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**Editorial**

The influence of humans on the earth is as evident as challenging. What is referred to as the Anthropocene is shaping our current environment. This is not only subject to research on geology, ecosystems, and biodiversity of earth, but also reflected and discussed in and through artistic works and work processes.

This issue brings together explicitly artistic perspectives on topics such as global warming, the influence of climate change on our environment ranging from melting of glaciers to the effects on indigenous cultures, new reflections resulting from listening to the environment, as well as reflections on how our own behavior in the field of music tech related arts may effect the ongoing environmental changes.

Thanks to this issue's guest editor, Scott Deal, we are able to present a variety of perspectives and artistic approaches, with which we hope to broaden the discussion of topics related to Anthropocene.

Miriam Akkermann

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**Flux in the Anthropocene: An Overview**

*By Scott Deal*

*Ring the bells that still can ring*
*Forget your perfect offering*
*There is a crack, a crack in everything*
*That's how the light gets in*

(From "Anthem", by Leonard Cohen)

The Anthropocene, the current epoch named for humanity's impact on earth systems, is characterized by some of the most pressing issues of our time, including global warming, biodiversity loss, mass pollution, water shortages, and more. Human activities, principally through emissions of greenhouse gases, have "unequivocally caused global warming, with global temperatures exceeding 1.1°C above 1850-1900" (United Nations IPCC, 2023). Global expansions in farming, fishing, construction, mining, and more is creating a crisis of biodiversity where more, than one million species are threatened with extinction (Tolleson, 2019). Fresh water resources are overburdened as overconsumption, pollution, and the depletion of groundwater threaten entire geographic regions. From mountain tops to ocean bottoms, the world is awash in plastic. As a result of these conditions, the Anthropocene has brought "an environmental phase shift, where formerly resilient eco-systems have been pushed into altered states" (Kelly, J. M. et al., 2018). This shift points to a state of "flux", the title word for this edition of Array. Throughout the world, this flux conjures a zeitgeist of uncertainty. Princeton scholar Richard Falk states that "for a long time we got along without worrying about the caring capacity of the earth, and now we are terrified by the limits that we are exceeding." (Rimona et al., 2021) But there is also room for hope, which is where expressive aesthetics come into play. Our turbulent world is the starting point for creative observation, absorption, and articulation, a process the authors in this edition of Array have aptly engaged. Their writings reflect personal explorations into paths of inquiry, resulting in unique forms of musical art that provide a basis for insight and reflection regarding our time in this world.

As a foundation of musical activity, the process of listening is a broad topic in these articles. Paulo C.

Chagas cites listening as the fundamental construct of *Sound Imaginations: Listening Cultures and Audiovisual Immersion*, writing of his motivation to "investigate sound phenomenon from the point of view of listening." He recorded environments in Brazil, California, and Russia, asking how "people hear the acoustic environment in its totality of nature and human cultural sound". Several writers describe their listening experiences as beginning with recordings from scientific remote devices. In *Aural Snapshots of Patagonia: An Acoustic Survey in Sub-Antarctic Chile*, Garrison Gerard writes of documenting the acoustic environment of Yendegaia National Park in Chile, an extremely remote natural setting that the Chilean government opened to the public by creating a road to access it. With plans to create a musical work from the recordings, the effort will publically call attention to the stark reality of a disappearing aural landscape. Amanda Stuart accessed original audio samples from the Canadian Array for Realtime Investigations of Magnetic Activity (CARISMA) to create her work *Magnetosphere*. In *Six Seasons*, *Composition Inspired by Ocean Sounds From the Arctic*, Zalles Ballivian describes a project employing hydrophones placed on the seafloor of the Chukchi Sea, 300 meters deep, to capture "the sounds of sea ice, marine mammals, and the underwater environment". Other writers pursue less conventional modes of listening. In her article *Indigeneity and Computer Music in the Anthropocene*, Chieh Huang writes of listening beyond the audible spectrum into a realm of sensations. "Vibrational sensations, not just audibility, lie at the core of all music". This world of vibrations not perceived by the human ear is particularly well suited for the technological capabilities of the computer music genre, and its exploration is an emerging creative territory.

In the natural world, devoid of any recording devices, the listening experience is a unique, non-repeatable moment. In *Glacial Music: Katie Paterson's Langjökull, Snæfellsjökull, Solheimajökull (2007)*, author Alexander Rehding describes how Paterson exploited this factor by recording the sounds of the three glaciers and then pressing the audio into phonograph records made from ice of same glaciers. When the ice records are played on a phono-

graph, it melts and the "recorded sound irrecoverably disappears". Highlighting temporality in this fashion recalls artists such as Andy Goldsworthy and Robert Smithson, whose works of natural materials deteriorate over time. Listening concepts are not limited to the experience itself but extend to aurally-based tools. In *Diverse Instrument Symphonic Ensembles as a Strategy for Sustainable Innovation*, Jason Palamara advocates for computer-based ensembles that use sustainable and recycled devices as musical instruments. His idea of a "Diverse Instrument Symphonic Ensemble (DISEnsemble)" seeks "increasingly environmentally neutral solutions to the task/problem of forward-looking musical innovation". In *Networks of (tele)presence: tuning in to the environment through the INTIMAL App©*, Ximena Alarcón Díaz describes a hybrid telematic mobile sonic environment she created that invites people to experience relational listening by collectively engaging "their sense of place and sense of presence across distant locations"…as a "negotiation between sensing place in a physical location, and, simultaneously, sensing presence and telepresence across distant locations".

When harnessing scientific data and field recordings for expression, how do composers shape empirical content into a musical work? What is to make of the sometimes-inevitable compromises that arise? How do emerging tools/techniques affect the musical direction and aesthetics of computer-based music? These and other questions provide valuable insight into the nature of environmentally based electroacoustic process. In *Currents: A Weather Data Sonification Project*, Andy Jarema writes of struggling how to best communicate a database from the National Oceanic and Atmospheric Administration (NOAA), eventually settling upon a combination of visual graphs, field recordings, and synthesized sounds. He also wrestled with mapping graphs to the audible hearing range, making decisions that "forced me to confront the boundaries between scientific accuracy and creative artistry, ultimately helping to shape my narrative intentions and clarify the messaging behind the piece". Stuart describes utilizing a 2-minute sample of Orca and Ross Seal calls that she transformed through various audio processes into 61 different sounds to create an imaginary

world with visuals of her paintings. Ballavian's project relied upon the creative activity of live musicians, in this case, the Mivos Quartet, to make choices regarding recorded data from the sea-submerged hydrophones. They were presented with a "living score" of the sounds and were asked to then "create for themselves a dictionary of techniques that can be invoked in response to various stimuli."

What are the conceptual intents of environmental creators, and what are the outcomes they seek from their audiences? Some hope to influence people to action. Palamara seeks to inspire sustainability, perhaps triggering "a global movement towards environmental awareness and action". Ballivian believes "we have a responsibility to faithfully present these sounds in an effort to sway public opinion and affect human behavior". Stuart seeks to "draw attention to these endangered soundscapes, combining scientific data and artistic perspectives to highlight the need to preserve these sounds - and what they represent - before it's too late". Jarema wonders "what we artists have to offer in terms of making people feel something different about the alarming climate data presented to us by the scientific community." However, other intentions come into play. Alarcón Díaz expresses hope that users of her application explore awareness through walking, to "awake a sense of agency, which might help us to become part of the individual and collective possibilities that emerge…a listening opportunity to become part of the Earth's resonance in its transition". Huang purposes to express connections to her indigenous Atayal culture, its teachings, and through those concepts, to bring others into a deeper connection to their own environments. She invites listeners to consider music as a bridge to cultural underpinnings of those who create it. Listeners are "ethically obliged to immerse themselves in the cultural context in which the composition was created, to be conscious of the diverse relationships it embodies, and to acknowledge that the interpretation extends beyond a mere musical performance". Paulo C. Chagas believes "that the fundamental purpose of his audiovisual installation is to "promote connectivity as an essential feature of human experience".

Creatively engaging others with important ideas is one of the most salient aspects of the arts. While the number of artists within these pages is small, they reflect a vast global community striving to connect with the environment and with those around them. In a world possessing the greatest interconnectivity in history, the need for art to fulfill this function is greater than ever. Computer music-media is what we do well, and when it is focused on the environment, our work certainly impacts society's perception of the world. The Anthropocene has brought threatening issues to bear. There is uncertainty, but there is hope.

Therefore, we ring the bells.

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**Glacial Music: Katie Paterson's *Langjökull, Snæfellsjökull, Solheimajökull* (2007)**
*By Alexander Rehding*

Glaciers are noisy things. They glug and pop, screech and sing, hiss and buzz, they crackle, clink, and fizzle. Environmental art has long discovered the hypnotic magic of the gigantic slow-moving icy mountain rivers, and sound art among them. Artists such as Jana Winderen, Philip Samarzis, Thomas Köner, Eliza Bozek, Chris Watson, or Susan Schuppli only scratch the surface of those who have engaged creatively with the icy, windy, and watery sounds captured at glaciers between Novaya Zemlya and New Zealand.[1] From minimally edited, lengthy sound collages to ambient synth against a backdrop of soothing nature sounds, recordings of arresting glacier music have earned their place as a staple of sound art.

Their importance has only gained in recent years in light of global warming, as environmental organizations warn that half of the 215,000 glaciers outside of Antartica and Greenland will have disappeared by the end of the century, that is, during the lifetime of many of our children. News flashes of glaciers vanishing at alarming rates in the Himalaya, in Africa, the Arctic, the US and Europe reach us with such frequency that many of us have become dulled to their impact, though they have lost none of their seriousness. No less important issues than the future of drinking water and sea level rise are directly affected by the health of our glaciers. In the not-too-distant future, their lively zapping and gurgling will be a thing of the past.

Are glacier sounds an aesthetic or an environmental phenomenon? A bit of both: as with a lot of art based on environmental recordings, the line between documentation and composition is moveable. A lot of sound art explicitly assumes its role as a historical record, in a future archive, preparing for the time when the last glacier has melted and when these noises no longer exist. This is in fact exactly in line with R. Murray Schafer's foundational ideas about what he dubbed the "soundscape" in the late 1960s, a term that grew out of the environmental movement but has long transcended it, and describes an aestheticized experience of site-specific

surround-sound. He spent much of his efforts in the 1970s mapping soundscapes – most famously the Vancouver bay – to counter their disappearance (Schafer 1994). Admittedly, Schafer's concerns remain firmly embedded in the world of sound: he considers sound pollution the worst problem of our times, which, with the benefit of fifty years of hindsight, seems outright quaint. He does make it clear, however, that he regards a changing soundscape as symptomatic of larger changes in society and in the world we inhabit. In Schafer's universe, protecting endangered sounds is not qualitatively different from protecting endangered species: one is directly connected to the other in his sonic ecology.[2]

In some cases, particularly in art with an explicitly ecological message, the impetus is to foster a sense of future nostalgia, to create a reason for why we should protect this sonic environment – why we should *care*. Like Roland Barthes in his famous reflections on photography, for whom every snapshot whispers: "you will have been," the soundscape exists forever in the future perfect; it captures a scenario that existed at the moment of its recording, but will only be preserved into the future thanks to recording technology (Barthes 1982, p. 115). This kind of nostalgia, by the way, needn't lead to passivity. It is entirely possible to endow these feelings of impending loss with a renewed sense of activism, a call to action.[3]

In other cases, the motivation may be more purely sonic: the iridescent, changeable noises may have an intrinsic beauty. Timothy Morton, the punk philosopher of the environment, has made a case specifically for the aesthetic aspects of ecology. He argues that it's not sufficient for environmental art to present data, no matter how shocking, but it must also work as art – it must offer an *aesthetic* experience (Morton 2022, p. 57–58). Specifically, the kind of environmental art Morton dreams of should be about *data-ness*, the "qualities we experience when we apprehend something." In analogy with the comedian Stephen Colbert's concept of "truthiness," i.e. the subjective feeling that something *should* be true (irrespective of whether it is so), data-ness conveys a feeling of solidarity with that which has been

given (literally, the "data").

Either way, whichever way we are leaning – toward the documentary end or the aesthetic in the spectrum of environmental sound art– the interest is in making people *listen up*.

Among these glacier-based sound works, the artwork *Langjökull, Snæfellsjökull, Solheimajökull* (2007) by the Scottish artist Katie Paterson stands out. Paterson identifies as a visual artist, but this is not the full story. She is a conceptual artist who is concerned with the position of the human in the universe. While past generations of artists and aestheticians would immediately think of the sublime here, this is not entirely wrong: Paterson's interest is to bring down the unfathomable temporal and spatial dimensions of the universe to human proportions that we can grasp and process, while salvaging a sense of wonder and awe. Her work typically cuts across multiple sensory dimensions, makes use of science and technology, and has an unfailing engaging, often quirky, quality. She has presented performance of Beethoven's *Moonlight Sonata* that has been beamed up to the moon and back, and sounds a little worse for wear after this long journey, has turned all the solar eclipses witnessed by humankind into a kind of cosmic disco ball, or has strung up fossil records from all periods of earth-bound life, rounded into beads, into a necklace that embraces our planet on a geological scale.[4]

Paterson's interest in glaciers goes back to her time in art school: the work with which she graduated was *Vatnajökull (the sound of)* (2007–08), which features a cell phone number that connects the viewer to a live phone line with a hydrophonic microphone submerged in a lagoon underneath the Icelandic glacier Vatnajökull, which allows viewers to listen to the sound of the melting glacier in real time. It is, quite literally, a direct line to global warming in action.

Its sister piece, *Langjökull, Snæfellsjökull, Solheimajökull*, which takes its name from three other Icelandic glaciers, pursues this interest in technologically mediated ice-melt much further. For this artwork, Paterson recorded the sounds of the three glaciers and pressed them onto phonograph records, made out of ice from the same glacier. The three recordings are played, and

the glacier sounds are heard one final time, as the ice melts and the recorded sound irrecoverably disappears.[5]

The recording technology poignantly interacts with the sound material. To fully appreciate this, we do well to delve a little deeper into some of the fundamentals of media theory. As Sybille Krämer has elucidated, the heart of Friedrich Kittler's influential media theory consists in a cultural technique known as "Time Axis Manipulation" TAM (Krämer 2006). All technological media, down to the most fundamental of them all – writing – enable a form of TAM. Perhaps the most important aspect of Krämer's interpretation is that the act of inscription allows repeated access in a way that unmediated communication, which is subject to the irreversible flow of time, does not. In other words, media spatialize the temporal aspect of communication, and expose it in this way to new forms of manipulation: a written text can be repeated and studied at length (not only in real time); a sound recording can be slowed down (for instance, playing a record at 78rpm instead of 33 1/3rpm on a turntable); or a tape can be played in reverse (remember the fad that 1970s pop songs would somehow spell out subliminal messages when played backwards?) All these are forms in which the flow of time can manipulated.

This idea of time axis manipulation as defined by Krämer, when brought to bear on Paterson, offers a poignant framework for Langjökull, Snæfellsjökull, Solheimajökull. If the reproducibility that lies at the core of TAM is also at the heart of the (stated or implicit) preservationist goal of environmental glacier sound recordings, then Paterson's performance piece turns this feature on its head.

