LightSound: The Sound of An Eclipse

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LightSound was originally developed as a tool for the blind and visually impaired (BVI) community to experience events, like solar eclipses, live. LightSound is a handheld device, built with Arduino components, that converts light into sound via a light sensor and MIDI board. It has an audio jack to output sound and can connect to a computer to record data via Python scripts. The software and instructions for assembly and use are open source and available online in English and Spanish. Through an IAU100 Special Project Grant, 21 LightSounds were distributed to schools, research centres and museums across Argentina and Chile that hosted events for the July 2019 solar eclipse. These events, which reached tens of thousands of people, were accessible to BVI observers with the help of the LightSound. The devices will also be used for the December 2020 South American eclipse. We discuss the highlights of the project and our future plans.

Introduction

A solar eclipse is one of the most visually striking astronomical phenomena. Astronomy is generally thought of as a visual science and because of this, resources for the sensorially-biased community, such as the BVI community, are often limited. For populations with some of their senses reduced, access to knowledge is hindered, complicated and sometimes impossible. The access to all aspects of astronomical phenomena should be, from the point of view of human rights, one of the objectives of astronomers dedicated to all natural aspects of the field.

LightSound is a sonification device that was designed as a tool for the blind and visually impaired (BVI) community for use during a solar eclipse (Figure 1). It was originally designed for the Great American Solar Eclipse in 2017. The idea came to be from a conversation between Allyson Bieryla and Wanda Diaz-Merced. Diaz-Merced was teaching in South Africa at the time and wanted her BVI students to have the opportunity to experience the much-hyped North American eclipse. Bieryla brought the idea to a prototype designer at Harvard University, Daniel Davis, and the work began to design the device. Three of the original prototype LightSound devices were set up at outreach events along the path of totality as a proof of concept. Bieryla took one to Jackson Hole, Wyoming and the two others were sent to schools in Kentucky. The devices in Kentucky were used to collect data and Bieryla used the device in Wyoming to stream sound on the internet for the students in South Africa and people all over the world to listen.

In 2019, Sóley Hyman, then a Harvard University undergraduate, joined the team. Repurposing Adafruit's PianoGlove project[1], Davis adapted the LightSound device to have a more robust chassis and include a MIDI synthesizer, enabling Hyman to develop a better sound profile to prepare for the 2019 South American solar eclipse. The redesigned LightSound project was awarded an International Astronomical Union (IAU) Special Project Grant to fund the distribution of 21 devices across Argentina and Chile. Bieryla and Hyman built the devices that were sent to Chile and Paulina Troncoso Iribarren and Erika Labbe distributed them across Chile. In Argentina, Beatriz Garcia and her team

Figure 1. *LightSound device on a portable tripod with headphones attached. Credit: Allyson Bieryla*

built and distributed the devices to the Argentinean sites.

The LightSound Device

Designed to be both low-cost and easy to assemble, LightSound uses Arduino technology[2] to sonify changing ambient light levels in real-time. The device consists of three main components, all of which are produced by Adafruit Industries[3]: the Flora v3 microcontroller board, the TSL2591 light sensor and the VS1053 Codec (MIDI synthesizer) board. The other components for the device are generic — a toggle switch for power, audio jack, 5-volt voltage regulator and a 9-volt battery. Although any type of box or casing can be used to house the completed LightSound circuit, we designed a custom chassis with Hammond Manufacturing[4] that has pre-cut holes for the power switch, audio jack and micro-USB port (located on the Flora microcontroller board). Excluding the costs of standard electrical and soldering equipment (e.g. soldering iron, wire strippers, hookup wire, etc.), the LightSound components total to around $70 USD.

Assembly of the device requires only basic soldering skills and can be completed in a few hours. Even those who have little to no experience soldering have been able to successfully build their own devices. Safe, inclusive-tested soldering methods for the BVI community have been developed by Dr Leonard Garcia and Diaz-Merced and are available upon request[5]. After assembly of the device circuit is complete, the LightSound code is uploaded to the Flora board via the micro-USB port. This port is also used to connect the device to a computer, where the LightSound can run off computer power and record the light intensity during observations. Figure 2 shows a side-by-side comparison of the original and re-designed LightSound with the components labelled.

Available Resources

We have gone to great lengths to make all documents and software open source. Detailed instructions to assemble a LightSound device are available online[6]. We also provide instructions to use the software, written in Python, which allows users to collect and plot data for future analysis, regardless of programming experience. All documentation is currently available in English and Spanish, and we hope to expand to other languages soon.

Part of the broader impact of the LightSound is the lesson plans. The LightSound device, while designed for use during a solar eclipse, can also be used as an educational tool in classrooms or outreach events for BVI students. Lesson plans on orbits and eclipses[7], which can be used for various age students, have also been developed and more lesson plans are currently under development.

