

SOUNDING NUMBERS: THE SONIFICATION OBJECT AS AN INTERFACE IN "I AM THE OCEAN"

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ABSTRACT

Designing sonification for music composition involves aesthetic and narrative manipulation through strategies based on compositional intent, sparking discussions of data clarity and understanding. This paper describes an autobiographical process of crafting an aesthetic sonification from climate change data, and its further musification. In this approach, the sonification is used as a material for composition and transformed into an interactive musical instrument, within contemporary aesthetics and live performance contexts. The sonification object becomes an interface for composition and performance. The resulting piece seeks to amplify engagement through affectivization while displaying data information via symbolic abstraction and musical narrative. The paper also describes the techniques and results of blending sonification sounds with mixed notation derived from the sonification object. The composed piece was recorded and played by an electronic-acoustic contemporary ensemble to an audience which later gave feedback. The conclusion drawn from this musification project was that even though the source data was not directly perceivable in detail by the audience, the piece does convey information via the power of emotional affectation, which aligns with the original intention of the project.

1. INTRODUCTION

The use of sonification as materiality for artistic production has gained popularity in recent years, driven by advancements in technology, increased data accessibility, and improved data literacy among artists who may not have a specialized background in data analysis [1]. This trend reflects a growing interest in exploring new ways to engage with data and transform it into creative and expressive forms through aesthetic ideation and data manipulation for phenomenological purposes [2].

The artistic application of sonification introduces certain challenges, as aesthetic treatments can obscure the translation process from data into sound [3]. This translation has been a central concern in the technical development of sonification, with Lindborg, Lenzy, and Chen [3] reviewing 32 projects that demonstrate significant progress in the field, and historically contextualizing that the development of sonification has focused on scientific utility,

bringing the field closer to information engineering, and noting a reaction to this development advocating for the integration of an aesthetic focus. Supper [4] compellingly supports this view, arguing that aesthetic considerations in sonification design can enrich the listening experience and promote a deeper understanding of the data. Similarly, Lenzi and Ciuccarelli [2] underscore the role of intentionality in sonification design, proposing that the process of transforming specific datasets into sounds is influenced by the designer's goals and context. This leads to an intriguing question: how can artists navigate the balance between intentionality and artistic techniques for aesthetic development in sonification design?

In this paper, I describe an autobiographical process for the creation of my composition "I AM THE OCEAN." While the paper is co-authored, the use of the first-person singular pronoun "I" is employed to reflect the personal nature of the creative process described. This artwork falls under the category of data activism [1], explained below. It seeks to engage the public in the scientific narrative of our ongoing climate crisis through the creation of aesthetic sonification and its further musification. I discuss my creation process from data to art, addressing the understanding of the data, sound design for sonification, re-understanding the sonification through a musical perception, using sonification as materiality for composition, and later sample the sonification to use it as a musical instrument.

Within the creation process, I navigate techniques to blend acoustic instruments with sonification electronic sounds which became a key element in achieving compositional balance through orchestration. The goal of "I AM THE OCEAN" is not just to present data, but to transform it into a narrative that resonates on an emotional level, encouraging a deeper connection with the global pressing issue of climate change, aiming to inspire action in the fight for climate solutions.

2. CONCEPTUAL FRAMEWORK AND BACKGROUND

There is an ambitious, exciting, and growing tendency within data perceptualization which combines data art with social action [5], merging the forms of data activism and activism. While *data activism*, according to Milan [6], is the strategic use of data and software design to challenge and reconfigure power dynamics and the socio-political narratives of big data, *artivism*, according to Aladro-Vico et al. [7], is a combination of art and activism, employing art's power to address social change and challenge conventional narratives of communication. Both forms of activism seek social awareness and change by disseminating new narra-



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tives based on informative processes and pursuing a change within power structures.

As contextualized by Aladro-Vico et al [7], activism has a long history that can be traced back to early avant-garde movements such as Dada, Futurism, and Surrealism in the 20th century, associated with the emergence of political and disruptive art. In their work, artists sought to transform the artistic object by proposing a critical approach to their forms of production charged with political meaning [7]. This tradition was particularly visible in movements such as agitprop in the 1920s, which used art to spread the Bolshevik political message [8]. Activism today addresses contemporary issues such as climate change [5] through a variety of media and performance forms [7]. Artist work is also discussed at conferences like *Data Art for Climate Action* [3] and exhibited in venues such as the recently celebrated *Biennale di Venezia*, which reflected on the themes of decolonization and decarbonization [9]. In addition, projects like the OneOcean Hubs' *Deep Emotional Engagement Program* (DEEP) support these artworks by funding community-based art projects to bring marginalized perspectives to the forefront of the ocean governance debate [10].