The no-longer-eternal ice of the glacier here provides not only the sound materials but also the recording materials. The sounds are thus doubly fragile. And in this situation, reproducing a recorded sound on a melting medium is not a repeatable act, but becomes a singular event. In being replayed, the sound, like Eurydice in the Orpheus myth, dies a second death, this time more definitive, with no further hope of being recovered. The tragedy of the ecological catastrophe is captured

in this overdetermined aural death; the recording that melts, in real time, before our ears and eyes, hammers the final nail in the coffin of the glacier's expiration.

*Langjökull, Snæfellsjökull, Solheimajökull* makes available to the senses the processes of global warming to which we can normally only gain access through our faculty of reason – if at all. The hope to which we typically cling, that we might preserve something, anything, for the future, melts away with the last sounds of the Icelandic glaciers.

**Notes**

[1] Even the New York Times reported on this phenomenon found in ambient and electronic music. www.nytimes.com/2023/03/16/arts/music/melting-ice-music.html (last access Nov 22, 2023).

[2] While there is much to criticize in Schafer – most recently by Robinson, D. (2019). *Hungry Listening,* Minneapolis: Univ. of Minnesota Press – in the hands of subsequent ecomusicologists, the study of soundscapes has flourished into an important branch of the field. See for instance, Guyette, M. Q. and Post, J. C. (2014). "Ecomusicology, Ethnomusicology, and Soundscape Ecology," in: A. Allen and K. Dawe (ed.), *Current Directions in Ecomusicology*, New York: Routledge, pp. 40–56.

[3] One might argue that the recent museum protests of the summer 2022 are trying to do exactly that. See Rehdig, A. (2023). "Mit Tütensuppe und Kartoffelbrei," *Neue Zeitschrift für Musik*.

[4] Earth-Moon-Earth (Moonlight Sonata Reflected from the Surface of the Moon) (2007), Totality (2016), and Fossil Necklace (2013).

[5] A video recording exists documenting the unique performance.

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***Six Seasons*: Composition Inspired by Ocean Sounds from the Arctic**
*By Gabriel Zalles Ballivian*

*Six Seasons* is a composition that features hydrophone recordings captured in the Chukchi Sea off the north coast of Alaska, one of the most inaccessible places to humans on earth due to the thick layers of ice that block access for most of the year. Hydrophones created at University of California, San Diego UCSD were deployed in this region and left alone for a full calendar cycle, while these recorded millions of data points at supersonic frequencies. The recordings were then studied to determine migratory patterns, and a microscopic subset of the entire data was shared with the music department to manipulate and amplify for live audiences. The final presentation of this work included a collaboration with the acclaimed Mivos Quartet[1], who at times provided antiphonal gestures and at others augmented the soundscape via mimetic techniques. The composition was written by Lei Liang, while the computer system which capacitates the work was designed by the author. The hydrophone recordings are the work of the Whale Acoustics Laboratory at UCSD. The aim of this article is to raise awareness for climate change and demonstrate a landmark case of computer music facilitating new music which broaches this theme. The title of the musical composition refers to the six seasons used by the Inuit population of Alaska, who demarcate these seasons by the changes in the environment, not by the strictly quantified passage of time. The six seasons are denoted and characterized as follows:

- Ukiuq - very cold, the sun returns (Jan-March).
- Upingaksaaq - bright, frozen days (March-May).
- Upingaaq - snow-free land (May-July).
- Aujuq - warmest time (July-Sept).
- Ukiaqsaaq - land is snow-covered (Sept-Nov).
- Ukiaq - dark days (Nov-Jan).

In *Six Seasons,* we begin our journey in October, during the Ukiaqsaaq season which we entitle “New Ice". To facilitate navigation with musicians, each season is assigned a specifier. Each season corresponds to roughly three months from the

Gregorian calendar and is denoted and characterized as follows:

- "New Ice" (Ukiaqsaaq) - new ice starts to form in the Arctic.
- "Darkness" (Ukiaq) - no daylight, total darkness.
- "Sunrise" (Ukiuq) - deep winter, snow, raging storms.
- "Migration" (Upingaksaaq) - enormous pieces of ice collide and break, and migration begins.
- "Cacophony" (Upingaaq) - migration of marine life in full force.
- "Bloom" (Aujuq) - bowhead whales are moving from east to west.

At the end of the piece, there is an added *coda* for dramatic purposes, in which we can hear the sound of a lonely beluga whale crying out for help. The beluga, trapped under the heavy ice, and separated from its pod, can be heard making a distress call. This final sound signifies the end of the piece. Each of these six seasons has its own distinct set of sound files which comprise both the listening material and the composition itself - that is, there is no written score for this piece. Instead, the sound material produced by the: ice, sea, and, wildlife within it, is meant to be used as creative material to which musicians respond. This extends one of the first metaphors of the work, that of *echolocation*. The animals who inhabit the Arctic Ocean rely on this technique for their survival. Here, we examine the notion of the musicians' senses behaving as the wall, from which these signals bounce, resulting in the "musical gestures" they create - a metaphor that can also be understood as the reaction of the audience to the interpretation of the musicians.

The score is of interactive nature, which in a direct sense defines what the score is in real-time. While some "cues" are established between the musicians, composer, and the rest of the personnel, the techniques and moments, and the sequence in which these occur, are not strict. In the world premiere of this piece on October 15th, 2022, the musicians were encouraged to use specific techniques at various points of the piece or to refrain from playing during other sections. There were a few choreographed entrances but none of these are considered formal requirements for the work to be performed. These techniques and choreographies as well as more

details about the instruments used to record these sounds are presented in the last part of the text.

***The Patch***

The MAX/MSP Version

The patch for *Six Seasons* comes both in Pure Data Pd and in MAX. I will describe the development of the software in the chronological order in which it was developed. The first *Six Seasons* patch was written by composer Theocharis Papatrechas in MAX/MSP using the IRCAM Spat5 package (Carpentier, 2018). Shortly thereafter, a new version of the patch was started from scratch using the very same tools. It was also decided that a simple MIDI controller would be used to control the program. The controller was chosen based on its low cost, popularity, and simplicity.

The new MAX patch was developed over the course of several weeks in collaboration between composer and engineer. Initial versions of the patch were tested in the spatial audio labs of UCSD using a 22.2 surround sound system which were connected via Dante Virtual Soundcard, a proprietary product by Audinate. The patch would encode the 5.1 surround sound files that had already been created into Ambisonics, allowing to playback the spatial audio mixes in any configuration desired: from quadraphonic to 128-channel systems. The additional benefit of Ambisonics was that it also allows to encode the various 5.1 files at various elevations, which provided the possibility of encasing the audience under the ice.

Many additional features were incorporated into the patch in order to create a tight loop between the hardware and software. One button was designed to move between “seasons" which effectively correspond to folders containing multiple surround sound mixes. Another button allowed to record the entire sound field as well as the raw microphone signals, which could be used to later produce a suitable CD-quality mix. Another feature was designed to add live processing to the microphone signals; this would pan the microphone inputs around the room while applying a delay with feedback, an aesthetic which was designed to fit the theme of echolocation.

Five additional controls were assigned to each of the eight sound file players (SFPs), which allow to:

solo, mute, restart, and control the gain, and reverb, of each layer of sound. It should be noted that each SFP plays only one particular type of sound at a time, such as ice, belugas, or wind, these are never mixed a priori but rather it is the job of the composer, acting as a conductor, to mix these signals in real-time. In other words, at any one time, it is possible to mix eight 5.1 surround sound files in real-time using this system and decode the resulting signals in arbitrary configurations, such as quadraphonic, octophonic, or the 16-channel system which was used at the premiere of *Six Seasons*, consisting of two octophonic systems stacked one on top of the other.

One final noteworthy aspect of the project involves the packaging of the software. Additional work was done in order to turn the MAX/MSP code into a standalone application that can run on OSX machines without an MSP license. The other benefit of this system is that one does not need to install Spat5 or configure the path to the sound files, this is all done automatically. In order to reduce the total size of the application the command line tool FFmpeg was employed allowing us to batch compress the original AIFF files into a lossless format requiring far less memory.

The Controller

In order to provide the composer with a greater sense of control over the playback of the sound files, a hardware system was selected and integrated into the compositional process. The selected device, Korg NK2, was chosen due to its low cost, popularity, and simplicity. In contrast to other hardware devices on the market which sometimes have hundreds of possible controls, the NK2 has only a few dozen buttons, which makes it possible for anyone to learn how to operate the system in less than half an hour. It was important to consider the replicability of the work, and to provide a simple framework that could be easily understood and deployed.
The track controls in the NK2 are assigned the task of switching between seasons, which updates the files with each of the SFPs references. The cycle button is used to reset the entire system, only the rotary knobs and faders are left unchanged. Since the device is not motorized resetting those values to zero could result in abrupt jumps,

therefore it is up to the operator to reset these controls manually. Backtrack and fast-forward work as anticipated, changing the playback speed by integer factors.

Due to technical differences between versions, in the MAX design, it is not possible to move backward, whereas in the Pd version one can scrub through files in reverse. Stop and play buttons work as one would imagine, while the recording buttons, as aforementioned, allow one to record the sound field together with the raw inputs. This method assumes that there are always four musicians performing. In the Pd version, the ambisonic order changes based on the number of speakers needed. For the 16-channel version, third-order ambisonics was recorded, for the octophonic version second order, and for the quadraphonic version, first order.[2] While the recording function assumes four musicians are always performing the piece, this is not a requirement of the work (e.g., one can perform this work with one to four musicians).[3]

The marker buttons on the controller are used to turn on and off the sound effects (SFX) for the live inputs. The left marker and right marker buttons are used to select the input, while *set* is used to enable, or shut off, the SFX for the selected input. One may choose using this logic to turn on the SFX for one, all, or none of the musicians at any time. The SFX module relies on the Vector-Based Amplitude Panning (VBAP)[4] (Pulkki, 1997) algorithm to pan the musicians' signals and four independent delay lines to create the echoing effect. When on, random low-frequency oscillator (LFO) values are selected, generating Lissajous curves that modulate the azimuth and elevation of each source. Random feedback coefficients and delay times are also generated such that each time the SFX module is engaged, the decay time of the delay and timing between each echo is different. When the module is shut off, the feedback coefficient is slowly returned to zero, and the position of the source is returned to its original location. By default *Six Seasons* anticipates the quartet to be positioned in four corners of the room following the order: North West (1), North East (2), South East (3), and South West (4). The rotary knobs in the NK2 are configured to control the dry/wet balance of the reverb units inside the

patch. This provides a psychoacoustic mechanism for controlling the perceived distance of sources. The faders are used to control the volume of the SFPs, as one would expect, and the S and M buttons are used for soloing and muting. The R buttons are used to "restart" sound files. These also act as independent "start" buttons if the global start button is not adequate, or one wishes to create different textures or sonic environments. In other words, with these "restart" buttons, the number of possible permutations that can be created jumps exponentially, as it provides the conductor with a means to re-trigger SFPs at any time.

***Score***

As was already mentioned, there is no formal score for this composition – in the traditional sense of the word. Instead, we make use of what we call a *living score*. The audio projected from the speakers, which is a direct result of the live manipulations the system operator performs, should be considered the real score. There were nonetheless some requests the composer made for the premiere of the work: he gave specific instructions for each season of the piece, and even for different sections of the seasons, which were agreed upon in advance. These instructions, however, were conceived in collaboration with the musicians themselves, who would propose a particular technique during rehearsals. Additionally, from all the possible combinations of sound files that could be played back in any given season, a specific sequence of sound files was chosen and their relative duration was set to create a cohesive narrative. In other words, *Six Seasons* invites the performers to listen to the sounds of the ocean and create for themselves a dictionary of techniques that can be invoked in response to various stimuli. No major alterations are performed upon the recorded sound besides spatialization or adding reverb, the principle was to maintain the pure essence of the original sound as unadulterated as possible.

In the first season, there is only the sound of ice present, and the overall volume is still low. At this stage, the musicians were asked to play pianissimo and use a mimetic approach to their playing. In the second season, there are more melodic techniques employed, but

the dynamics are still subdued and the lights in the room are dimmed to match the theme of the season. The third season include a sequence in which each musician plays a solo, and as the recording gets louder, their dynamics, too, create a crescendo. Then, the recordings were abruptly stopped to hear only the musicians playing at full force. The lights shut off immediately and the musicians stopped as well. The sound of ice collapsing plays and migration begins, the musicians then continue to play along with the sea mammals. During season five, the musicians were asked to stop playing altogether, and only the sounds of animals should be enjoyed together with the ice sounds. Season six gives the performers one more opportunity to play along with the fauna until they slowly fade out. The coda is reserved for only the single sound of the stranded beluga, which calls out a couple of times before the piece concludes. It should be noted, that all these notes are not a formal requirement for the performance of the piece. Rather, each composer interpreting the work is invited to craft their own narrative around the sounds. The duration of each season, the number of musicians, the instrumentation, and the number of seasons played are also up to the discretion of the interpreters. In addition to these sonic elements, for the premiere, also satellite images from the recording site were employed to provide technical information about each season using the QLab software. This is also an optional part of the experience.

Some additional techniques, composed by Olivia De Prato, Maya Bennardo, Victor Lowrie Tafoya, and Tyler J. Borden at the time of this writing, were employed over the course of the piece by the Mivos quartet, including:

- Crunching - applying pressure to strings with the bow, to imitate ice sounds.
- Bowing on wood - to imitate the sound of the wind.
- Sul Pont bowing - bowing close to bridge; a responsive gesture.
- Rubbing wood - either with hands or super ball to imitate bowheads.
- Multiphonics - multiple notes from a single string, extended technique.
- Muted pizzicato - plucking strings to imitate loud ice pops and clicks.

• Rattling with clothespins - attaching clothespins to the instrument and intentionally hitting them.

This is by no means an exhaustive list of all the techniques used, but it should provide an impression of the type of musical material in use. One more detail about the patch that is compositionally relevant: there is no way to cross-fade between seasons. In order to maintain momentum, the musicians were asked to perform between certain seasons.

***The Hydrophones***

Hydrophones were placed about 300 meters below the sea surface at a seafloor recording location 160km north of Utqiagvik, Alaska. These captured the sounds of sea ice, marine mammals, and the underwater environment over the course of one year. Careful attention was required to preserve the timestamps associated with each sound file, which allows to pinpoint exactly the hour at which these different passages were recorded. The first recordings began on October 29, 2015, just three days after new ice had started to form.

The High-frequency Acoustic Recording Packages (HARPs) were developed at UCSD over many decades by the Whale Acoustics Laboratory (WAL) with the purpose of studying marine life and determining how anthropogenic activity is affecting wildlife in these remote regions. Climate change has directly affected these populations, and the primary purpose of these recording devices is to evaluate the effects of man-made climate change. The cycles of ice, flora, and changes in sea currents, all affect the lives of these creatures. Noise pollution caused by large ships breaking through the ice can also affect species' migratory patterns and ability to echolocate food. These devices have to consider: the pressure created by water at the bottom of the ocean, battery requirements for such a system, and the quality of recordings, which is a function of the design of the electronics (Jones et al, 2022).