In an attempt to reach more people, we developed a workshop which we debuted at the American Astronomical Meeting in Honolulu, Hawai'i in January 2020[6]. The two-day workshop aimed to guide participants through the process of building a LightSound device and learning how to use and edit the software. Each participant was able to go back to their home institution with the LightSound they built and the tools that they learned, in hopes that they would transfer their new knowledge to their community. Our goal is to hold more workshops in the coming years in preparation for the next North American solar eclipse in 2024.

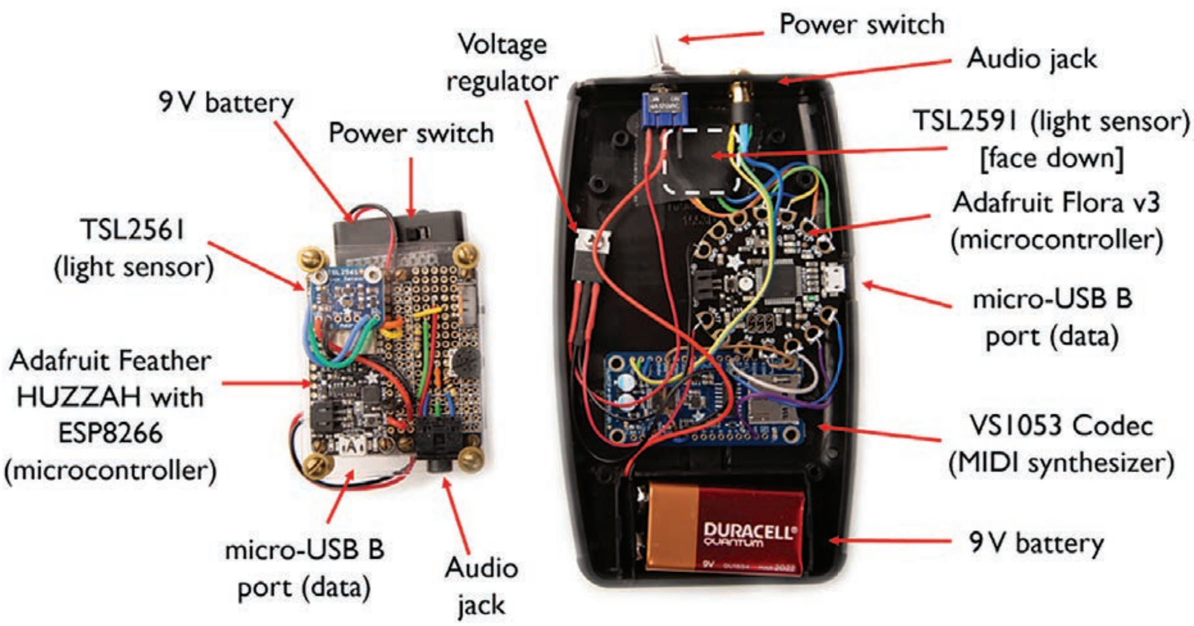

Figure 2. *Comparison of LightSound 1.0 (left, designed for 2017 eclipse) and LightSound 2.0 (right, designed for 2019 eclipse) with components labeled. Credit: Sóley Hyman*

2019 South American Solar Eclipse

Through an IAU100 Special Project Grant, we built and distributed 21 LightSound devices throughout Argentina and Chile in preparation for the July 2019 solar eclipse (see Table 1 and Figure 3). Over 10 000 people attended these events across Argentina and Chile. Figure 4 shows an event held in La Serena, Chile where people gathered at a local stadium. The LightSound devices were used during the solar eclipse to sonify the diminishing light of the Sun as it was being eclipsed by the Moon. This made the event accessible to a larger group of individuals including those with different perceptual styles.

The 2019 solar eclipse was the news highlight of the year for many countries in South America. Hundreds of interviews, newspaper articles, blogs and social media posts were geared toward these events highlighting the LightSound. Hyman gathered the data from the sites where the LightSound recorded the eclipse data and made a video sonification map[8]. The video plays the sonified data from four locations in South America, synchronised with a NASA animation of the eclipse.

