Revista Mexicana de Astronomía y Astrofísica Serie de Conferencias (RMxAC), **57**, 53–56 (2024)

https://doi.org/10.22201/ia.14052059p.2024.57.13

III Workshop for Astronomy Beyond the Common Senses for Accessibility and Inclusion (3WAI) (November 29-30, 2023)
Editors: Santiago Vargas, Beatriz García, Johana Casado, Breezy Ocaña, and Angela Pérez - DOI: https://doi.org/10.22201/ia.14052059p.2024.57.13

THE LIGHTSOUND PROJECT: USING SONIFICATION TO OBSERVE A SOLAR ECLIPSE

S. Ó. Hyman[1] and A. Bieryla[2]

RESUMEN

El proyecto LightSound comenzó en 2017 cuando el Gran Eclipse Solar Americano pasó por América del Norte. El dispositivo LightSound fue diseñado para convertir la luz en sonido como una forma de involucrar a personas ciegas, con baja visión y no visuales en la observación y recopilación de datos de eclipses solares. El dispositivo puede utilizarse como herramienta educativa/divulgativa y/o como dispositivo de observación de eclipses. Utiliza tecnología Arduino para convertir la luz en sonido y hacer los eclipses más accesibles para los no videntes. Durante los eclipses sudamericanos de 2019/2020, se distribuyeron más de 100 dispositivos en Chile y Argentina, con decenas de miles de personas que tuvieron acceso a la herramienta. En preparación para los eclipses norteamericanos de 2023 y 2024, el proyecto está construyendo y distribuyendo más de 750 dispositivos a comunidades en Estados Unidos, México, Canadá y partes de América del Sur. Para lograr este objetivo, el proyecto está llevando a cabo talleres para enseñar a los participantes habilidades de soldadura mientras construyen dispositivos que luego se donan, sin costo alguno, a educadores y organizaciones que organizan eventos o buscan involucrar al público en la ciencia de los eclipses. El proyecto es completamente de código abierto y la documentación está disponible en inglés, español y francés. Nuestro objetivo es llegar a la mayor cantidad de organizadores posible para destacar la importancia de la accesibilidad como una herramienta de planificación y no como una idea secundaria.

ABSTRACT

The LightSound Project began in 2017 when the Great American Solar Eclipse passed through North America. The LightSound device was designed to convert light to sound as a way to engage blind, low-vision, and non-visual learners in solar eclipse observing and data collection. The device can be used as an educational/outreach teaching tool and/or an eclipse observing device. The device uses Arduino technology to convert light to sound to make eclipses more accessible to non-visual learners. During the 2019/2020 South American eclipses 100+ devices were distributed across Chile and Argentina with tens of thousands of people having access to the tool. In preparation for the 2023 and 2024 North American eclipses, the project is building and distributing 750+ devices to communities across the United States, Mexico, Canada, and parts of South America. To achieve this goal, the project is running workshops to teach participants soldering skills while building devices that are then donated, at no-cost, to educators and organizations hosting events or looking to engage the public in eclipse science. The project is completely open source and documentation is available in English, Spanish, and French. Our goal is to reach as many organizers as possible to stress the importance of accessibility as a planning tool and not an afterthought.

Key Words: Solar Eclipse — BLV tool — sonification

1. INTRODUCTION

On average, any given spot on Earth will experience a total solar eclipse once every 375 years and an annular eclipse once every 225 years (Meeus 1982). Solar eclipses can be an intense emotional experience and are typically described in visual terms, but there are many other things that occur during the few minutes of totality. The temperature changes. Animals react. Humans may cheer, cry, or stand in silence. As communities in the path of totality organize eclipse-viewing events, accessibility should be in the forefront of their minds in order to make the eclipse as inclusive as possible.

LightSound (Fig. 1) is a tool that uses sonification (i.e., converting data or signals into sound)[3] that enables a blind or low vision (BLV) individual to experience the changing ambient light during a solar

[1]Steward Observatory and Department of Astronomy, University of Arizona, 933 N. Cherry Ave., Tucson, AZ 85721, USA.

[2]Center for Astrophysics | Harvard & Smithsonian, 60 Garden Street, Cambridge, MA 02138, USA.

[3]For an review of uses of sonification in astronomy, see Zanella et al. (2022).