The HARPs were designed to remain underwater over the course of an entire calendar year recording the sounds of the ocean at a rate of 200kHz, well above the audible frequency range of humans.[5] Massive memory units were installed allowing the team at UCDS to record terabytes of information. Using signal

processing techniques, it was possible to quickly analyze, detect, and isolate regions of high activity, which were used for bio-marine studies and later in our compositional interdisciplinary collaboration.

***Processing the Raw Data***

Prior to encoding the sound files using Zachary Seldess's (2014) MIAP software into a surround sound mix, the hydrophone recordings underwent a series of additional steps carried out by collaborators Nick Solem and Theocharis Papatrechas. Firstly, the audio files needed to be re-sampled into 44.1kHz but in addition to this, there were several noises that needed to be manually removed. Every few minutes the HARPs suffer from digital noises created by the mechanism of the recording device. Unfortunately, there was no way to automate the removal of these glitches so many hours of manual work were undertaken to clean the sounds. There were also subtle but noticeable discontinuities in the recordings which had to be fixed including thudding caused by hydrophone displacement. However, it should be possible to create an automated system to automatically remove all these anomalies and generate the final sound files; this system is the subject of future work.

***Summary***

This paper has described the development of an artistic work entitled *Six Seasons*, a multi-year interdisciplinary collaboration between the departments of marine biology and music at UCSD. Supersonic hydrophones deployed off the north coast of Alaska captured the ecological acoustic signature of one of the most remote places on earth, allowing to hear the calls of some of the rarest species on earth. These sounds, along with the sounds of polar ice and wind, were incorporated into a computer music program which allowed for multi-channel interactive playback in a concert setting. The piece featured performances by the Mivos quartet, who used this sonic material to advise their playing. No written score was created for this performance, yet it is not entirely improvisatory: the musicians and composer co-created the rendition of the piece drawing inspiration from the sonic material provided, creating – and employing – a

language of both imitative and contrapuntal musical gestures.
As an artist operating in an interdisciplinary project with marine scientists, I believe that we have a responsibility to faithfully present these sounds in an effort to sway public opinion and affect human behavior. My hope is that this work can serve as an emotional catalyst, resulting in some net gain for the environment. This is where I believe the sciences may rely on the arts, to make the objective data into something moving, which can influence people who we know from research are not only driven by logic but also emotions. Furthermore, it is unclear from an evolutionary perspective if these species will be able to survive the changes to the environment that are currently ongoing – preserving and disseminating these sounds, therefore, is part of a global cultural heritage mission. The Inuit people themselves have been an integral part of this research, collaborating closely with the marine science lab and providing critical feedback which has been driving the work.

**Acknowledgments**

Whale Acoustics Laboratory (WAL) and John Hildebrand for the hydrophone recordings; Division of Arts and Humanities at UC San Diego for making the project possible; Lei Liang and the Mivos Quartet who are recognized as composers and interpreters of this work.

**Music**

Lei Liang and the Mivos Quartet: *Six Seasons*
http://mediathek.slub-dresden.de/vid90003602.html

**Notes**

[1] https://www.mivosquartet.com/.
[2] The ambisonic recording in Pd follows the SID channel format implemented in the iem_ambi package from IEM Graz. The MAX version records in the more standard Ambix format (Nachbar, 2011). The Ambix toolkit is recommended to convert between formats.
[3] In the Pd version there is no way yet to change the direction from which the musicians' sounds are projecting, this is the subject of future work.
[4] Professional closed-source software typically uses a combination of ambisonics for environmental sounds and VBAP for point sources, so we decided to implement a simi-

lar approach.
[5] A future work is to isolate spectra outside the human hearing range and transpose it for human listening.

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**Creating Imaginary Worlds from Scientific Data: An Interview with Amanda Stuart**

*By Scott Deal*

British composer and media artist Amanda Stuart uses narratives of form and shape, juxtaposing contrasting translucent colors with dense sonic textures, woven together in an audiovisual tapestry. From the tiniest of gestures to dramatic powerful climaxes, she immerses the listener in fantasy landscapes creating beautiful and dramatic sound worlds. Her piece *Song of the Trees* won the IAWM Pauline Oliveros Prize for Electroacoustic Media 2015 and Not Missing You received an Honorary Mention for the same prize in 2014, with one reviewer writing, …It's as beautiful to look at as it is to hear" (Boston Classical Review). Her work has been presented throughout the world in venues that include Earth Day Art Model Festival, New York Electroacoustic Music Festival, Boston New Music Initiative, International Computer Music Conference, and Understanding Visual Music in Buenos Aires, to name a few. She has held residencies for the City of Peterborough, the Cambridge Festival, Suffolk County Council and the Firebird Trust. Her commissions include compositions for the London Festival Orchestra and The City of Peterborough Symphony Orchestra. The following is a transcript of an interview that was conducted in October, 2023.

Scott Deal: Amanda, in looking at your work, it seems that you cover a wide range of earth-related phenomena. For example, *Bubbleflux* explores the notion of bubbles forming in the ocean, as well as the functions they carry out in animal bodies. *Magnetosphere* draws from scientific data of electronic activity in the atmosphere. These two works seem to capture what you are doing broadly, and I'm wondering how would you frame them in the context of your creative process and artistic intents?

Amanda Stuart: When I first composed *Bubbleflux*, I was certainly attracted to the pure joy of bubbles, but I was also incredulous at how vital they are to life. For instance, in medicine they are used to transport drugs to specific parts of the body. And it seemed to me that you could celebrate these aspects of our world, and not to be too grand, but

through compositions, one could take people into a different world and allow them to focus on it. It's not just another scroll of …bubbles in this", or …the magnetosphere is doing that", but rather that you are immersed in it and that gives you time to really think about what you're listening to, and to think about earth. Most importantly, it's about treasuring the earth, now more than ever. With *Bubbleflux*, I was attracted to the idea of creating a video graphic score that could be understood by non-musicians, so we could have audience members on stage performing spontaneously. During the piece, the audience joins in making popping sounds with their mouths and there is great fun and laughter. But they've also been reading the program notes and getting a bit more information. Hopefully, this makes them think a bit differently about things than they perhaps would otherwise. And with *Magnetosphere*, I think of how incredible it was to work with the real sounds from the atmosphere, and to create a work that transforms the notion from those sounds into a whole creative world, which is quite a different experience from understanding a scientific report, for instance.

SD: Where did the recordings for *Magnetosphere* come from?

AS: There was a call for works from *CARISMA*, a project funded by the Canadian Space Agency, using recorded sounds they had captured from the magnetosphere of the earth. In the call they made clear they were interested in music to accompany the sounds. But I was interested in using just the sounds themselves, so while I knew my work most likely would not be selected, I thought wow, these sounds are so amazing, what a fantastic opportunity! I didn't really write to their brief, but I used the material for what I wanted, which was to take these tiny sounds and make an incredibly imaginative world by transforming them, giving the agency publicity as it is cited every time the work is presented.

SD: I'm reading on your website about the various sounds they supplied….*Sferics, tweeks, whistlers, dawn choruses and hisses*. Seems like a big variety of sounds. Perhaps you can talk about your process. How did you take these various sounds and term them into a media piece?

AS: If I remember correctly there were four types of sounds recorded in the magnetosphere that you could use. The sounds were interesting but limited in number – but I like that. I wanted the piece to literally feel like you were in space and that things were coming at you. This is also why I chose to make it in surround sound, so that you had that real sense of being up in the atmosphere. After choosing sounds, I go through every sort of transformation I can think of, using any weird bit of software that I have that might do something. This takes *a long time*, because I'm following my sense of what's right for the piece and what's not. If it's too electronic, it doesn't work because I want it to feel like it is in the sound world. In essence, the first step is just to go through all different creative processes that I can to get a sort of library for the piece. And then while I'm doing that, I'm starting to imagine a structure. It doesn't have to be an obvious structure, but it does have a sense of journey. I think, oh, well, I want it to start really quiet. and I'm always going to have soft bits and dramatic bits because that's what my pieces are. They'll take you on journeys, but there'll be these wild bits in the middle, or it might start with a wild bit or whatever it might be, but it's going to be big and powerful and then completely tranquil and silent in other bits. The sounds must have a reason for them being there, so there is a sense that they belong in that place because they're part of that storytelling, which is very important to me. Structure will create emotional movement in the piece in the sense that I want the listener to respond and to be immersed in it. Life itself is small and joyful and big and powerful….all these things. And somehow, I want these in all of my pieces.

***SONG OF THE TREES***

SD: *Moving to Song of the Trees*, can you discuss your inspiration and process for its creation?

AS: I went to see David Hockney's big exhibition at the Royal College of Art London. Walking into the exhibit, there were some massive tree paintings from his *Woldgate* series. For some reason I just looked at them and strongly sensed the structure of a musical piece. The view was a huge tunnel of trees to walk through which struck me as both

imposing and peaceful. I just knew then I wanted it to be like that, to be peaceful and to be very dramatic in the middle and then be peaceful again. I also wanted the instruments to be somehow connected with the trees. As I was imagining these trees, I wondered, what would they sound like? I settled on clarinet and flute and wrote the instrumental score first as a duet. I wanted it to have a sense of wind, so that the two melodic lines would float above the wind. The wind would come and go, giving the listener a sense of space and being surrounded by the sounds. I created wind sounds by recording an associate blowing air into a bassoon and did the same for the clarinet, and then processed those sounds.

I had the wind in the trees and the two melodic lines from the clarinet and flute, which I decided to transform in live performance. The piece begins quite simply and the transformations are quite simple, but in the middle section there is this whole whirly section where the two instruments are processed live, and it's just wild. An audience member described it as like somebody bull dozing down the forest in the middle of the piece, just an explosion of sounds, all created live. At the end you come back into a transformed version of the original melody, a return to an altered beginning. Then when I did the film, I drew from hundreds of photos I'd taken in the village over the last few years. I selected pictures and started to experiment with them and realized I could create a sensation flying over the trees. It looks like you're in a drone, but actually all the trees aren't moving. It's uncanny that the photos are all taken from the ground, but in the film it looks like you're flying over the trees, and through them. I layered the images and moved them in the software, but it was all really tough because I didn't realize that I could do that sort of thing. It was all very experimental, and I was creating this all the while I was learning how to use the software (laughter). But it's like, gosh, that's the joy of creating, isn't it? You don't know…it's like, wow, what if I could do that! (more laughter).

SD: *Oceania* is derived from a two-minute sample of Ross Seal and Orca Whale calls. Could you discuss a bit about your process in creating the audio for the work, and if you want to get a little technical, which

software, what processes you liked, or that you felt worked well?

AS: I was delighted to be chosen to take part in the Polar Sounds project, which was a collaboration between Cities and Memory, the Helmholtz Institute for Functional Marine Biodiversity, and the Alfred Wegener Institute at the Helmholtz Centre for Polar and Marine Research. The aim of the project was to highlight the soundscapes of the Antarctica and the importance of sound communication between the animals and how it is affected by climate change. From what was offered, I chose the sample of the recording of Ross Seals and Killer Whales because although they're very repetitive, two different sounds in all, I thought I could create the whole piece from just this one sample. Then I literally went through every single processing software app I have; Everything in Ableton, Max for Live, Native Instruments, UAD and IRCAM GRM Plug-ins. I put the single sample through everything, which produced around 83 sounds that I liked and then I cut that down to 61 sounds which were then used in the piece.
The crazy thing is that I had all these sounds and you know, I'm starting to get overwhelmed very quickly. Then I divided them up into categories, like, oh, that sounds like a washing machine. Okay, I'm gonna have washing machine sounds, and these are low sounds, swooping sounds, etc. I knew I didn't want anything to sound electronic, because I was creating an imaginary world underwater. I wanted the sound to be organic and natural, of course they weren't, but I wanted them to feel as if you really would hear those sounds underneath the water. You hear the original recording twice in the piece - most clearly at one minute 15 seconds from the start of the piece. It was very important to me that you hear what the whole piece was made from. The idea is that you would start in the depths of water. It's an imaginary underwater world, and you don't really know where you are. It feels familiar but completely unfamiliar and again, sounds are all moving so you get sense of the whale, and it's moving further away or coming near, and it's swimming up to you but you're not certain as to what it is. And there's a big storm after which, you just like gently float away. So that's how the audio of the piece came together.

SD: And how did you integrate the audio part with the video?

AS: Having created the piece, I thought it would be great to put some pictures to it. I began researching media of the Antarctic, which is fascinating look at, seeing waterfalls in the ocean and all these things, and to see where these animals lived. But I couldn't create visuals that worked in the context of Ross Seals and Killer Whales. I returned to the idea I began with the audio component, of just creating my own world…. the imagined world under water. And then I started experimenting with some of my digital paintings and tried transforming them and suddenly I realized it was going to work! I used about 13 of my paintings of various media, digital and acrylic. They all had been experimental paintings, but then when I layered, transformed and animated the images, they came together into this imaginary world in my mind, and that's how the visuals came together and were synced with the sounds.

SD: Amanda, it's exciting to hear you talk about your process, and I appreciate how intuitively it is that you work. Thank you for taking time to talk with us today.

AS: My pleasure!

**Music**

Amanda Stuart: *Oceana*
World Premiere: Earth Day Art Model Festival IUPUI Indianapolis - April 22, 2023
http://mediathek.slub-dresden.de/vid90003603.html

Amanda Stuart: *Song of Trees*
Clarinet: Gareth Stuart
Electroacoustic World Premiere: Light and Sharpness Concert 2013, Mumford Theatre, ARU, Cambridge; Film Premiere: Earth Day Art Model Festival 2022, Indiana University Purdue University Indianopolis (IUPUI).
http://mediathek.slub-dresden.de/vid90003604.html

Amanda Stuart: *MAGNETOSPHERE - Sounds of the Earth*
Electroacoustic World Premiere: New York City Electroacoustic Music Festival - 2017; Film World Premiere: Earth Day Art Model Festival 2021, IUPUI.
http://mediathek.slub-dresden.de/vid90003605.html

**Indigeneity and Computer Music in the Anthropocene**

*By Chieh Huang*

We are living in the Anthropocene epoch, a time when music artists are truly shaping our perceptions—from cultural norms to environmental consciousness. It is an exciting era for computer music as it continually morphs under various global influences. What if our knowledge of the world could propel computer music even more? I will explore that very concept using Indigenous musical elements and notions as starting point. My mission is simple yet profound – to investigate how Indigenous elements through computer music composition can echo throughout our current period – the Anthropocene. I will discuss Atayal principles – an Indigenous perspective with the potential to shift paradigms deriving from the Atayal/Tayal, Taiwanese Indigenous people, one of the largest Indigenous groups of Taiwan. And finally, I will dive deep into how all these transformations ripple through society and reshape the soundscapes around us.