Argentina	Chile
Colegio Provincial de Santa Lucía, Santa Lucía, San Juan	AstroBVI/U. Antofagasta — Municipalidad de Antofagasta, Antofagasta
Municialidad de Calingasta y CASLEO, Calingasta, San Juan	ALMA — Atacama
Club de Astronomía Villa Mercedes, San Luis	NPF/IFA/MAS — Atacama
Escuela Especial Vicenta Castro Cambon, Río IV, Córdoba	GEMINI/CTIO — Coquimbo
Escuela Especial Luciernagas, Río IV, Córdoba	IFA — Valparaíso
Escuela Especial Dra Cecilia Grierson, Centro de Atención para Discapacitados Auditivos, Rio IV, Córdoba	AstroUDP/AstroTactil — Santiago
Instituto Helen Keller, Córdoba Capital	MIM — Santiago
Municipal camping of Villa Cañas, Santa Fe	U Autónoma — Planetario Chile — Santiago
Escuela Helen Keller, Godoy Cruz, Mendoza	Dedoscopio — Penco, Biobío, Chile
Fac. de Cs. Astronómicas y Geofísicas y Fac. De Arquitectura, La Plata, BsAs	Patricio Antiman — Plaza de Armas de Aysén, Aysén
Centro de Recursos Educativos para Personas con Discapacidad, Córdoba Capital	

***Table 1.** Location of LightSound devices during the 2019 South American Eclipse.*

***Figure 3.** Map of the LightSound locations during the solar eclipse on 2 July 2019. Credit: Google Maps.*

Conclusion and Future Plans

We are continually trying to build the community of LightSound users[9]. LightSound is a low-cost, high-impact project. Each LightSound can potentially impact hundreds to thousands of people. We intend to explore the use of haptics (vibration) and the use of a memory card for data storage. This would extend access to more platforms. Our hope is that we can spread knowledge and resources through continued workshops and online open-source documents. But this is not enough. We want and need to be able to reach all communities, including those communities with very limited resources and funds. To tackle this problem, we rely on grants from organisations to fund endeavours for communities most in need. LightSound can be used with and without a computer and can provide an entire school or community access. It can give all participants a needed tool to aid in the immersion of astronomy, science and phenomena that was previously a more abstract concept.

Building on the success of the LightSound, we developed a second device called Orchestar[10]. Orchestar works using the same technology with the major difference being that the light sensor is now multi-wavelength. The sound is output based on the colour of the light with longer wavelength light having a lower pitch sound as compared to higher wavelength light. Orchestar has a great potential impact. One focus of this project has been to develop Orchestar as an observing tool on a telescope. Orchestar has been highlighted in the IAU Inspiring Stars[11] travelling exhibit that focuses on inclusive and accessible astronomy resources and tools. It was also used to listen to Atacama Large Millimeter/submillimeter

Figure 4. *Thousands of people gather at Estadio La Portada in La Serena, Chile to witness the solar eclipse on 2 July 2019. LightSound is shown on the table connected to speakers for BVI individuals to hear the sound of the solar eclipse. Credit: Katherine Marchant, Estadio La Portada.*

Box 1. Selected testimonials from the July 2019 solar eclipse events

"The activity went really well, beautiful experience. All impressed by such beauty. We had a great expectation. The students enjoyed it immensely. At the time of the totality that lasted 30 seconds, all of the people were amazed. Total euphoria! Thank you all very much, especially for the possibility of providing the opportunity for blind people to perceive the eclipse."

Ana Belén de Alias - Primary Teacher, San Juan, Argentina

"Today, July 2, was a very exciting day, beautiful and unforgettable, enjoying a wonderful event such as a solar eclipse in the stadium 'La Portada', and best of all, there was a machine that transformed the solar light into sound ... And when the Sun was completely covered by the Moon, the machine began to sound lower until there was a small moment of silence. (...) this made the eclipse more inclusive and blind people could enjoy this wonderful event just like everyone else."

Katherine Marchant, La Serena, Chile

Array (ALMA) maps and Hubble Space Telescope (HST) images at the First Stars IV conference (Figure 5)[12].

The LightSound devices that were used during the 2019 solar eclipse will also be used during the upcoming South American solar eclipse in December 2020. In Chile, funded by the Gemini Observatory and the European Southern Observatory (ESO), Troncoso Iribarren and her team are building more than 200 LightSound and Orchestar devices for distribution to outreach centres and some rural schools for the 2020 eclipse.

Notes:

[1] Adafruit's PianoGlove project: https://learn.adafruit.com/pianoglove/what-youll-need

[2] Arduino website: https://www.arduino.cc

[3] Adafruit Industries website: https://adafruit.com/

[4] Hammond Manufacturing website: https://www.hammfg.com

[5] Information about the development of the soldering techniques can be found in this article: https://www.nasa.gov/audience/foreducators/k-4/features/F_Tuning_in_Sounds_of_Space.html. Please contact abieryla@cfa.harvard.edu if you are interested in learning more about the soldering techniques.

