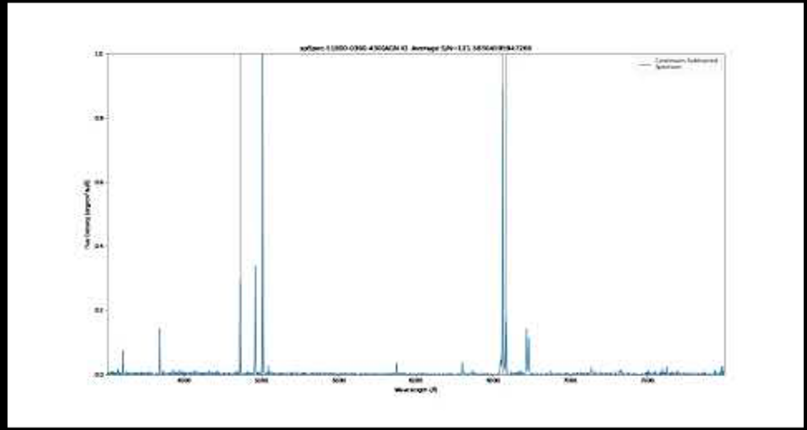
Method Development - STRAUSS

STRAUSS, Python code by James Trayford (Portsmouth) - many sonification functions

Example: sonification of spectra

Trayford (2021)