Firstly, to evaluate computer music composition, I will use four key concepts: relation, creolization, listening positionality, and three fundamental Atayal aspects. In "Poetics of Relation," Edouard Glissant defines relation as interconnectedness and shared knowledge instead of isolation (Glissant, 1997, p. 131). He rejects the notion of a single origin and instead emphasizes identity as a network of relationships within Indigenous cultures. Glissant's framework emphasizes the importance of recognizing the diverse nature of our world. He suggests that instead of a singular origin, multiple interconnected histories exist. He promotes the idea of creolization, which embraces transformation rather than focusing on roots. This concept can be seen as a fitting analogy for a composer's creative process.

In his work "Hungry Listening," Dylan Robinson digs into how who we are - our privileges, biases, and skills - can impact what we hear for better or worse. (Robinson, 2020) He breaks down how our understanding is shaped by settler colonial beliefs, and makes a case that shaking things up – what he calls "unsettling" – can give a boost to Indigenous sovereignty. The idea of “unset-

tling" asks us to stretch beyond our narrow viewpoint. Looking at it from an Atayal point of view, the focus isn't just on the listeners but also their connection with whatever they are listening to. This underscores just how different Indigenous viewpoints are compared to settler colonial ones when it comes to thinking about time, space, and balance.

***Origin of Life***[1]

The piece, *Origin of Life,* metaphors that the concept of life can be divided into three fundamental aspects of Indigenous existence: these aspects are the self, influenced by its surroundings; the essence of sound, which involves vibrations from human and nonhuman entities; and the self as an initiating force, connected to relationality. These components are important for understanding Indigeneity as they reveal the interconnected relationships that define relationality. This also is useful to understand surrounded interconnected relationships in Anthropocene.

*Origin of Life* combines a motion sensor[2], acoustic sounds, and a computer-generated backing track. The motion sensor represents the dependence of an embryo on its maternal environment, while the backing track serves as a metaphorical backdrop like the womb. The acoustic sounds represent organic movements, with the vibraphone producing sound through mallets. Each movement symbolizes nurturing care, performed with attention and precision, reflecting a mother's care for her offspring.

*Origin of Life* also metaphorically explores the three aspects of Indigenous existence. The acoustic sound represents the individual's awareness and perception of the surrounding world, while also passively absorbing the environment. The backing track serves as ambient noise, sometimes interrupting the flow as discussed by Danielle Goldman (Goldman, 2007),

The motion sensor symbolizes the dynamic, interconnected, resonant, and self-influencing element. Identity and relationality are closely connected, as suggested by Edouard Glissant. Glissant's framework encourages to see the diversity of the world and the interconnectedness of histories. He emphasizes the dynamic process of creolization and the importance of si-

multaneous presence and coexistence in understanding and relating to indigeneity. (Glissant 1997, p. 89)

***Indigeneity***

Approximately 370 million Indigenous individuals exist worldwide. The term 'Indigenous' emerged in the 1990s to recognize the original inhabitants of specific regions, in response to the struggles of colonized communities against erasure, genocide, and forced assimilation under colonial rule. The Austronesian Taiwanese, known as the Indigenous peoples of Taiwan, have lived in the region for over 5,000-6,000 years. The Atayal tribe, led by my grandfather, holds a prominent position among them. Despite my grandfather passing away before my birth and restrictions on practicing our language and culture, I still feel a strong connection with this tribe. My experiences resonate with many and shape my creative process. The changing physical environment, with its excessive development and loss of original charm, greatly influences my composition. The faded colors of tribal heritage speak to the impact of the Anthropocene era.

***Various conceptions in Origin of Life***

In *Origin of Life,* the initial self is characterized by diverse facets and connections. The concept of origin encompasses multiple histories and communities. Glissant's *Poetics* introduces opacity as a form of relationality, rejecting hierarchy and embracing a global perspective. The self is complex and embodies opacity, reflecting elusive parts of my persona. Opacity allows for freedom and existence beyond comprehension. In this piece, opacity is represented by acoustic sounds produced on the vibraphone keys.

One key concept in the first layer is opacity, represented by a descending three-note figure: two thirty-second notes followed by a sixteenth note. The first phrase is an eight-bar phrase, with the top notes (E-D-C-B) acting as pedal tones and gradually decreasing in volume as they descend. Opacity symbolizes the indescribable. The notation may seem simple, but the performance requires subtle nuances. While playing the first phrase, I adjust the tempo, similar to how individual sentences are articulated, in order to engage in a musical dialogue with

the backing track. The *ritardando* aligns with the "ha," "shi," and the sound of a water bell in the backing track. Additionally, the motion sensor, triggered by the speed of the mallet stroke, influences the tempo of the music in the backing track.

The piece's beginning also explores the idea of defense, a different form of relationship than opacity. The consonant sound represents a warning, as Indigenous cultures had to protect themselves from colonization. The constant ringing bell represents time, which is important for cultural changes caused by colonization and environmental shifts.

The first layer, the self, explores relation, opacity, and identity in Atayal culture. Musically, it focuses on tempo and the interweaving of multiple lines. Using a three-note figure and eight-bar phrasing, I interact with the backing track, constructing and articulating each phrase. Simultaneously listening and playing requires complex reception and execution. Each note's touch expresses emotion and must blend harmoniously with the backing track.

Dynamics are important, as each phrase connects to the next.

Around 1'28", the sound gate opens and the motion sensor is activated, triggering prayer and insect sounds. This event highlights the theme of vibration. According to Nina Sun Eidsheim, action is intermaterial vibration. Playing the vibraphone and listening to the motion sensor output show that listening is an active process involving the transmission and transduction of sound. In her book "Sensing Sound" Eidsheim argues that all sounds are interconnected, from air molecules to sound technologies, performance spaces, and human bodies. Vibrational sensations, not just audibility, are fundamental to music. Eidsheim also emphasizes that auditory events can occur in any direction relative to the listener, and factors such as familiarity with the sound and the uniqueness of human anatomy affect how we perceive and locate sounds. Vibrational experiences help us understand the connections between materials and human/non-human bodies, which contribute to the creation, processing, and production of music. (Eidsheim, 2015)

Vibration occurs when the arms lift and prepare to strike the vibraphone bar. At 1'28" , sound waves from the sample (the prayer) enter

the ear and travel to the eardrum. As I recognize the sound, I lift my arms and prepare to strike the vibraphone bar. The mallet's movement generates energy that strikes the vibraphone bar, causing air particles to vibrate and collide, creating sound waves. This vibration also affects atoms, body parts, and organs within the body. My expression of the need for decolonization and freedom resonates through these stages of vibration. The computer-generated sound greatly impacts my body, showing the interconnectedness between human gestures, movements, vibrations, and computer technology, similar to the influence of environmental changes.

In the second phase, my physical movements, particularly of the arms and hands, activate the motion sensor, creating an overflow of sound beyond my limitations. This interaction between my movements and the motion sensor forms a connection. I am both producing and receiving sound as I improvise on the vibraphone. To compose this piece, I incorporated recorded prayers from Atayal culture into sound samples, some of which were played in reverse. Specific movements at certain measures activate the reversing prayer. The phrase undergoes transformations as the prayers manifest. I revisit the original phrase with double stops and ascending/descending stepwise movements. This continuous motion enhances the prayers and intensifies the piece. Switching to the drum, I transition from quiet to loud, along with jingles, representing indigeneity. The drums and vibraphone play together, showcasing their intricate relationship. The vibes and gestures increase, triggering the motion sensor and blending acoustic and sensor-generated sounds. Techniques include broken chords, rolls, and tremolos, depicting different aspects of indigeneity. Eventually, the speed of the rolls aligns with the rapidly-paced phrase, metaphorically depicting the influence and pressure on Atayal culture.

The interrelation of sound, backing track, and motion sensor represents indigeneity and computer music in the Anthropocene era. According to Dylan Robinson's "Hungry Listening," genuine listening to Indigenous music involves uncertainty. Settler and Indigenous listening methods differ. Prayer serves as a reminder of origin and highlights coexistence and presence. Glissant

suggests that connectivity reveals different sources of indigeneity. Listening becomes the audience's active responsibility.

The motion sensor activates different sounds based on the performer's hand movements. Water noise is triggered by sudden motion or change of speed caused by a certain energy level. The degree of hand movement determines which sound samples are played. Steadiness triggers the music box sound, and an energy level above 20 also triggers music box notes. Sound samples are controlled by the hands' jolting motions at specific time points. All clips have the same amount of reverb to match the natural sound of the vibraphone. The prayer is treated with reversal, amplification, change of speed, echo, tremolo, and reverb. The sound treatments and motion sensor-triggered sounds convey a shared message of responsibility.

In the final section, the motion sensor echoes the initial phrase of the vibraphone's statement: a three-note figure descending. Acoustic playing introduces steady and up-and-down motions. To simulate Indigenous sound stereotypes, I enhance the initial vibraphone sound with jingles and drums. Initially, I played only the floor drum with steady sixteenth notes and rolls, gradually adding the vibraphone to pair its metallic sound with the drum. The rhythm intensifies as the speed and energy increase with higher strokes. The vibraphone creates various textures, while the motion sensor plays the three-note figure. As the rolls and textures change, I bring back the drum with a more intense triplet, reminiscent of Atayal ritual music. The interaction between the background, foreground, and middle ground emphasizes the theme of relationality, with distortion reflecting the oppression present in our environment.

***Through the lens of Indigenous values***

In *Origin of Life*, I invite to plunge into a world brimming with Indigenous wisdom, particularly that of Atayal culture. The audience begin to grasp its depth when diving deeper than the surface-level act of music listening—it's an immersive cultural journey, not just passive sound consumption. This composition is not only about melody and rhythm; it's a tapestry woven from

threads representing time, space, and beings. The listeners' challenge is to understand these complex relationships presented within the piece and how they reflect Atayal values. The beauty here is in understanding this musical work as more than performance art. It represents intertwined connections among spirituality, arts, culture – even ourselves – as if inviting us all onto one shared dance floor. It is worthwhile to remember that there's no finish line for composers on this creative quest – they continuously seek balance in their work – just like life itself.

***Reflections***

Growing up in an Atayal family has taught me three important aspects. These aspects are reflected in this composition: The first aspect is cross-generational and timeless. Music and gatherings in Atayal culture create a sense of community. Our music is passed down through generations and carries a disciplined essence and spirit. Dylan Robinson quotes in his chapter on Indigenous space in "Hungry Listening" his mentor, Lumlamelut Wee Lay Laq, who said, "It is good to remember the teachings of our ancestors." (Robinson 2020, p. 27). This phrase is often repeated during gatherings to honor our elders and ancestors. Esteemed leaders play a crucial role in creating spaces that nurture the growth of Indigenous artists and thinkers across generations. In the Anthropocene, it is equally crucial for humans to create spaces that allow the natural landscape to change and evolve, and thus allow the musicians to create the right environment in the appropriate landscape – a natural landscape that fosters biodiversity.

According to Robinson, the current resurgence of work by Indigenous artists and scholars is thanks to the efforts of previous generations. These elders, artists, and ancestors created Indigenous spaces by challenging colonial systems and establishing new ones that benefit younger Indigenous scholars and artists. Robinson's discussion on ancestral connections and respect aligns with the first Atayal aspect, which highlights the importance of intergenerational dialogue, honoring elders, and passing down crucial disciplines through generations. The idea focuses on timelessness and is all about staying fresh and meaningful through the ages. Think of a

catchy tune that sums up its decade but fades as years pass – it lacks that timeless quality. The real power behind a piece lies in its ability to serve a purpose, be functional across generations, and resonate with listeners young and old.

The first aspect of *Origin of Life* exemplifies cross-generational and timeless characteristics. Performers must understand the culture and its values, as reflected in the patterns of the bells and sound syllables, to faithfully pass these elements to future generations. In Atayal culture, place plays a crucial role in fostering relationships. It goes beyond geography and time, encompassing one to three-dimensional areas and an infinite three-dimensional realm where events occur. In the second aspect, place; according to Dene scholar Glen Coulthard, place is not only a way to understand and engage with the world but also a source of resistance against power structures that seek to erase our sense of place (Coulthard 2016, 79). This knowledge is fundamental to our vision of postcolonial coexistence. In music, the essence of place is expressed as a spatial-relational aspect of sound.

The concept of place is seen in *Origin of Life*, with the first place being formed during the creation of my compositional ideas. The birth of the first place coincided with the translation of my ideas into notations, marking the piece's genesis. The second place is created through the dialogue between the performer and the composer. Here, I, as the composer, can fully understand my own concepts. The third place emerges when the performer conveys the music to the audience. While it is important for the musical components to be accurately relayed, the audience's perception can vary based on their experiences and training.

The third aspect of Atayal culture is all about togetherness and harmony. This unique philosophy focuses on fostering a healthy artist from every angle—mind, body, and spirit. It was my father who drilled into me how important this balance between nature and us humans really is. In the Anthropocene, awareness of place also affects how computer music is composed.

Think of interdependence as our natural state. As defined by cultural psychologists – it's not just you

alone in your bubble but a network where we're all intertwined. These connections have massive sway over Indigenous composers dipping their toes in classical music – a rich tapestry woven from countless personal experiences. These experiences also shaped the Anthropocene and the direction of computer music. Additionally, the cross-cultural musical materials in *Origin of Life* may not be as firmly anchored as expected. Various musical structures from the West, such as scale, mode, harmony, and meter, can be observed. Instead of relying solely on Western theory, I encourage readers to explore the music's relationships, dynamics, orientations, and essence from interconnected perspectives.

When engaging with *Origin of Life*, it is important to respect the culture, follow the composer's directions, maintain an open-minded and generous outlook, and embody humility in the Anthropocene epoch. The three Atayal aspects can be organized and seen as time, place, and beings - can enhance creativity. Time surpasses traditional boundaries, allowing for new forms and the transmission of legacies. The perspectives of performers, composers, and audiences shed light on place, resulting in three unique musical dimensions. Composers aim to harmonize with the world in terms of beings. The piece *Origin of Life* exemplifies the aspects of time, place, and partially, beings.

In conclusion, the grand orchestra of existence prizes variety over singularity and values many origins instead of one. In this epoch marked by human impact – dubbed Anthropocene – it's on us to strengthen ties not just among individuals but across landscapes too. Our obligation runs deep, weaving through all aspects we've discussed in this article. From Atayal values of coexistence, harmony, and place, one understands the importance of allowing enough space for composers and musicians to create content that is suitable for the environment. A suitable environment produces electronic computer music that contributes to the fostering of an environment rich in biodiversity. In an era defined by human impact - the Anthropocene, computer music continues to evolve alongside environmental shifts, with humans playing a leading role as composers of these sonic changes. We are em-

barked on a complex odyssey where unpredictability is the only certainty.

**Notes**

[1] *Origin of Life* performance https://youtu.be/pNLsQzBvqWg (last access Nov 27, 2023).

[2] The motion sensor is called MUGIC, designed by Mari Kimura.