As sonification expands its traditional role of analysis and exploration, it morphs into an ontological affection of data through aestheticization [4]. Consequently, artistic intentionality gains traction toward communication for social action entering the field of activism. To paraphrase Stammen and Meissner [13], by infusing data with aesthetic qualities and artistic strategies, sonification can evoke emotional responses and create a deeper connection with the audience, potentially leading to increased awareness and action on important social issues, such as climate change, enhancing cognition, engagement, and dissemination.

In this line of artistic intent, Andrea Polli's work *Sonic Antarctica* [11] combines field recordings and sonification with fragments of radio-style interviews. Polli's intention with this piece is to create new and broader ways of scientific dissemination and collaboration between art and science. Jacob Kirkegaard's *IS-FALD* [12] is also based on field recordings and audification techniques, but takes a different approach than Polli's *Sonic Antarctica*. Kirkegaard's artistic intention for this piece is to immerse the listener in the phenomena of receding glaciers and to create a space for reflection on nature's constant flow and power, rather than to comment directly on climate change.

I situate my composition *I am the Ocean* in the context of sonification and activism, where the use of data with artistic intent fosters collaborations between art and science. Supper [4] sums up in her paper the intentions of such collaborations under the logic of accountability, innovation, and ontology, concluding that sonification projects fall under this logic, with a prominent role of accountability and ontology. Lindborg, Lenzi, and Chen's [3] analysis of selected pieces dedicated to climate action exemplifies this approach, concluding that "design informed by research in auditory perception and aesthetics plays a central role in creating multisensory experiences that make scientific climate data both meaningful and exciting", and making the case to explore further "intention strategies, meaning, and aesthetics" within multimodal communication techniques.

It is possible to draw a close link between these artistic and communicative capacities of auditory displays and intentionality [2]. In their creative process, artists choose tools to shape data into an aesthetic experience, encoding *intentionality* within the artwork and further shaping its *indexicality*, as conceptualized by Vickers and Hogg [14] with their Aesthetic Perspective Space (APS) con-

cept. The APS is a framework for categorizing auditory displays based on the information being presented and the level of abstraction and comprises two axes: *intentionality* (ranging from utilitarian to artistic) and *indexicality* (spanning from concrete to abstract sonic materials).

The information and abstraction levels in the work are connected to how the composition is designed for a perception of familiarity in the overall soundscape that is progressively transformed, creating a sense of unease in the listener. Lindborg, Chopra, and Groß-Vogt [5] describe this method as 'ontological instability', and highlight its potential to lead the audience to new insights and engagement referring to the problem the artist is addressing. Lindborg et al. [5] argue that an "artwork is successful if it can simultaneously achieve both information transfer and affectivization".

In the work, I am interested in the transfer of the global meaning of the data through the notion of affect, conceptualized by Buening et al. [15] as "*affectivization*", meaning transforming data into emotionally resonant experiences, allowing the artwork to communicate within defined intentionality and potentially facilitate processes of intersubjectivity or perspective-sharing among the audience. "I am the Ocean" relates to how Buening et al. [15] characterize the role of the artwork; it dances in a fragile balance of factual and counterfactual elements, while simultaneously facing the challenge of stimulating imagination and communicating information contained in the data. Lindborg et al. [5] and Buening et al. [15] agree on the critical nature of this balance—Lindborg emphasizes its role in defining the success of the sonification, and Buening encourages artistic responsibility while rendering an aesthetic representation of data, which should offer diverse perspectives for the audience to explore.

There is a wide variety of artworks in the field of visual and sound pieces working with social awareness and action through the affectivization of data, and an exhaustive analysis of these artworks from various academic and artistic researchers. Suarez-Val et al. [1] analyze artworks at the intersection of data activism and femicide, showcasing how data is used "to transform horror into beauty and data into visual resistance". As an example, they analyze *No Estamos Todas*, a social media account where they post illustrations to remember the beauty in the victims' lives, creating a project opposed to mainstream media whose main focus is on the violence of the femicide cases [1].

Zelada and Çamcı [16] present their sound installation *Unnatural Nature*. The piece seeks to create an emotional connection to data and enhance awareness of climate change by creating an immersive sonification of climate change data. They implement third-order ambisonics for immersive auditory experiences and display data trends by creating natural sounds through modeling different signals and altering their "naturalness" to express climate change phenomena. Within the same contextual framework, *I am the Ocean* aligns closely with *Unnatural Nature*.