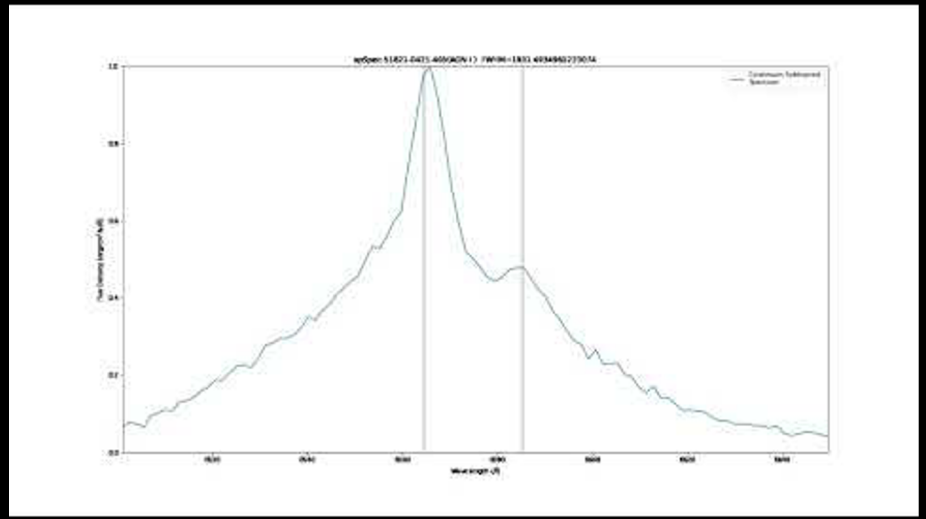


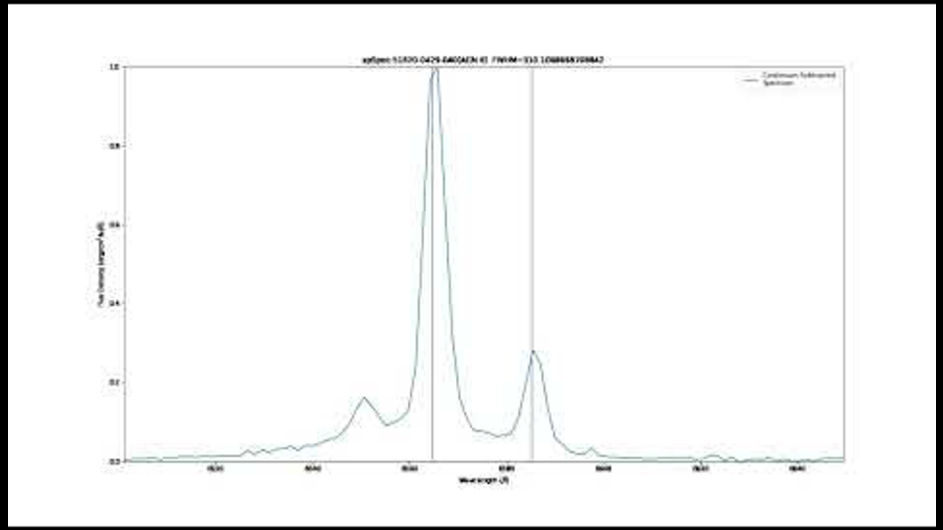
Hinz, Harrison et al. in prep

Method Development - STRAUSS

Hinz, Harrison et al. in prep

Type 1 vs. Type 2 AGN
(widths of emission line)

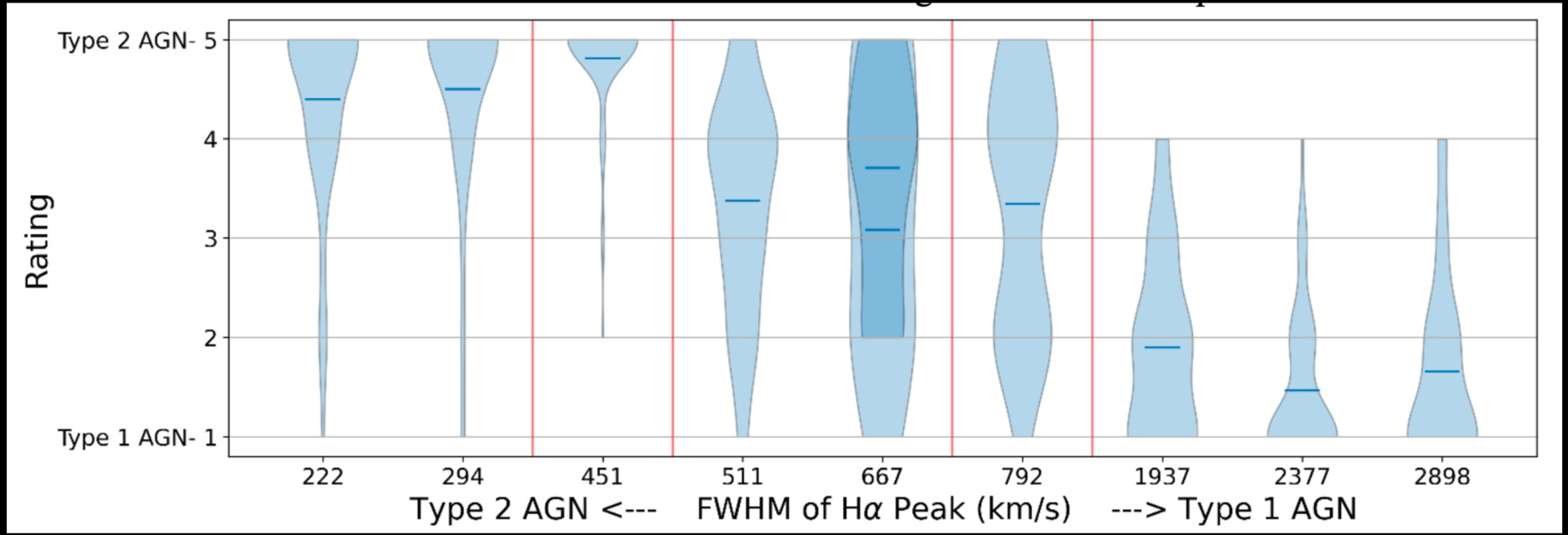




Method Development - STRAUSS

Hinz, Harrison et al. in prep

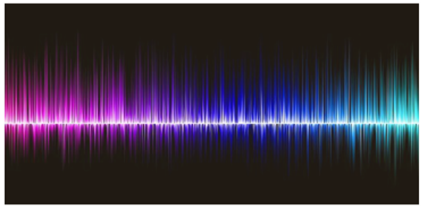
Asking participants to rank what they heard (with no explanation of what hearing)….