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**Networks of (tele)presence: tuning in to the environment through the INTIMAL App©**

*By Ximena Alarcón Díaz*

The migratory relational listening perspective connects people and environments, beyond identities, moving towards transcendental forms of embodied connection across the distance. This perspective might position Earth as a migrant itself in its accelerated transition with a climate breakdown. While we all meet in these transitions, the INTIMAL App© positions itself between a telematic embodied interface and an instrument that contributes to the creation of networks of (tele)presence as we "tune in" with the environment and become part of its resonance.

In this article, I present a series of artistic telematic sonic performances, facilitated through the INTIMAL App©, a hybrid mobile telematic sonic environment' that I have created.

Rooted on the experience of migration, the performances are staged as mobile hybrid listening rituals in sonic migrations: the resonances left in-between geographies and cultures when we migrate. The rituals are mediated by the application, specifically with sound frequencies, activated by people's walking steps, implying the use of an 'embodied' telematic technology to connect with such resonances. I hereby reflect on how a relatively simple sonic interface and such frequencies, when used collectively, awake connections between humans and the more-than-human, and ask how a 'synthesized' sound helps us to tune with our surroundings, bringing us closer to the reality of the environment rather than detaching us from it.

***Breathing and walking: sensing place and sensing (tele)presence***

The INTIMAL App© is a telematic environment that invites people to simultaneously and collectively engage their sense of place and sense of presence across distant locations, experiencing relational listening. This is a negotiation between sensing place in a physical location, and, simultaneously, sensing presence and telepresence across distant locations. It is rooted in experiences of human migration and the 'estrangement' (Ahmed, 1999) which happens between native and host

lands, and which affects the embodied perception of time and space and the surrounding acoustic environment, as well as the perception of one's own voice. It derived from the INTIMAL physical/virtual 'embodied' system for relational listening in telematic performance, created between 2017-2019. The system was designed and informed first by researching Colombian migrant women's sonic experiences of their migrations to Europe using Pauline Oliveros' Deep Listening practice and Embodied Music Cognition methods, and an oral archive of other Colombian women in exile in an exercise of collective memory (Alarcón Díaz, 2019; Alarcón Díaz et al, 2019a). INTIMAL involved three software prototypes: MEMENTO to interact with oral archives using walking movement, RESPIRO for transmission and sonification of breathing data, and TRANSMISSION to mix and broadcast improvisers' voices from distant locations (Alarcón Díaz, 2019b).

In that project, walking was stated as the migratory movement that helps us to sense place and find directions, while breathing was chosen as the body micro-movement to state each human's body presence and telepresence, its rhythms, emotional states, and vocal expressions. The system was tested in a telematic sonic improvisation between the women participating in the project, connecting from Oslo, Barcelona and London. Derived from this experience, I suggested that sonification of breathing patterns can create an emotional bridge between body movement and sound for telepresence (see Alarcón Díaz, 2022a), expanding the forms of embodiment within telematic performances.

I used Jensenius' taxonomy of body movement (Figure 1), to position sound expressions in relation to body movements (Alarcón Díaz and Jensenius, 2019). For further developments, my intention has been to interrelate these forms of body movement and vocal expression as breathing becomes a bridge for emotional telepresence.

### *Tuning in: between an interface and an instrument*

Detached from screen and video interfaces, and from the staged sound performances with microphones and a controlled sound space with audiences, the INTIMAL App© was

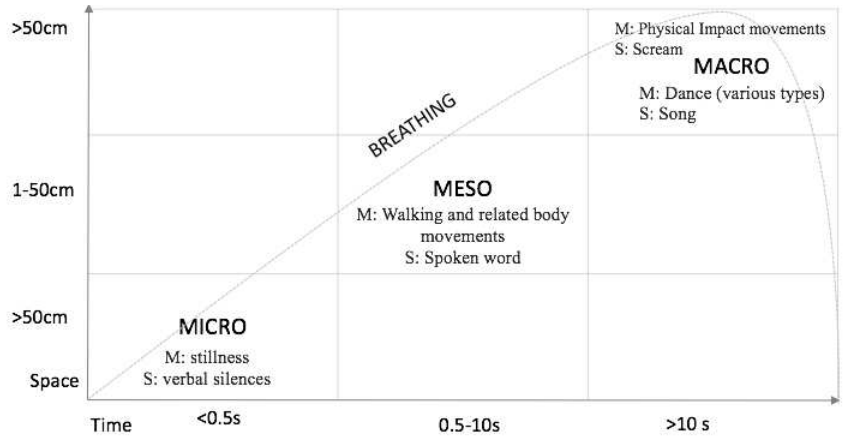


Figure 1: Analysis of INTIMAL performance, and breathing as emotional bridge using Jensenius' Taxonomy of Body Motion (Alarcón Díaz & Jensenius, 2019)

created in 2021 in the midst of the pandemic. The App became a synthesis of the prototypes of the INTIMAL system, combining walking and breathing as interdependent movements that bring together people's rhythms as they simultaneously explore their surroundings and connect across distant locations.

The INTIMAL App© tracks people's walking rhythms and converts these into sound resembling a breathing wave. When used collectively, people can hear through headphones each other's walking patterns and playback stories that have been left by other walkers/improvisers, responding to listening 'prompts' or text scores. As a preparation for the journey, the App asks participants to 'Tune In' using sine wave frequencies ranging between 174Hz, 396Hz and 528Hz, and state their bearings by finding their North.

Thanks to the project Unlock[1], the App was developed and tested first in its individual and collective mode with women in Bath (UK), listening to excerpts of migratory journeys of Colombian women from the INTIMAL project in order to trigger their own migratory journeys (Alarcón Díaz, 2022b). Since 2021, the INTIMAL App© has been tested in

eight other different spaces and contexts,[2] and I have composed mobile listening rituals for each occasion. These rituals set the paths and the intention for people to "tune in" with themselves, the earth, the environment and others across distant locations.

The sounds of the frequencies have become a fascination and a mystery. For instance, in the project Unlock, the frequencies helped women to listen to words of pre-recorded stories, connecting them with inner sounds, as well as with birds: "When the tone stopped, I felt more connected to the sounds around me (such as birdsong)". The collective drone created across distant locations created a sense of togetherness: "It [The environment] felt fuller in a way, hearing their frequencies was like being in the company of others". (Alarcón Díaz, 2022b)

In the Earth Festival 2022, I invited eight improvisers connected from São Paulo, New York, Vienna, London, Madrid, Sweden, and Boston, to listen to their surroundings following the score *Dreaming while awake: a network of Presence*.[3] The network they created brought connections as they tuned in with the built and natural environment, in estrangement, recognition, acknowledgement, and reflection of what is changing in their environments, of what leaves traces, and the unnoticed; they connected emotionally as in search of a deep source of presence. One of the improvisers, the musician Cassia Bomfin connected from a car park and expressed poetically, within the piece, how her imagination through this connection *despertou um algo* ("something woke up"). Others' improvisers' voices described sensory experiences with the sun, the voices of children and the relationship with the trees and humans. The experience felt like an awakening of details of life that are not usually noticed as with rich value.

***Synthesis***

As stated before, I used the mobile phone and its technological possibilities to make a *synthesis* of an artistic concept. With this, I arrived at the use of "waves" without harmonic spectrum. Individual and collective listening through the INTIMAL App© seemed to follow a subtraction experience within the

environment. From a practical technological perspective, the sine wave was chosen as the simplest form of sonifying walking steps in relation to a breathing rhythm. A minimal sound is produced in each phone, with the transmitted data across distant locations. But why use a synthesized sound to connect people with the outer environment? Could it perhaps become a contradiction, if I am using a sine wave to imitate a breathing wave, activated with my very human steps, unlike the previous more sophisticated sonifications imitating for instance wind?

From a cultural and historical perspective, Tara Rodgers explores in her writing "Synthesis" the origin of synthesized sounds, reminding us that synthetic sounds are parallel to the creation of synthetic materials in organic chemistry: " 'manmade' imitations of natural substances" (Rodgers, 2015, p. 213). At that time, this created a fascination and also a critical perspective on the novelty of such sounds. Rodgers also reminds us, how the analysis and synthesis of musical sound were understood by Harry Olson and colleagues at RCA Laboratories , in the 1950s, as "analogous to the process of decoding and coding a signal in a communication channel" (Rodgers, 2015, p. 210), opening ideas "for a cybernetic era, where multiplicity of forms could be expressed as patterns of data" (idem, p.211). I suggest that in the INTIMAL App©, the sine wave might trigger our memory of a telephone tone and the expectancy of someone else might pick up the call. The wave brings a beginning and an end, creating a flow activated by people's walking rhythm. Stillness becomes individual silence but, if desired, the listening of others' signals is still active.

Beyond the oppositions and embrace of these sounds, Rodgers suggests that "synthesis, then, is not merely a means of creating novel sounds. It also directs us to a charged moment: that fleeting "interruption of time" (4) that follows a retrospective analysis and precedes a new synthesis. Through this opening, we may listen for the cultural histories and sonic epistemologies that reside within technological forms, and for logics of part-whole relations and complex systems that frame the contours of everyday soundscapes" (Rodgers, 2015, p. 217).

***INTIMAL App©***

I situate the INTIMAL App© in a middle ground between an interface and an instrument.
When described as a technological interface, it involves the embodied and movement transmission in-between people who are connecting across distances. This transmission, in turn, when sonified, creates a sonic interface with the sum of frequencies, rhythms, and interferences occurring simultaneously between the walkers. The walkers can record sounds which can be heard by others if they choose to activate these by their steps. Metaphorically the body becomes the interface that interacts with each environment, wandering in its own way, and receiving a tuning response according to their walking rhythm. Sonically, the experience becomes an improvisatory-sounding experience which requires full-body listening, generating musical and extra-musical experiences between people.

The App becomes an instrument when the walker focuses on the control of features such as choice of frequencies, tuning with the rotation of the body to the right or to the left tuning up or down the frequencies. When being outdoors, the tuning becomes also a reference to listening to the surrounding environment.

The use of different equipment that states their technological interfaces, mobile phones, embedded microphones, headphones, and reliable internet connection, become part of the ritual within an environment. The role of the interface is to highlight a sonic event consisting of different vibrations that are involved in the connection, from the perspective of each distant listener in a difficult-to-control space. When people detach from control and focus on the tuning, the walking ritual extraordinary degrees of the perception emerge.

***Togetherness and becoming part of the resonance***

In 2023, the INTIMAL App© was used in a co-located telematic experience of *Tuning In with Silences* at Scenario 22 in the STRP Festival of Art and Technology in Eindhoven. Forty participants became part of the experience situated in an empty non-place at the back of the city's train station. The invitation was to

"Tune In" with silence, and when they wanted, they could "voice their silences". They could choose spaces within the application to tune in, using metaphors in the walk: "stepping on ancient roots", "gazing stars", and "dreaming".

A feedback from one of the participants at STRP Festival 2023 was as follows:

> Getting "in tune" with others, while exploring a relatively inhospitable and public space, resulted in something quite unexpected.
>
> Walk, listen, imagine. Everything was slowly changing as one intertwined with the other. The experience was decidedly focused (on the device, on the walk, on the listening) but at the same time sensory expansive: the sound of the wind, the sunlight, the sounds of the facilities around us; everything took on a very strong emotional component, almost psychedelic.
>
> All this mixed with the awareness that we were not alone in that place, that there were others exploring the same space, trying to capture the same sensation of free discovery within the determined. What caught my attention the most about the INTIMAL app was how it managed to create a connection between people who had (almost) never seen each other before, who had never spoken to each other (since we had been sharing a state of quite a bit of silence, before we started). In that strange space next to the train station, we all became erratic entities in search of others, but also in search of ourselves. Thanks to the technological medium (forgive the irony), we were able to share this unique experience and connect looking for harmony, syntax and synchronicity." Zorro Fork (translation from original text in Spanish)

Within such a connection between humans, inner connections, and open and green environments, these sounds highlight a transcendental experience.

Early experiments with sound frequencies by the composer Pauline Oliveros were inspired by their mystery and the ability of these sounds to connect with inner sounds she was hearing. Elaine Radigue's work with electronic sounds invites us to listen to the slow changes in-between them and listen to what these awaken on us (Eckart, 2020). In her piece *Environmental Dialogue* (1997), Pauline Oliveros invites us to listen either indoors or outdoors, first observing our own breathing. Becoming aware of the field of sounds in the environment, each

Tuning in with Silence. STRP Festival 2023, Eindhoven.
Still image from video by Pablo Sanz.

person is invited to 'reinforce' the pitch or timbre of sounds that call our attention within the environment. She insists on the meaning of 'reinforcing,' which "means to merge rather than imitate". If we 'reinforce' we "might produce a resonance in the environment (…) [m]erging with sound or silence will produce a resonant state of awareness" (Oliveros 2013).

In my own experience with this simple and challenging exercise, when successful, we experience a subtraction of what we are listening within the environment, in order to become a part of it and stimulate a resonance in the environment.

The INTIMAL App©, positions us within the environment, inviting us to explore awareness through walking and producing a sine wave tone with our pace. I suggest that this movement awakes a sense of agency, which might help us to become part of the individual and collective possibilities that emerge in shared social, cultural and geographical environments, in connection to ourselves, other humans, and the more-than-human. A listening opportunity to become part of the Earth's resonance in its transition.

**Notes**

[1] The project Unlock was funded by The Studio Recovery Fund 2021, Bath Spa University, and was developed in collaboration with Dr Liliana Rodriguez, Service Designer, and Kieran Harte, Computer Programmer.

[2] The INTIMAL App© has been experienced as an interface/instrument with others in the Intimal Collective, STRP Festival 2023 Scenario 22 (Eindhoven), Soundings: Assemblies of Listenings and Voices across the Souths (Berlin, August 2022), Museo de Arte Moderno de Medellín (July, 2022), Migration Matters Festival with the Intimal Collective (Sheffield, June 2022), GEXLAT with Intimal Collective (April 2022), Earth Day Telematic Festival (April 2022), Sensing: The Knowledge of Sensitive Media Research Group – The Brandenburg Centre for Media Studies (ZeM) (June, 2021), and originally developed and tested in Bath with the project UNLOCK, awarded by The Studio Recovery Fund, Bath Spa University 2021.

[3] Link to the piece: https://soundcloud.com/networkedmigrations/dreaming-while-awake-a-network-of-presence-by-ximena-alarcon (last access Nov 11, 2023).

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## *Currents*: A Weather Data Sonification Project

*By Andy Jarema*

Communicating the existential threat posed by climate change is essential to achieving a courageous leadership and strong policy changes needed to avoid the most catastrophic possible futures in store for our planet. Composers and other artists have much to offer in the conversation about our shifting planet through the power of artistic storytelling mediums. Making an audience *feel* scientific data can keep the conversation afloat about the urgency of climate change and the ominous shifts in weather patterns on our planet.

*Currents* is a multifaceted and ongoing musical work that centers around two guiding questions: How can we use sonification to musically depict weather and climate data, and how can this musical narrative affect how we feel about the data? Specifically, *Currents* sonifies a database comprising forty years of data created by the National Oceanic and Atmospheric Administration (NOAA) that tracks Billion-Dollar Weather and Climate Disasters in the United States. In this article, I discuss my first iteration of the piece, providing insight into the sonification process of *Currents,* including technical challenges in the sonification process, how the data elements were sonified, and important questions that emerged when translating big data into a creative musical work.