III Workshop for Astronomy Beyond the Common Senses for Accessibility and Inclusion (3WAI) (November 29-30, 2023)
Editors: Santiago Vargas, Beatriz García, Johana Casado, Breezy Ocaña, and Angela Pérez - DOI: https://doi.org/10.22201/ia.14052059p.2024.57.13

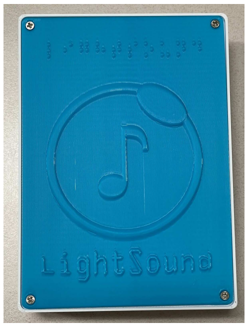

Fig. 1. LightSound device in 3D printed case.

eclipse with sound. The device can be used by an individual wearing headphones or it can be attached to a speaker for a group experience. The device can also collect data for re-sonification or analysis after the event. To date, the devices have been used for four different solar eclipses: the 2017 North American total eclipse, the 2019 and 2020 South American total eclipse, and the 2023 North/Central/South American annular eclipse. We are aiming to distribute 750 devices across the path of totality in preparation for the 2024 April 8 total solar eclipse across North America, Mexico, and parts of South America.

2. EVOLUTION OF THE LIGHTSOUND DEVICE

LightSound (Bieryla et al. 2020) is an Arduino-based, open-source device that was designed to be a low-cost sonification tool for blind or low-vision individuals to experience the changing light during a solar eclipse. At its core, LightSound has five main components: a light sensor, an Arduino-based microcontroller board for computer interface and for the code, a method to sonify the light sensor readings, an audio jack for audio output, and a power source. Since its development in 2017, the device has undergone several iterations.

2.1. *Prototype (2017)*

The LightSound prototype (Fig. 2, left panel) was designed in collaboration with Daniel Davis (Harvard University) and blind astronomer Wanda Díaz-Merced for the August 2017 total solar eclipse across North America. This version used an Adafruit TSL2561 light sensor (now discontinued) and an Adafruit Feather HUZZAH with ESP8266 microcontroller and was powered by a 9-volt battery. At this time, the sonification was a simple square wave with higher frequencies mapped to brighter light measurements and lower frequencies mapped to lower light measurements.

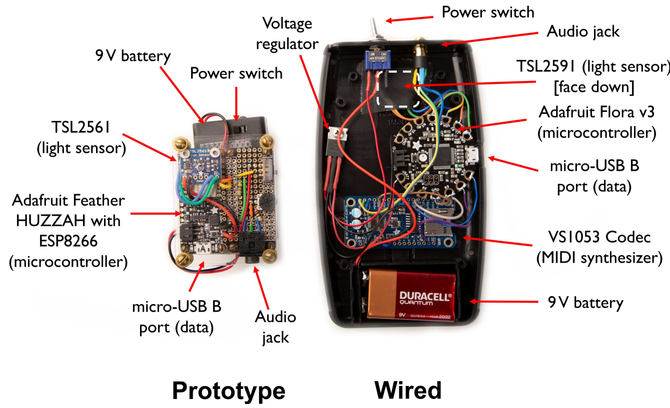

Fig. 2. Left: Labeled LightSound prototype. Right: Wired LightSound in a custom-milled case.

Only three prototype LightSounds were made as a proof-of-concept. During the 2017 North American eclipse, two devices were used in Kentucky to collect data for later re-sonification, and the other was taken to Wyoming to live-stream the sound over the internet during the eclipse.

After the event, it was determined that the light sensor did not have the dynamic range available to capture the darkest part of the eclipse. Comments from the users also indicated that the device would benefit from a different sound mapping.

2.2. *Wired Version (2018-present)*

In preparation for the 2019 and 2020 total solar eclipses across South America, we redesigned LightSound (Fig. 2, right panel) by updating the light sensor to an Adafruit TSL2591, which has a much higher dynamic range, and incorporating a MIDI board (Adafruit VS1053), which has sound libraries that allow the sonification to be played by different instruments. The microcontroller board was changed to an Adafruit Flora. The device can run off a 9-volt battery or computer via a micro USB-B cord.

The addition of the MIDI board offered an advantage, beyond improving the listening experience for the user. The MIDI library allowed for different ranges of light brightness to correspond to different instruments, which creates auditory “signposts” that guide the listener.