Accessible Engagement

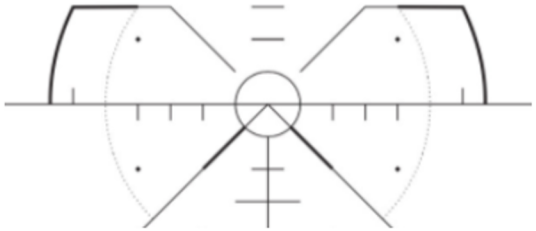
Find links at: www.audiouniverse.org/education-and-outreach

SonoKids Ballyland

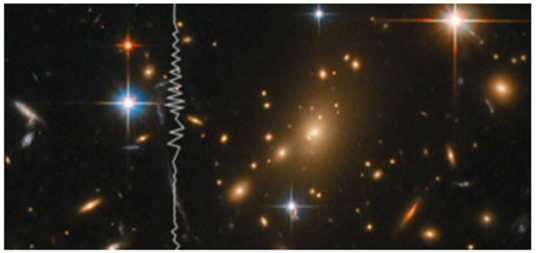


CosMonic

SYSTEM Sounds



AstreOS



From Space to Sound

also see e.g., Bieryla et al., 2020, AAS 235, 203; Garcia-Benito et al. 2022, arXiv:2205.12984; Bardelli et al., 2022, arXiv:2202.05539

Audio Universe: Tour of the Solar System

www.audiouniverse.org

Same STRAUSS code as for our Research activities

Educational show: everything is represented with sounds
(as well as visuals)

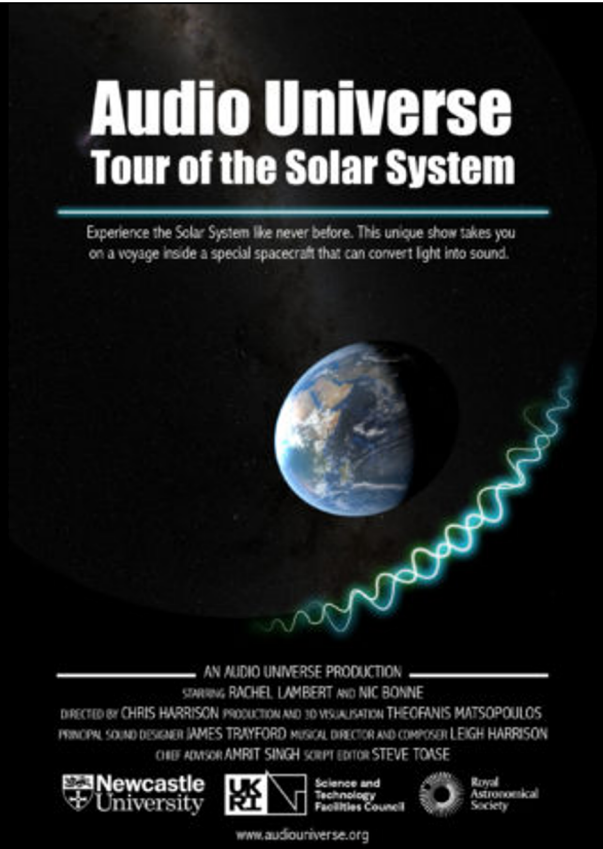
Created *with* members of VI community (children, adults, specialist teachers), musicians and educators