### *Currents*

Information about climate change traditionally relies on communicating rigorous evidence from the scientific community: facts, figures, graphs, and data. But truthfully, I have only personally been moved to change by artistic works. It was a film that first lit my passion to fight climate change (*An Inconvenient Truth*, a documentary by Davis Guggenheim from 2006), and an author that convinced me to take my most potent individual climate action by eating no animal products (Jonathan Safran Foer's *We Are The Weather: Saving the Planet Begins at Breakfast*). As a composer, I find myself wondering what we artists have to offer in terms of making people feel something different about the alarming climate data presented to us by the scientific community.

*Currents* is a fixed audio-visual work created in Max/MSP that covers all forty years of data (1980-2019) in roughly eight minutes.[1] It utilizes visual graphs, field recordings, and synthesized sounds to provide a lofty overview of the entire dataset and gives the numbers a more compelling artistic narrative.

I want to begin by outlining the initial challenging steps of working with the data used for creating *Currents*. I hope that this will help illuminate the issues with big data sonification other composers might face in the future. Max/MSP was the software I chose for the data sonification process due to my familiarity with the programming language, however my technological abilities quickly had to expand to accommodate the multiple moving parts needed to access and sort such a large web-based data set. The composition's Max patch utilizes a feature introduced in Max 8 known as "Node.js," which is a Javascript-based method of communicating with web-based resources. "Node.js" assisted with accessing a JSON data file of the Billion-Dollar Weather and Climate Disasters database through the NOAA website, including sorting and parsing the data into three columns of information: number of billion-dollar weather events per year, the cost of each individual billion-dollar weather event, and the number of deaths that occurred with each event. From there, a "coll" object in Max was used to store and export the three columns of data as three separate .txt files to my harddrive. By reimporting the .txt files back into three separate "coll" objects, Max was able to travel through the data and create the basis for translating these numbers into sonic information.

I want to stress that accessing and parsing this data was non-intuitive, oblique, and challenging. It was a frustrating monthslong endeavor filled with failed experiments, desperate shifting through YouTube tutorials, and re-tooling existing Java script code designed for other purposes entirely. Smaller data sets might be able to be fed into an audio program like Max/MSP rather quickly, but there seems to be no single method of sonifying large data sets without the use of multiple programming techniques (Max/MSP, Node.js, Javascript, JSON files) which creates a high barrier of entry into this process for the average

composer.

After accessing and parsing the data, Max/MSP was used to sonify the weather data using field recordings and generative FM synthesized sounds. The field recordings used in this piece were recorded with my Zoom H4 recorder in Great Smoky Mountains National Park (crickets, birds) and Hawai'i Volcanoes National Park (hydrophone recording of the ocean). The three sets of natural sounds (crickets, birds, ocean) represent three different environments (land, sky, and sea), functioning as an abstract barometer that allows us to check in and take readings on the health of three distant biomes on our planet.

The top graph tracks the number of billion dollar weather events that occur in each year (40 data points) and is sonically depicted with crickets (center pan). There is an inverse pitch relationship between the sound and the data, where a higher number of weather events correlates to a lower shift in the pitch of the cricket recording. This was primarily an artistic choice given that the cricket recording takes on an alarm bell-like quality at lower pitch levels. The middle graph tracks the cost of each individual weather event (258 data points) and is sonically depicted with a crackling underwater hydrophone recording of the ocean (right pan). A higher cost triggers a longer articulation (envelope release) of the sound, and significantly high-cost events over $20 billion trigger the sound of loud ocean waves. The bottom graph tracks the deaths caused by each individual weather event (258 data points) and is sonically depicted with a bird call (left pan). There is also an inverse pitch relationship similar to the cricket sounds (a higher death toll triggers a ghostly, lower pitched bird call) and significantly fatal events over 100 deaths trigger the sound of chickadees (chickadees use an intricate language of bird calls as a way to broadcast perceived threat levels in its environment).

In addition to the three sonified elements operating at a micro level in the piece, there are sonic elements that function on a much larger time scale to convey a broader narrative in the data. Taken as a whole, the forty year data set outlines an overall rising trend of billion dollar weather events. To artistically reflect the urgency of this narrative, certain

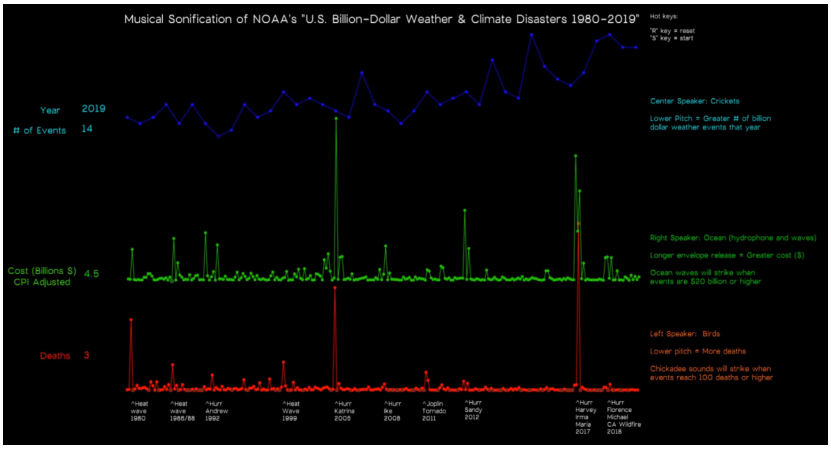


Figure 1: still taken from *Currents* to demonstrate these visual graphs and sonified elements

musical elements such as tempo (a gradual accelerando over time) and timbre (stark FM synthesized sounds layering in over the field recordings) unfurl over the eight minutes time span of the piece. Approximately half way through the piece, another hydrophone recording sneaks into the right speaker. The recording slowly begins creeping to fill the left speaker, dropping in pitch as it goes along. The recording wildly increases in pitch and speed at the end of the piece (the year 2020), further signifying urgency as the sound burns and crackles out of control.

One question that frequently emerged in the sonification process of *Currents* was how to address the tension between data accuracy and creative artistry. Being faithful to the data in order to tell a scientifically sound narrative was a priority, but on the other hand I found myself taking creative licenses in the sake of creating a compelling musical narrative. One of these challenges was figuring out how to scale and calibrate the data in the sonic domain. For example, the number of events per year was easy to sonify into the pitch domain due to its relatively limited range of data (there were 0 to 16 events, which was sonified into a two octave range of notes from C2 to C4). But the cost

provided a unique challenge since this data mostly operated in a narrow band (costs for each weather event hovered mostly between one and 20 billion) with occasional outliers stretching the upper bounds of the data (Hurricane Katrina's 192 billion being the highest). If this data was sonified directly into the pitch domain, it resulted in a flat pitch output with mostly imperceptible pitch changes (semitones or tones) with occasional jumps to a higher note when an outlier occurred. On the other hand, adjusting my sonification to pick up the nuance in smaller values failed to sonically capture the magnitude of the outliers when they occurred (in some cases, the outlier was so high it produced a pitch outside the range of human hearing). To fix this, I created "parameter bands" (Figure 2) that would sonify different ranges of data to different ranges of pitches: 1-10 billion was sonified within a one octave range (C4 to C5), 10-100 billion in another octave (C5 to C6), and the upper outliers between 100-167 in a final octave (C6 to C7). These types of decisions throughout the sonification process of *Currents* forced me to confront the boundaries between scientific accuracy and creative artistry, ultimately helping to shape my narrative intentions and clarify the messaging behind the piece.

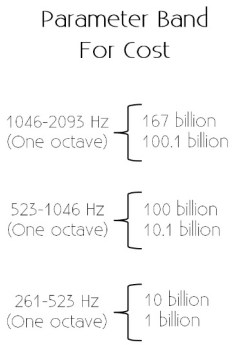


Figure 2: Paramter Bands

Another question that emerged in the sonification process was how to utilize big data in an ethical way. A valid critique of *Currents* is that the data points scrolling across the screen can feel objective, impersonal, and disconnected from individual experience. I myself was a part of one of these extreme weather events (2014 Detroit flooding) and seeing the data point slip so quickly across the screen somewhat diminishes my harrowing recollection of that day. It especially makes me uncomfortable to see the data points for deaths, real human lives being lost, ticking away across the screen with an almost impassionate calculus. It reinforces the

narrative that the problem of climate change feels too massive, its complexities and horrors beyond any sort of action that can possibly reverse its course. If the objective of climate-related art is to emotionally move people to awareness (and therefore- action), I sometimes wonder if using such a large data set is always the most potent approach.

This is where *Currents* blossoms into not just one iteration, but an overarching weather data sonification project. Shortly after the premiere of this fixed audio-visual iteration at the 2020 Earth Day Art Model Festival, I began working on the next chapter of the *Currents* project. As opposed to a fixed audio-visual piece sweeping through mountains of data, the next iteration of *Currents* zoomed in on seven specific weather events out of the 258 catalogued in the database. I crafted notated sheet music shaped by data sonification techniques and enlisted seven wind/percussion players to perform these short solo works with live electronic processing via Max/MSP. For example, the aforementioned 2014 Detroit flooding was outlined by a percussion player using five different instruments to depict the five inches that fell on Detroit in roughly five hours. Using hourly precipitation amounts from the Weather Underground, I mapped out the rate of rainfall and projected this timeline overtop the 31 measures of the piece. The percussion player adds a new instrument into the mix after each new inch of rain falls, leading to an eventual flood of five instrument sounds bolstered by Max's live processing into back-masked "waves" of percussion sound. This iteration of *Currents* felt so much more personal: the depiction of individual weather events, a community of live musicians tangibly engaging with the music, the inclusion of a single weather event that personally affected me and my community. Though, related to the previous question of data accuracy versus creative artistry, this project took many more artistic liberties and did not have the same rigorous adherence to the numbers that the first audio-visual iteration did.

To me, *Currents* functions as a blueprint, an ever evolving set of works that strives to make artistic narratives out of scientific data. At its heart it is a project concerned with communicating an artistic narrative

about climate change, and I hope to continue to adapt the project into radically new mediums to reach as many audiences as possible. Perhaps it could be adapted into sheet music for young beginning band players and include a curricular element that could facilitate climate change discussion in the classroom. Or perhaps it could function as a video game, an interactive fiction piece using the programming language Twine that combines written and sonic narratives in a way that implicates the audience into its process (video games demand the player's participation for the genesis of the story to occur). I believe we as artists have so much to offer in the conversation about our shifting planet through the power of artistic storytelling mediums, and making an audience feel something different then scientific data can show, keeping the conversation afloat about the urgency of climate change and the ominous shifts in weather patterns on our planet.

**Notes**

[1] Recording of *Currents* www.youtube.com/watch?v=97J1CG88UV0 (last access Nov 11, 2023).

## ***Sound Imaginations*: Listening Cultures and Audiovisual Immersion**

*By Paulo C. Chagas*

*Sound Imaginations* is an interdisciplinary project I conducted from 2016 to 2019 as a Senior Fellow at the Center for Ideas and Society at the University of California Riverside, that combines scholarship on sound studies with field research and artistic expression. This article provides an overview of the project and its outcomes. It begins with the theoretical background before moving into a description of the field research and concludes with an account of the artistic result, *Sound Imaginations: Audiovisual Immersive Installation*, presented at the beginning of 2020 in the Culver Center in Riverside, California, just before the COVID-19 pandemic shutdown.

### *Sound as Listening*

The initial motivation was to investigate a sound phenomenon from the point of view of *listening*. What is listening? How do we perceive sounds? The simplest answer is to say: we hear the sound. In fact, a sound phenomenon is intrinsically associated with our ability to perceive and identify sounds, which is linked to the idea that we are immersed in an acoustic environment constituting a fundamental of human communication. The acoustic environment enables the creativity of music and all communication through sound, including language, music, sound design, and sound art. Between silence and cacophony, music makes tangible the active principles of *sound* and *listening* as fundamental signatures. Sound is embodied in everything all the time, even if we are not listening. Music embodies the desire to comprehend the ubiquity of all sounds. The belief that everything can resonate can be traced to the mythological roots of Western music extending back to Antiquity. It expresses our desire to listen to sounds everywhere, resonating in different spaces and temporalities, from molecular vibrations of the planet to other cosmic entities of the universe (Chagas 2021, p. 12). As Kahn claims, sound is pervasive, "all space becomes indelibly, inaudibly, or pervasively filled with voices and sounds awaiting to be heard" (Kahn 2001, p. 200).

Then how should we define listen-

ing? Chion (1994) identifies three modes of listening: causal, semantic, and reduced. The most common is causal listening, which consists of listening to a sound to gather information about its cause or origin. Through causal listening we recognize the voice of a specific person or a sound produced by a particular object, such as a moving automobile or a bird singing. We recognize the general nature of what caused a sound – human, animal, mechanical, electronic, etc. — though we need a context to understand the sound. We also recognize that sound can have several causes, origins, and sources, insofar as perception is an experience of simultaneity: the listener must separate sounds from background noise and identify sound objects and events (Chagas, 2005).

The second mode as defined by Chion is *semantic* listening, which contains the possibility of interpreting the meaning of an acoustic message, whose model is language. It works in an extremely complex way. For example, a phoneme is heard not strictly for its acoustic properties, but as part of a whole system of oppositions and differences. In this sense, semantic listening is articulated through semiotic systems, such as the different languages of the world, sonic codes of communication such as a drum sound or Morse code, as well as music and sound art that can symbolically interpret sonic creativity. Additionally, there is the contribution of sound design, which has become prevalent in the contemporary world of electronic and digital devices.

The third mode is *reduced* listening, which focuses on the traces of the sound itself, regardless of cause and meaning. This concept was proposed by the "musique concrète" movement that emerged in Paris at the end of the World War II around Pierre Schaeffer. Inspired by Husserl's phenomenology, the aesthetics of concrete music came to be from the interaction of sound material with technical devices, especially the tape recorder. In the *Traité des objects musicaux*, Schaeffer (1966) proposes the concept of *acousmatics* to characterize the awareness of a listening that extrapolates the causal and visual sources of sound production. The term acousmatic goes back to the pre-Socratic concept of aurally transmitted knowledge. For five years, Pythagoras' disciples sat behind a

curtain listening to the master's lectures without seeing him, concentrating only on the sound of his voice. Acousmatics proposes hearing sound as an invisible phenomenon. Schaeffer's approach is an attempt to overcome historical and cultural habits of musical, vocal, and instrumental listening, and to unveil new possibilities of musical creativity with the use of technical apparatuses. Sound must be separated from its external connections so that the fantasy can focus entirely on the sound phenomenon without cultural, social, and historical connotations and, above all, musical stereotypes. We must listen to sound and music as the disciples of Pythagoras listened to the master's lectures; we must let the sound speak for itself through its inner voice (Chagas 2014, p. 128).