While the standard range for human ear is typically quoted at 20 Hz to 20 kHz, individual sensitivities vary, especially for those with hearing loss. Furthermore, extreme high and low frequencies can be painful or unpleasant to hear, especially over long durations of time. To accommodate a spectrum of hearing abilities and preserve the resolution of the

III Workshop for Astronomy Beyond the Common Senses for Accessibility and Inclusion (3WAI) (November 29-30, 2023)
Editors: Santiago Vargas, Beatriz García, Johana Casado, Breezy Ocaña, and Angela Pérez - DOI: https://doi.org/10.22201/ia.14052059p.2024.57.13

pitch mapping, LightSound maps ambient light values of less than 61 Lux (i.e., low light) to a series of clicks (i.e., a square wave) that slow as the light dims. In ranges of 61 Lux to 10,000 Lux (i.e., indoor lighting, shade, etc.), the device plays a clarinet sound between the musical pitches of B1 and A5 (61.74 Hz and 880.00 Hz), where higher frequencies correspond to brighter light. In ambient light of 10,000 Lux to the maximum sensor value of 131,072 Lux (i.e., very bright daylight or direct sunlight), the device plays a flute sound between the musical pitches of A5 and F#6 (880.00 Hz and 1479.98 Hz). If the sensor is saturated, the sound of a plucked string plays.

For the July 2019 total solar eclipse across Chile and Argentina, support from an IAU100 Special Projects grant enabled us to partner with our colleagues in Argentina (Beatriz García) and Chile (Paulina Troncoso Iribarren and Erika Labbé) to build and distribute 20 LightSound devices to communities and organizations on and near the path of totality as part of the effort to make eclipse events more accessible to BLV individuals. In preparation for the December 2020 total solar eclipse, our South American colleagues collected and redistributed those devices to other locations that would be holding events. Grant support from the European Southern Observatory (ESO), allowed our Chilean colleagues to build and distribute approximately one hundred additional devices.

For the 2023 annular eclipse, we designed a 3D printable case (Figs. 1 and 3, left panel) that is publicly available (See Section 3).

2.3. *PCB Version (2023-present)*

With growing interest and more demand for LightSound devices for the 2023 annular and 2024 total solar eclipses in North America, we again redesigned LightSound to use a printed circuit board (PCB) instead of wires (Fig. 3, right panel), with the aid of engineer Elliot Richards (Center for Astrophysics — Harvard & Smithsonian). While the overall design of the device stayed the same, we changed the microcontroller board from the Adafruit Feather to an Adafruit Feather 328p[4] for easier placement on the PCB. The PCB version also uses a rechargeable Lithium-ion (Li-ion) battery to power the device and can also run off computer power via a micro USB-B cable. The PCB version is very easy and fast to build, which makes it ideal for "make-a-thon" workshops, where the goal is to build many devices.

[4]The Adafruit Feather 32u4 can also be used in place of the Adafruit Feather 328p.

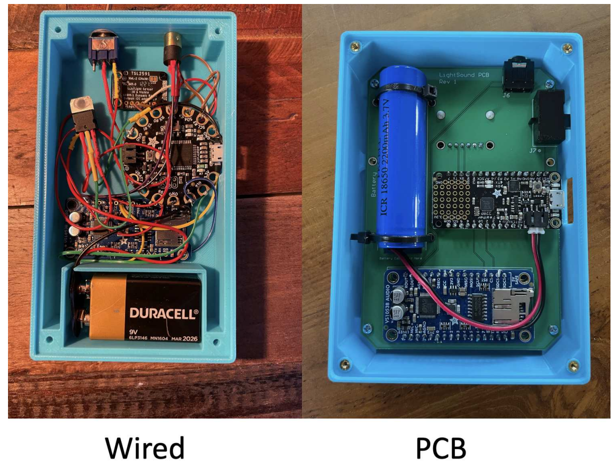

Fig. 3. Left: Interior of wired LightSound in a 3D printed case. Right: Interior of a PCB LightSound in a 3D printed case.

Around 200 PCB LightSound devices were distributed along the path of annularity to communities and eclipse events for the October 2023 annular eclipse, which passed over the western half of the United States and areas of Central America and norther Brazil. To facilitate easy use of the device, we developed and circulated usage instructions and an observing guide for users who were demonstrating the device at a viewing event or who planned to collect data. We also created a submission box for recorded data, photos, and videos that users wanted to share.

3. RESOURCES

The LightSound Project is entirely open source. The device code and printable 3D case designs are available on GitHub[5]. Users can modify the instruments used or any other aspect of the code to customize the device to their needs. The GitHub repository also has code and corresponding instructions for logging and LightSound data.