For use in planetariums, at home or in schools

Dr Nic Bonne is a narrator

Evaluation of Audio Universe: Tour of the Solar System

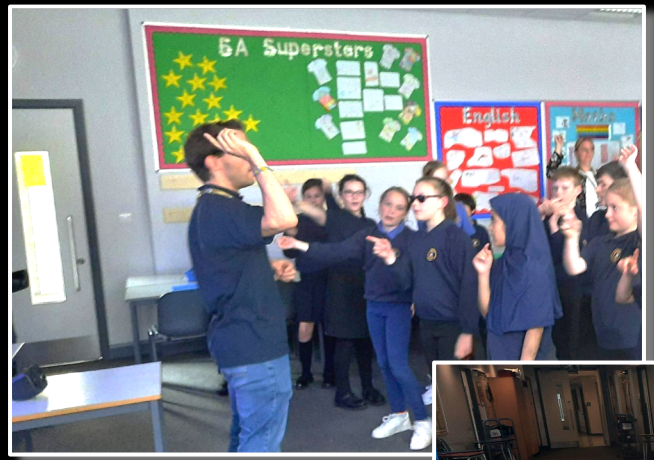
www.audiouniverse.org



~200 surveys conducted

- 87% found sounds useful or very useful
- 76% now more convinced astronomy is accessible for vision impaired
- 88% now want to find out more about science
- Quotes from sight impaired audience…

Audio Universe - Inclusive Educational Activities



Inclusive Educational Activities

sonic.py [in development]
Coded by Michele Ginolfi
and Luca Di Mascolo

Find out more, including links to various projects:
www.audiouniverse.org

Review of Astronomy Sound & Sonification, and Accessibility:

Harrison et al. (2022a), Nature Astronomy, 6, 22, *arXiv:2206.13542*
Zanella et al. (2022), Nature Astronomy, in press, *arXiv:2206.13536,*
Noel-Storr & Willebrands (2022), Nature Astronomy, in press, *arXiv:2206.13815*

Audio Universe: Tour of the Solar System

Harrison et al., (2022b), Astronomy & Geophysics, 62, 2.38, *arXiv:2112.02110*

Efficacy testing of sonification (astronify)

Tucker-Brown, Harrison et al., MNRAS, *arXiv:2209.04465*

STRAUSS Code:

Trayford (2021), doi:10.5281/zenodo.5776280
https://github.com/james-trayford/strauss

Newcastle University

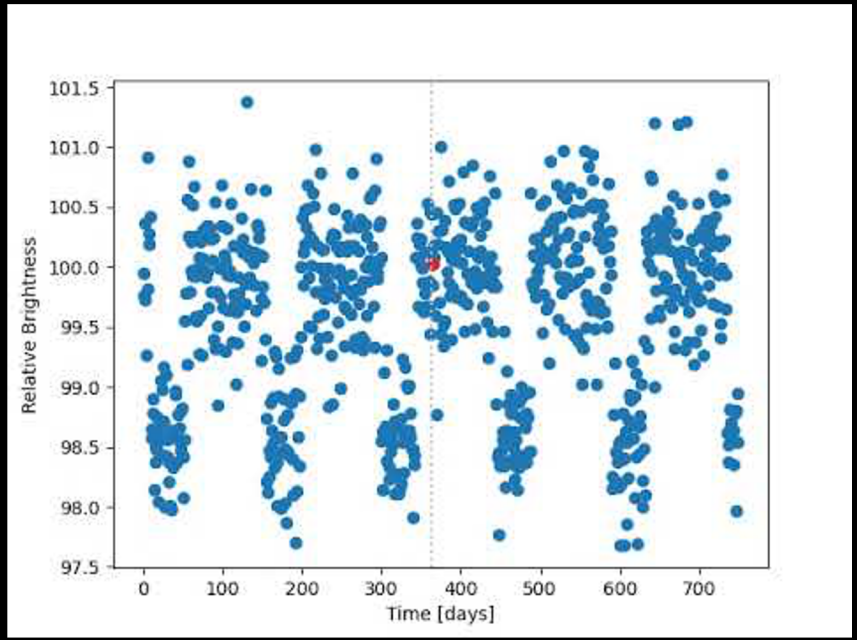
Sound Design and Sonification

Sound Design - *use of sound to make an intention audible, i.e., to represent something other than itself such as an object, concept or system*

Credit: C. Harrison, J. Trayford

Sound Design and Sonification

Sonification - *technique for representing information and data using non-speech audio*