As Chion states, "reduced listening has the enormous advantage of opening our ears and sharpening our power of listening. […] The emotional, physical, and aesthetic value of a sound is linked not only to the causal explanation we attribute to it, but also to its own qualities of timbre and texture, to its own personal vibration" (Chion 1994, p. 31). In cinema, for example, sound, much more than image, can become a means of affective and semantic manipulation. On the one hand, sound acts directly on us, physiologically (breathing noises in a movie can directly affect our own breathing); on the other hand, sound influences perception through the phenomenon of added value. It interprets the meaning of the image and makes us see in the image what we would not see or would see otherwise. Unlike image, which is localized, sound is all-encompassing.

***Sound as Discipline and Soundscape***

The development of sound technology has drastically changed the way we produce and consume sound. New forms of technologically mediated listening, new processes of manipulation, treatment, and electronic sound processing, shape our lives and occupy our physical and existential spaces. From the 20th century onward, we have observed an exponential growth in sound emissions, together with a decrease in centralized sound sources. Loudspeakers of all sizes and types, and machines and digital devices that

emit sounds, surround us in private and public spaces. By 2021, an estimated 15 billion mobile devices were operating worldwide — a number expected to reach 18.22 billion units by 2025, increasing our dependence on this equipment to run our daily activities. In other words, we will be sharing our acoustic space with increasingly intelligent devices that reproduce electronic sounds, voices, noises, and music. Mobile listening in cars and the emergence of new genres of digital music based on sound creation are intrinsic aspects of the contextual changes that impact our listening experience and acoustic creativity.

We are moving into new and rich areas for which we need to find the right approaches and methodologies. Wittgenstein suggests that sound is just the surface of music and that the musical work hides something deeper, insufficiently described by philosophical models or scientific theories (Wittgenstein 1998, p. 11). The infinite complexity of music can only be understood in the context of its use, which includes the understanding of cultural and social references that create meaning beyond what is expressed by sound (Chagas 2014, p. 24). The same argument applies to the artistic realm of sound creation and production: we can only understand sound when we realize how it is used.

*Sound studies* is an emerging interdisciplinary field that investigates the material production and consuming of sound, noise, and silence — and how this connects to our history and culture. Sound is an analytical point of departure or arrival. By analyzing both sonic practices and narratives to describe them, it reframes the question of what sound is and explores how we express ourselves in and through sonic worlds. Sound studies reaches across disciplines and traditions, it extends both in time and space. It investigates sound phenomena in a relational context including music, listening, media, space, architecture, poetry, technology, performance or any other aspect of our sonic life.

In the introduction of T*he Sound Studies Reader*, Sterner proposes the concept of *sonic imagination* as a synesthetic neologism to emphasize how sound observation "occupies an ambiguous position between

sound culture and a space of contemplation outside. Sonic imaginations are necessarily plural, recursive, reflexive, driven to represent, refigure and redescribe" (Sterne 2012, p. 5). Sound studies should not follow a single methodology but a plurality of approaches: "Instead, sonic imaginations are guided by an orienting curiosity, a figural practice that reaches into fields of sonic knowledge and practice, and blends them with other questions, problems, fields, spaces and histories" (Sterne 2012, p. 6).

The pioneering notion of *soundspace* proposed by the Canadian composer and scholar Murray Schafer in the 1970s is a key concept in sound studies (Schafer 1994). It refers to the sonic environment and includes not only the "natural" environment of sounds but also the entire culture characterizing the sonic environment of any specific space or object of study. Driven by Schafer's ideas, many scholars and artists have been pursuing the mapping of historical and contemporary soundscapes and observing the transformation of soundscapes in the industrial and digital society. The concept of soundscape inspired the World Soundscape Project (Truax 2000) and scholarly narratives in acoustic ecology, history, anthropology, and sociology. Many authors have criticized Schafer for having projected the problematic concept of 'landscape' borrowed from visual art into sound studies, as it suggests a static perspective rather than the kinetic and surrounding characteristic of sound phenomena. It also implies a division between hearing and seeing, which is highly problematic in the contemporary world shaped by the connective reality of audiovisual and multimedia technology.

Feld (2003), for instance, proposes the concept of *acoustemology* – the union of acoustics and epistemology, which investigates the primacy of sound as a modality of knowing and being in the world. Soundscapes are not just physical exteriors, they are perceived and interpreted by human actors and are invested with significance by those whose bodies and lives resonate with them in social time and space. As a cultural system, sound both penetrates bodies and emanates from them; hearing and producing sound are thus embodied with

competencies that situate actors and their agency in particular historical worlds.

***Listening Cultures***

In the second part of the Sound Imaginations project, I collected field recordings of audio and video material in various geographic regions of the world. Inspired by the concept of listening cultures, proposed by Schultze (2015), I set out to investigate listening habits and techniques and the cultural and historical aspects associated with them. I aimed to observe myriad phenomena, such as human relations and technical devices, architectures, and structures of space and time that represent contexts of individual and social listening. Three questions underpinned the research:

1. How do different cultures approach listening?

2. How do human beings listen in different ways?

3. How do we hear the acoustic environment, living beings, surrounding machines, architecture, natural and cultural spaces?

Based on Schultze's methodology, I systematized the research into seven listening categories:

1) Listening cultures of relationships – the sonic phenomena that shape the layers of co-existence between human beings, animals, plants and machines.

2) Listening cultures of work – cultures of evaluation, collective work rhythms, auditory cultures of technology.

3) Listening cultures of entertainment – popular cultures of entertainment, rituals, sonic cultures of the body.

4) Listening cultures of protest – presence of political activity through noise, singing, talking, aural forms of protest.

5) Listening cultures of violence – sonic violence, impairment of the senses, connection to drugs and work cultures.

6) Listening cultures of no-sound – sounds that are not perceived by human beings, the unheard, the "unsound."

7) Future of listening – listening as an active process; the diversity of material and sensorial listening cultures; embodiment and disembodiment of listening.

***Recordings***

The field research was conducted between January and July 2019, during a sabbatical semester. In early January, I purchased an equipment package for 360 3D video and ambisonics sound recording consisting of:
• Video camera (Insta360 ONE X) with various tripods and accessories.
• Multichannel audio recording (SoundDevice PreMix6).
• Ambisonic microphone (Sennheiser Ambeo) with tripods and accessories.

With this equipment, I travelled to capture audio and video material in the following geographic locations and dates:

1) São Paulo, Brazil from January 19 to February 17, 2019. Recordings were made in Trianon Park in downtown São Paulo and in the Studio dos Lagos in the outskirts of the city. Trianon Park, located on the Paulista Avenue, contains part of the Atlantic Forest, which covers the São Paulo region. Paulista Avenue is a financial and commercial district located in the core of the city, whose ambitious buildings represent the modern architecture of Brazil. Some recordings were made on Sunday when the avenue is closed to the traffic and over one million people use this public space for recreational purposes. Studio dos Lagos is a state-of-the-art sound recording studio located in an area of environmental preservation in the Atlantic Forest. I made recordings both outside and inside the studio.

2) Riverside, California, USA March 1, 2019. I made recordings in the UC Riverside Citrus Collection, facilitated by Dr. Tracy L. Kahn, Curator and Givaudan Citrus Variety Collection Endowed Chair. Recordings were created on the agricultural unity located on Martin Luther King Boulevard. With the assistance of Nikolay Maslov, curator of Film & Media Project of the Culver Center, I aimed to document the variety of species and richness of the UCR citrus collection and to capture the surrounding environment.

3) Moscow, Russia from March 13 to June 12, 2019. I made sound and video recordings in multiple environments. Over a period of three months, I explored a significant number of locations and situations to gain insight on the cultural diversity and richness of the

Russian capital. A highlight of this work is the footage made on May 9th in the so-called march of the "Immortal Regiment," which is part of the celebrations of the end of World War II. Up to 1 million people took part in this procession through the streets of Moscow carrying portraits of their relatives who fought or died during the war. I marched with the crowd and recorded videos of the procession flowing down Tverskaya Street, one of the capital's main roads, through Red Square. Additionally, I made recordings in different parks, boulevards, the traditional Arbat Street, and the Trinity Lavra of St. Sergius, a monastery located outside Moscow and a major symbol of the Russian Orthodox Church. My goal was to capture the manifoldness of the fascinating Russian capital and culture.

4) Mannheim, Germany – May 16-20, 2019. I recorded urban and industrial landscapes in the major industrial city of Manheim in central Germany. During this short trip, I made recordings on the Wasserturm, a Romanesque water tower that is the civic symbol of the city, on a river port that concentrates major industrial plants, and in the Luisenpark, an impressive green area containing many gardens.

5) Pune, India – June 12 to July 24, 2019. Pune is a vibrant city located in the state of Maharashtra. It has an important concentration of universities and educational institutions, which gives the city a flair of freshness and modernity. Over a period of six weeks, I made a significant number of sound and video recordings in many different locations including streets, parks, workplaces, temples, and a religion procession. On a side trip to a surrounding region, I recorded in three locations: Ramdara Shiva Temple, Bhuleshwar Shiva Temple, a 12th century landmark, and the Changa Vateshwar Shiva Temple. The extensive sound and video material collected in India are diverse, unique, and captivating.

***First-Person Methodologies***

To make the audio and video recordings, I applied first-person methodologies, which means that the process of being observed appears as relevant and manifest *for* a 'self' or 'subject' and is associated with cognitive and mental events that accounts for the lived *experi-*

*ence*. Varela and Shear (1999) outline the first-person method as an interplay between observations and validations, which accounts for the changeable and fluid character of the human experience. An example of this can be found in the domain of musical performance, in which the performer undergoes disciplined training to acquire technical and musical skills, but the experience of performing music has to be explored and modified in non-arbitrary ways.

This pragmatical approach guided the choice of the recording equipment. The Sennheiser Ambeo microphone, the Sound Devices MixPre-6 recorder used for recording ambisonic sounds, and the camera Insta 360 ONE X and different tripods used for capturing 3D images, are portable devices easily carried by a single person. The way this equipment was used varied according to the objective and subjective conditions of each location and situation. For example, in protected locations such as Trianon Park or areas without human presence, like the UCR citrus collection, it was possible to position the microphone/recorder in one place and leave them alone for longer periods of time, simultaneously capturing sound and image. In other situations where there was a strong human presence, it was necessary to stay close to the equipment. In events such as walking inside the "March of the Immortal Regiment" and wandering through the busy streets of Moscow and Pune, I carried the camera attached to an invisible baton. In these instances, it was not possible to carry both the camera and the ambisonics microphone, so I recorded sounds with the camera microphone.

This kind of equipment favors the auditory and immersive experience of the observer himself. The microphone and the camera can be considered extensions or replacements of the sensory and cognitive system of the subject immersed in the soundscape and landscape, suggesting an apparent objectivity in the process of capturing sounds and images from the environment. However, what we consider objective, that which allows the constitution of a corpus of shared knowledge about objects and natural events we observe, is, in fact, "partly subjective, as it depends on individual observation and experience, and partly ob-

jective, as it is limited and regulated by empirical and natural phenomena" (Varela and Shear 1999, 1). In other words, the subjective is not the same as dealing with purely personal experiences, as is often assumed, but is already implicit in the objective and in dealing with objective phenomena. First-person subjective experience is thus an explicit and active component of the observation process.

***Audiovisual Immersive Installation***

The artistic output of the project is the exhibit *Sound Imaginations: Audiovisual Immersive Installation*, presented between February 29 and March 5, 2020, in the Culver Center of the Arts in Riverside, California. The installation was created with the ambisonic sounds and 360 3D videos recorded during the field trips to São Paulo, Riverside, Moscow, Mannheim, and Pune. The process of creating the installation was accomplished in three stages:
1. Selection and editing of the video footage.
2. Producing of audio and video material.
3. Installation design and exhibition setup.

I accomplished the first stage working solo, and Nikolay Maslov actively participated in stages two and three and curated the installation.

In the first stage, I selected a variety of footage showing different aspects of each geographic location. The edition of 360 3D videos was accomplished with the software Insta 360 Studio. Editing 360 footage is a complex task as the video allows multiple editing options in three dimensions. The software offers fours views – default, crystal ball, tiny planet and natural view – and five parameters to adjust – pan angle, tilt angle, roll angle, field of view (FOV) control, and distortion control. The editing process is accomplished by setting keyframes in the timeline and defining the views and parameters for each keyframe. We were also able to alter the transition settings between the keyframes to create smooth movements and different combinations of fade-ins and fade-outs. With these settings it is possible to create a great variety of tridimensional movements that can be extremely dynamic and sophisticated. After defining all keyframes, the 3D video was converted to a conventional video format (mp4).

All videos were edited to play on a loop.
I created a total of 89 videos consisting of:
• 11 videos from São Paulo, Brazil
• 10 videos from Riverside, California
• 28 videos from Moscow, Russia
• 11 videos from Mannheim, Germany
• 29 videos from Pune, India
The length of these videos varies between three seconds and six minutes and thirty-four seconds.

I organized the videos under four categories:

1. Short videos: <= 00:55" – 34 videos

2. Medium videos: between 00:56"–02:30" – 32 videos

3. Long videos: > 02:30" – 13 videos

4. Videos to be used in the main large projection (see below) – 10 videos

In the second stage, we created 14 videos for the audiovisual immersive installation: a main video and 13 other videos. The main video was conceived to be projected onto the installation's central screen. It is an audiovisual composition of 26:53" in length and 7.1 surround multichannel audio, featuring ten videos that create a narrative. It is the only video of the installation that has sound. The other 13 videos were conceived to be shown without sound on monitors distributed throughout the installation space. Nikolay Maslov assembled these videos according to the following themes: (1) Title and Presentation (2) India (3) Germany (4) Riverside (5) Russia (6) Brazil (7) Temples (India, Russia) (8) Crowds (9) Trees (10) Sky (11) Buildings (12) Water (13) Interiors.

In the third stage, we designed and created the exhibition in the Black Box of the Culver Center of the Arts. The installation consisted of a 7.1 multichannel surround sound system (seven speakers and a subwoofer) and a multichannel visual projection system comprising a large central projection screen extended along one wall, 12 video monitors distributed through the space of the Black Box, and one video monitor (title and presentation) placed outside the entrance.

The exhibition accounts for the preliminary results of the investigation on listening categories, which constitutes the theoretical framework of the research project. The first four listening categories – relationships,

work, entertainment, and protest – are the most represented in the field recordings. It was not my intention to carry out a systematic investigation, nor did the project provide for the logistical infrastructure to explore the vast potential of listening categories. I recorded dozens of hours of video and audio material from which only a very small fraction was shown. The installation in the Culver Center is an autonomous artistic work, independent from the theoretical premises and ideas that guided the research. It was not my purpose to demonstrate the listening categories, but rather, to suggest further areas of inquiry, research, and artistic creativity.

Conceptually, the installation develops an aesthetics of audiovisual immersivity in terms of both physical and virtual spaces. In the physical dimension, it places the observer inside a space populated by sounds and images projected by loudspeakers and video monitors, whose design can be varied depending on the characteristics of the space and the audio and video equipment available. We used a 7.1 surround sound system and 13 video monitors, though we could theoretically expand the installation to a much larger number of speakers and monitors and, consequently, create an audiovisual immersive space with a much more detailed definition both in terms of sound and image.