The LightSound device is Arduino-based[6]. All of the circuit board components are produced by Adafruit Industries [7]. Detailed instructions for building and using the LightSound are available online[8] in English, Spanish, and French.

4. WORKSHOPS

We developed a full-day workshop to teach participants how to build and use the LightSound de-

[5]`https://github.com/soleyhyman/LightSound2.0`
[6]`https://www.arduino.cc`
[7]`https://www.adafruit.com`
[8]`https://astrolab.fas.harvard.edu/LightSound.html\#documentation`

III Workshop for Astronomy Beyond the Common Senses for Accessibility and Inclusion (3WAI) (November 29-30, 2023)
Editors: Santiago Vargas, Beatriz García, Johana Casado, Breezy Ocaña, and Angela Pérez - DOI: https://doi.org/10.22201/ia.14052059p.2024.57.13

vice. We held the first LightSound workshop at the 235th Meeting of the American Astronomical Society in January 2020. Since then, we have held six other workshops (with several more planned) across the United States. in order to build 750 hundred LightSound devices to distribute for the 2024 North American total solar eclipse.

The workshop does not require soldering skills, and a majority of our participants have never soldered before. The setup of the workshop allows for every participant to learn the necessary skills to fully complete a LightSound. Several workshop alumni have organized or helped run additional workshops as well.

Both wired and PCB LightSound versions can be built in a workshop. The wired version is more intensive and time-consuming, but it teaches basics of electrical circuitry and troubleshooting in addition to soldering. Wired-version LightSound workshops are best as a full-day event. PCB-version LightSound workshops focus primarily on learning soldering and are best run as multiple sessions of two hours over the course of a day or two, depending on the number of participants.

5. PREPARING FOR THE 2024 TOTAL SOLAR ECLIPSE

The 2024 April 8 total solar eclipse passes through five Mexican states (Sinaloa, Durango, Coahuila, Chihuahua, and Nayarit), thirteen U.S. states (Texas, Oklahoma, Arkansas, Missouri, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, New York, Vermont, New Hampshire, and Maine), and five Canadian provinces (Québec, New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland and Labrador). See Fig. 4 for details.

The path of totality passes through major cities in all three countries. With the support of funding from the American Astronomical Society, International Astronomical Union, National Science Foundation, and Simons Foundation In the Path of Totality, we are distributing several hundred devices across the path of totality. The devices have been

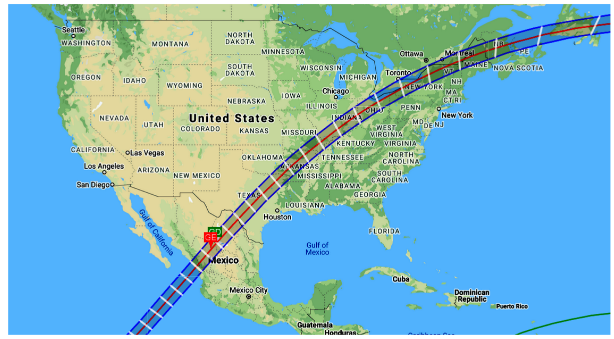

Fig. 4. Map showing path of totality of the solar eclipse on 2024 April 8 across Mexico, the United States, and Canada.

(and are being) built with the help of volunteers through a series of workshops (Section 4).

In addition to distributing to communities and organizations that have requested a LightSound, we partnered with the American Printing House for the Blind to connect with schools for the blind along the path of totality. As with the 2023 annular eclipse, we will have a repository for users to submit LightSound data, photos, and videos. The data will be re-sonified to create an eclipse map, similar to the one made for the 2019 total solar eclipse.[9]

6. LOOKING TO THE FUTURE

After the 2024 total solar eclipse, we plan to connect with other international colleagues who will be organizing eclipse efforts in their respective countries. By sharing the materials, documentation, and workshop model we have developed, we hope that the LightSound Project will continue to make eclipses accessible for all.

REFERENCES

Bieryla, A., Diaz-Merced, W., Davis, D., et al. 2020, Communicating Astronomy with the Public Journal, 28, 38

Meeus, J. 1982, Journal of the British Astronomical Association, 92, 124

Zanella, A., Harrison, C. M., Lenzi, S., et al. 2022, Nature Astronomy, 6, 1241. doi:10.1038/s41550-022-01721-z

[9] https://www.youtube.com/watch?v=RraNpZkSxNY