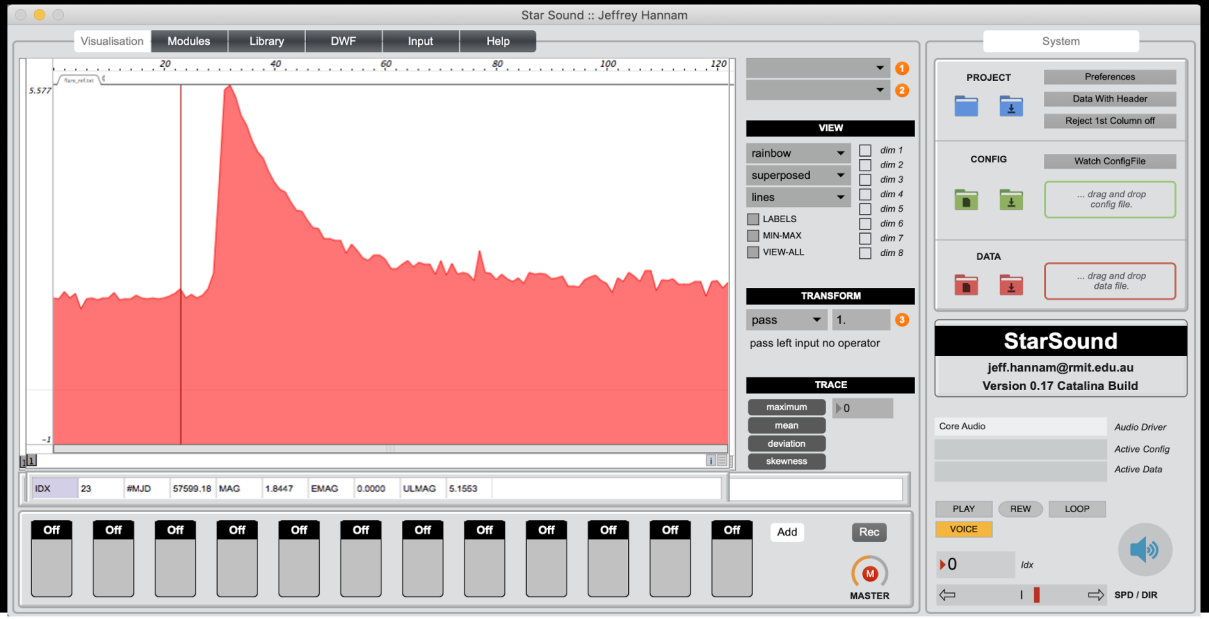
Tucker-Brown et al., MNRAS, submitted

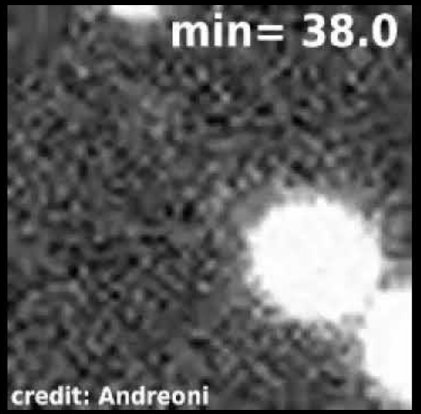
Sonification Review: *Sonification Handbook Edited by Hermann, Hun, Neuhoff, 2011, Logos Publishing House*

Deeper Wider Faster Multi-Messenger: Star Sound

https://www.jeffreyhannam.com/software

- Developing transient monitoring with sonification
- Goal to enhance multi-messenger follow-up
- For researchers and citizen scientists





J. Cooke, J. Hannan; Swinburne University, RMIT University USA

SYSTEM Sounds with NASA

https://chandra.si.edu/sound/

Artistic

Inspiring to new audiences

To be confirmed if features in images are interpretable with sound only

Credit: NASA/CXC/SAO/K.Arcand, SYSTEM Sounds (M. Russo, A. Santaguida)