[6] LightSound IAU100 Project website in English: http://astrolab.fas.harvard.edu/LightSound-IAU100.html. LightSound IAU100 Project website in Spanish: http://astrolab.fas.harvard.edu/LightSound-IAU100-sp.html

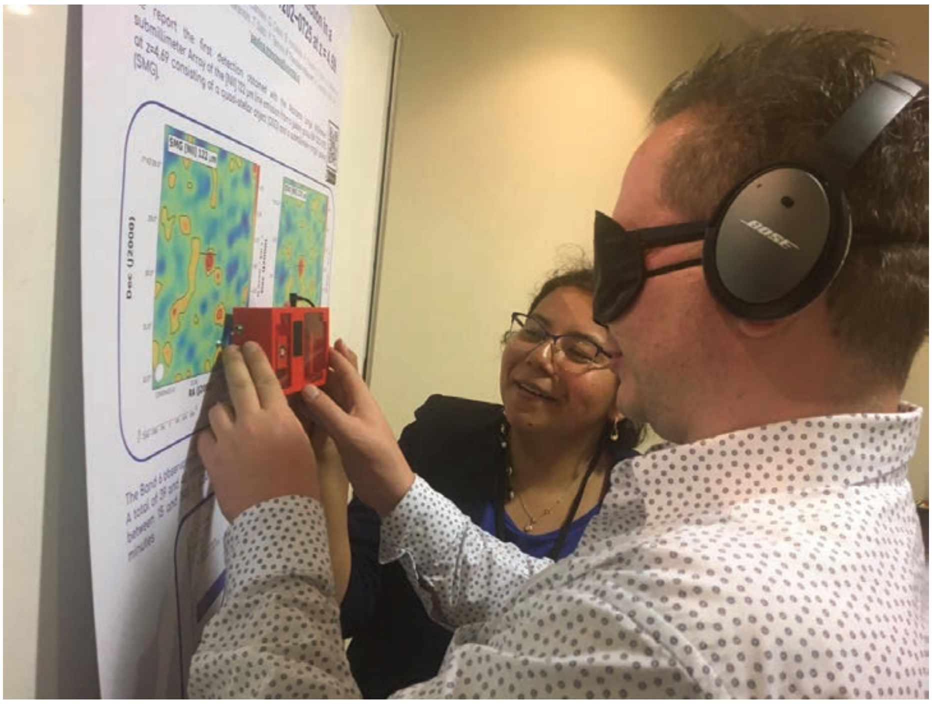

Figure 5. *Orchestar being used to listen to ALMA maps and Hubble Space Telescope images during the First Stars IV conference. Credit: Paulina Troncoso Iribarren*

[7] AAS 235 Workshop and Events website: https://aas.org/meetings/aas235/workshops-events

[8] Video sonification map: https://www.youtube.com/watch?v=RraNpZkSxNY

[9] We are always interested in feedback and collaboration! Please do so by contacting abieryla@cfa.harvard.edu.

[10] Harvard Astronomy lab accessibility website with information about the Orchestar: http://astrolab.fas.harvard.edu/accessibility.html Spanish documentation available (still under development): https://drive.google.com/drive/folders/18kJ-43SJCuozmF4ysBqpPCVQ0T_C3Bfr

[11] Inspiring Stars website: https://sites.google.com/oao.iau.org/inspiringstars

[12] First Stars IV conference: http://www.astro.udec.cl/FirstStarsVI/Program.pdf

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Biographies

Allyson Bieryla is an astronomer at the Center for Astrophysics | Harvard & Smithsonian. She is involved in exoplanet research and manages the astronomy lab and telescopes for undergraduate courses at Harvard University.

Sóley Hyman is a graduate student at the University of Arizona's Department of Astronomy and studies the orbit of the star S2 around our galaxy's supermassive black hole. She also became involved in multiwavelength AGN research while at the Harvard-Smithsonian Center for Astrophysics.

Beatriz García is an astronomer at the Instituto de Tecnologías en Detección y Astropartículas, a subsidiary of CNEA, CONICET and UNSAM. She works on topics related to Ultra High Energy Cosmic Rays and CMB and conducts research on inclusive astronomy.

Wanda Diaz-Merced is an astronomer from Puerto Rico. She has worked on various topics in high-energy astrophysics and uses sonification techniques in her research.

Paulina Troncoso Iribarren is an extragalactic astronomer, focusing on the birth and evolution of galaxies using the synergy of simulations and observations. She is the director of the astronomy major at the Universidad Central de Chile, where she is teaching about inclusive technology in the formal education of future teachers and astronomers.

Erika Labbé Waghorn is an astronomer and Outreach Coordinator for the Astronomy Nucleus of Diego Portales University. She has taught general formation courses in astronomy and scientific communication in several universities. In 2015 she started the astronomy outreach project for the UDP Astronomy Nucleus, which quickly extended to areas such as art and inclusion.

Daniel Davis is an applied physicist, educator, and Director of Harvard Natural Sciences Lecture Demonstrations, whose work is to reveal the wonder and utility of phenomena to enhance their perception, enjoyment, and implementation.