3D rotations, circular movements, and changes of perspective continuously reshape the 360º space of the installation. The constant flow of 3D images generates sometimes vertiginous movements. The sound surrounds the listener with a vibrational system that physically affects the body. The observer is absorbed by a kind of audiovisual vortex, which also contributes to the multiple relations between image and sound, oscillating between synchrony and non-synchrony. For example, in the main video of the installation, we see images of the exuberant tropical vegetation of Trianon Park in São Paulo while hearing noise of a heavy traffic, which is counterpoint to the impression of tranquility. Indeed, the sounds of the traffic are what one hears in the park, but the ambiguity between the perception of sound and image – which may even go unnoticed by a park visitor – is not evident to anyone watching the video. The observer probably does not

São Paulo – Trianon Park. View from the top of the tripod, microphone is on the ground.

Riverside, California, USA – Citrus collection, University of California, Riverside.

Moscow, Russia – March of the Immortal Regiment on 9th May 2019. I am on the middle front of the picture (bald head) holding the camera with an invisible stick.

Mannheim, Germany – Wasserturm (Water Tower), a city landmark.

Pune, India – Temple (Siddheshwar).

Pune, India – Pilgrimage (Pandharpur Wari).

realize they are dealing with a park within a dense urban environment, and may be led to think the image and sound don't belong to the same environment and therefore are not synchronized. In fact, in other moments of the main video, we listen to multiple simultaneous soundscapes, reinforcing the aesthetic of non-synchronization. For example, we see images of Moscow's cityscape while we hear a soundscape of birds recorded in India.

Uncertainty and ambivalence are attributes of the relation between sound and image in the audiovisual immersive installation. Confusion and doubt contribute to questioning the observation and expanding the space of experience through the entanglement between the perceptions of the real and the symbolic. The opening of the space for multiple and simultaneous instances of listening and seeing is precisely in accordance with the foundational concept of the installation to develop "sound imaginations." This idea can be approached from two perspectives: as sounds imagined by images or images induced by sounds.

***Conclusion***

Participating in the acoustic space is the basis of the conception of listening as shared activity. Listening is an intervention in the acoustic environment, a way of creating a sense of the self and preserving the relationship of ourselves to others, which is fundamental to constructing human subjectivity. Human beings are immersed in a vibrating world. Beyond the vibrations our ears can perceive, our bodies and minds vibrate sympathetically – both consciously and not-consciously – with other entities, matters and energies of the environment. The sonic present is an uninterrupted flux of vibrations, a resonant space with dilatations and reverberations in which the listening subject becomes itself a place of resonance. To listen is to endeavor to find possible meaning, while seeking reference in a vibrational world of omnipresent feedback loops of internal and external references, for which Nancy (2002) coined the term "re-soundings." Our understanding of music implies the possibility of entering this resonating spatiality and negotiating meaning by projecting ourselves to the others. This happens when we listen

to music performed live in a shared space, for instance a concert hall, but also when the sounds are presented to ourselves as products of recording technology or artificial objects. In the current post-human society populated by technical sounds, images and all kinds of electronic and telematic devices, sound presents itself as modulated by significant processes of reconstruction of the body and the relationship between presence and absence. Our sense of listening and seeing are increasingly shaped by intelligent systems that intensify the sensory perception and projects our imagination into the reality of an ongoing human-machine interface.

The idea of immersion emerges in recent developments in audiovisual experience as a cognitive modality based on the sensation of the observer in a physical or virtual space that intensifies the relationship with the object of listening and seeing. The audiovisual immersive work creates the illusion that the observer and the object of observation – the self and the other – are no longer separated in the shared space of live experience. The primary goal is to generate a presence, a cognitive paradigm that privileges presence rather than representation as in traditional art. In other words, simulation instead of mimeses. In the project *Sound Imaginations*, the construction of audiovisual immersion results from the research on cultures of listening and the interweaving of listening and seeing as perceptional categories and objects of observation. The audiovisual installation addresses some possibilities of these categories and creates an immersive environment to experience them. However, this project is far from an exhaustive treatise on the cognitive and artistic potential of the subject. A systematic approach and a larger infrastructure in terms of both human and technical resources would be required to delve deeper.

The foundational concept of a 360º 3D space determined a series of choices in the process of capturing sound and video material and furthering the compositional strategies adopted for designing and building the installation. However, the concept of audiovisual immersion is not restricted to the multiple relationships between sound and image, but extends to an intrinsic social and cultural dimension. The variety

of experiences captured during my travels through different continents and geographic locations are in line with the ethical and aesthetic paradigm that places diversity and heterogeneity of cultural values in the very core of my artistic work. In this sense, I believe that the fundamental purpose of the audiovisual immersive installation is to promote connectivity as an essential feature of human experience. As I stated in an interview, "I want to make a connection as humans, to be inspired by listening cultures. When you look at different aspects of life, sound and vision are very important components. With this project, I want to emphasize both the ambiguity and the plurality of life" (Baltazar, 2020).

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**Diverse Instrument Symphonic Ensembles as a Strategy for Sustainable Innovation**

*By Jason Palamara*

If the Anthropocene is characterized by human-driven ecological transformation, the traditional Western-instrument orchestra was founded as a musical analog, cutting trees into violin bodies, animal flesh into drumheads, and even digging up copper and nickel to fashion into flutes. While little research has been done to evaluate the total ecological impact of large musical ensembles (Prado-Guerra et al., 2020), it is logical that if traditional orchestral instruments (instruments used and continually valued over decades or even centuries) have any detrimental ecological impact, non-traditional, electronic instruments such as computers, speakers, mixers, and MIDI controllers – each with their requisite complement of cables and adaptors – must present an even more significant detriment to the environment. Moreover, suppose the central instrument of the computer music is to remain the computer. In that case, the field must address the problems inherent in using a technology intentionally manufactured to be momentary, expensive, wholly toxic to the environment, and, worst of all – short-lived due to purely capitalistic incentives which drive manufacturers into planned obsolescence (Aladeojebi, 2013).

The proposed model, a Diverse Instrument Symphonic Ensemble (DISEnsemble), is the musical inverse, not seeking to change the landscape but instead seeking increasingly environmentally neutral solutions to the task/problem of forward-looking musical innovation. The sustainable focus of a DISEnsemble exists throughout the "food chain," from repertoire to instruments to production; the technologies must be sustainably sourced (Trott, Even, and Frame, 2020).

This practice contradicts the general thrust of traditional technological musical pursuits, which generally require the best (not to mention expensive) cutting-edge technology powered primarily by lithium batteries and chips composed of similarly rare earth metals. Sustainably sourcing technological instruments and equipment solves many problems,

not the least of which is economic. As with academia writ large, many large ensemble leaders are undoubtedly finding that budgets are being stretched thin as enrollments are similarly declining (Fulk, 2023) at a rapid pace. By contrast, sustainably sourced technology is cheaper and may save the host institution money.

***Background***

Indiana University – Purdue University Indianapolis IUPUI's DISEnsemble was started in 2018 during more favorable economic conditions to meet the educational needs of a fast-growing department. While enrollment at IUPUI's Department of Music and Arts Technology has continued to grow steadily even throughout the past three years of upheaval, the evidence nationwide is that since the COVID-19 pandemic, enrollment at higher education institutions has been decreasing rapidly in the U.S. (Fischer, 2023).

With this prognosis in view, the outlook seems dire for large musical ensembles of all varieties, as they are traditionally the most complicated and expensive musical endeavors to support. Technology-focused ensembles may suffer even more tremendous strain, as they require more significant funding for expensive equipment and, often, lower enrollment than the traditional ensembles. The IUPUI DISEnsemble began with a mission of investigating hardware hacking and musical instrument development as a method for innovative music-making, so sustainability was built into the group from the beginning.

***Methodology***

Developing a methodology for the success of a group such as DISEnsemble is a radical and continual process, much more so for the uninitiated. This group has many of the traditional problems of a more conventional laptop orchestra but also some of the difficulties of a performing big-band jazz group (assuming it grows to the size of IUPUI's DISEnsemble). Some of the issues encountered by large orchestras, and yet more problems one might only encounter while trying to perform at televised awards shows like the Grammys. IUPUI's DISEnsemble has succeeded for the past five years by utilizing the following principles:

1. Engage in radical acceptance of any diverse instrument the student plays, assuming it is logistically possible and their skills are acceptable. Never place the needs of a chosen repertoire above or below the technological forces available at hand.

2. Approach all aspects of this group less as a music-performing ensemble and more as a musical production company, which employs performing musicians, sound engineers (mixing live and for documentation), visual media designers, lighting designers, instrument designers, and personnel who document the ensemble's activities for later dissemination. A DISEnsemble is less of a band or an orchestra and more of an ecosystem.

3. Wherever possible, acquire materials needed to pursue ensemble activities from sustainable sources. Donations, second-hand stores, and institutional surplus are all excellent sources that will contain practical options for music-making. For reference on music-making options from dilapidated or seemingly obsolete technology, see Nicholas Collins' book Handmade Electronic Music (Collins, 2009).

4. Since circuit-bending, hardware-hacking, and instrument design takes a very long time to produce successful results, encourage the long-term development of reproducible novel instruments, which will stay with the group as students move on and graduate. Students interested in this type of work may be shunted into a separate course (such as IUPUI's DISEnsemble Content Creator section) to avoid bogging down the performing ensemble's rehearsals with time-consuming (often failed) experiments. Use this separate course as a research and development lab for the main ensemble's activities.

5. Identify and promote promising ensemble members who exhibit natural leadership tendencies. A group in this manner is too complex to be run by one individual, which is why traditional orchestras and wind ensembles often developed to have section leaders. Leadership roles can take many forms in a group with this much instrumental diversity, but leaders must be clearly identified and promoted early. Leadership tasks and responsibilities must be delineated and standardized at any level possible.

6. The group must spend a significant amount of rehearsal and performance time improvising, which aids in the development of novel instrumental performance practice.

IUPUI's DISEnsemble (which has a continual open-door policy regarding technological donations) has often been gifted a device erroneously believed to be unusable when a simple workaround or hack was only a Google search away. Similarly, much of what ends up at a university surplus department is perfectly useable for various musical situations. Older PCs or outdated desktop computers can be wiped, cleaned, optimized, and used as musical instruments. Past examples of instruments and equipment successfully redeemed by the IUPUI DISEnsemble include The Apocalypse Piano (a novel method for piano preparation, electrification, and amplification using old speakers and almost-dead batteries), the Squish controller (a MIDI controller played with palms and fists), and a new kind of instrument cable called a DIS-cable (which facilitates easy amplification of nearly any RF-emitting device).

Once the DISEnsemble takes ownership of a new item, an exploration of its musical usefulness usually follows. Sometimes this process takes considerable time, leading to several devices sitting in a faculty office until the right opportunity presents itself. This approach reduces waste and carbon emissions associated with new instrument manufacturing and promotes the reuse of materials, extending their lifespan and minimizing their environmental impact (Brennan, 2020).

***The DISEnsemble / University Surplus Bartering Pilot Project***

Those involved in this musical pursuit must continually seek exciting devices or supplies. It is possible to take this practice of material scavenging too far. Some devices, products, or surplus items are too far gone to be musically redeemed. For this reason, the IUPUI DISEnsemble has recently devised a pilot program as a bartering partnership with IUPUI's University Surplus and the Office of Sustainability, hopefully serving as a pivotal new component of DISEnsemble's regular practice. Under the new initiative, DISEnsemble will no longer seek out musical

and audio equipment for its own needs but for the needs of the IUPUI community. Accordingly, DISEnsemble personnel will work with University Surplus staff to identify musical and audio equipment which is still useable, and these items will be placed in a lending library managed by the University Library Staff and loanable to any student or faculty member. In this way, the university will support the needs of its diverse students (many of whom are under-resourced) and cut down on the technological waste the university system produces. This initiative will also establish a sustainable exchange system within the university community, allowing members of the Music and Arts Technology Faculty to trade their unused equipment for new, usable equipment from the University Surplus. If this method of inter-departmental bartering proves helpful, it should be rolled out by the IUPUI Office of Sustainability soon. This initiative will not only make musical instruments more accessible to artists but will also reduce waste by repurposing idle equipment from university inventories (Cooper & Gutowski, 2017).

***Future Prospects***

Looking ahead, DISEnsemble aims to expand its reach and impact. The bartering project outlined above will hopefully cut down on university waste to such a significant degree that it will warrant scaling up the project's scope to the university community. By continuing to champion sustainability and creativity innovation in computer music, DISEnsemble seeks to inspire similar initiatives worldwide, fostering a global movement towards environmental awareness and action. Dissemination of these ideas could be a good thing for the environment and a way for computer musicians to continue innovating sustainably.

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**Authors of this issue**

Ximena Alarcón-Díaz is a sound artist-researcher, creating telematic sonic performances and embodied interfaces for relational listening, to listen collectively to our sonic migrations. She works independently in her project INTIMAL and teaches at the Center for Deep Listening, at Rensselaer Polytechnic Institute.

Paulo C. Chagas is composer and researcher on music semiotics and philosophy, electroacoustic music, multimedia, and music technology. He is professor of composition at the University of California, Riverside. He created more than 200 works for orchestra, chamber music, electroacoustic, audiovisual and multimedia.

Performer, composer and media artist Scott Deal engages new works of computer interactivity, networked systems, electronics and percussion. He is a Professor and the Director of the Donald Tavel Arts and Technology Research Center at Indiana University Indianapolis.

Garrison Gerard is an American Composer and a Fulbright Fellow at the Hornafjörður Research Centre of the University of Iceland. His work focuses on ecoacoustics and the intersection of ecology and music.

Chieh Huang, an innovative percussionist and composer, is currently completing her Ph.D. in Integrated Composition, Improvisation, and Technology (ICIT) at the University of California, Irvine. Her work involves experimenting with sounds by incorporating keyboard percussion instruments and utilizing the Atayal language as one of the parameters in music composition.

Andy Jarema is a music educator and composer from metro-Detroit, Michigan. A two-time Artist-in-Resident with the National Park Service, he continues to compose music using electronically processed natural sound. He currently operates a virtual private lessons studio with students from around the world.

Jason Palamara is a technologist, composer, and educator studying the intersection of AI, music and sustainability. Palamara is an Assistant Professor of Music Technology at Indiana University, Indianapolis (IUI).

Alexander Rehding is Fanny Peabody Professor at Harvard, where he founded the Harvard Sound Lab. He is currently working on a book on music and climate change.

British composer and media artist Amanda Stuart uses narratives of form and shape, juxtaposing contrasting translucent colors with dense sonic textures, woven together in an audiovisual tapestry. Her commissions include compositions for the London Festival Orchestra and The City of Peterborough Symphony Orchestra.

Gabriel Zalles Ballivian is a musician and educator working in electroacoustic composition, with a special interest in ambisonics. Zalles Ballivian is a graduate from the computer music program at UC San Diego from La Paz, Bolivia.



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