As the use of sonification as artistic material becomes more popular, the artistic intentions and methods expand. In this evolving landscape, *I am the Ocean* offers new insights into the integration of sonification objects as an interface for contemporary composition and its transformation into an instrument for performance. From sound design for sonification to musical expression, the sonification object is created to serve as the main material for composition and repurposed as an instrument for performance, becoming an interface to shaping the sounding output through different means of expression and expressivity.

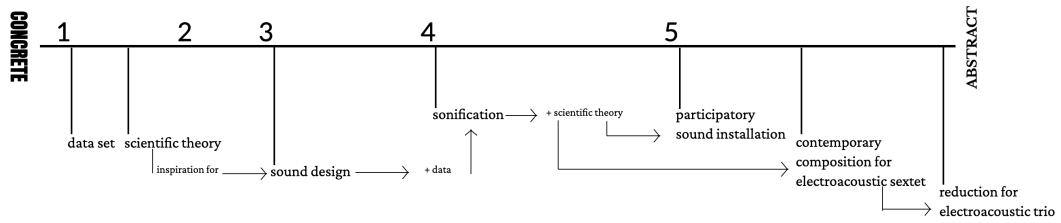


Figure 1: Mapping the process from data to composition.

3. I AM THE OCEAN

"I am the Ocean" is the final composition in my artistic research project *Sounding Numbers*, conducted between 2020 and 2022, where I explored the creation of aesthetic sonification as materialities in contemporary compositions and participatory sound installations. This composition can be framed under the aforementioned concepts of *data activism* and contributes to the development of *affectivization* in data perceptualization, working within contemporary music aesthetics, and compositional techniques, thus framing the sonification object as an interface.

My creation approach involved engaging with the data from a sonification designer towards a composer’s perspective (see Fig. 1). The process started by selecting, cleaning, preparing, and understanding the data, to later design the sound for sonification and output the data-to-sound representation. After carefully listening to the sonification, I encoded it under musical parameters, which served as material for my composition, and then transformed the sonification into a musical instrument for live performance.

"I am the Ocean" was composed for an ensemble of human performers playing string and woodwind conventional instruments, an electronic instrument derived from the sonification, and a human voice. The piece is a three-movement full-scored composition mixing detailed music notation and graphic score techniques.

The intention with the piece was to immerse the audience in an emotional experience by making them feel enchanted by the aesthetic qualities of the music while everything becomes strange. This strangeness aims to open possibilities in the audience’s perception for understanding new perspectives about climate change and create a potential for awareness and engagement, referring to the idea developed by Lindborg et al. [5] through the concept of "ontological instability".

An APS analysis of "I am the Ocean" positions the piece’s intentionality close to *ARS Musica*, and its indexicality leans towards abstraction. In the case of this piece, it is impossible to access details of the data from the musification output. However, the piece successfully creates a symbolic and aesthetic experience for the audience, with high levels of affectivization and potential for audience engagement.

3.1. Data Source

Data sets from the U.S. Environmental Protection Agency (EPA) [17] were the primary sources for the project. The data are part of the Climate Change Indicators that the EPA collects from various partners in order to provide access to these indicators and keep them up to date. The indicators I selected for this project fall under the category of oceans and greenhouse gases, and from these cat-

Year	ocean heat mean	ocean level mean	ocean temp mean	Carbon dioxide
0 1979	0.035300	0.000000	0.155172	0.000000
1 1980	0.099454	0.057375	0.172414	0.029552
2 1981	0.109863	0.175950	0.103448	0.047664
3 1982	0.042818	0.120488	0.103448	0.059104
4 1983	0.000000	0.200813	0.241379	0.083889

Figure 2: Head of merged and normalized data sets of selected features for sonification.

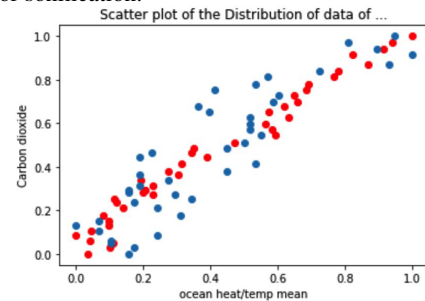


Figure 3: Example of visual exploration. Plotting "ocean heat" (red) and "ocean temperature" (blue) against "carbon dioxide" data features.

egories, I retrieved historical data sets for ocean heat, sea surface temperature, sea level, and climate forcing. The datasets downloaded from the EPA contained different time frames, all based on annual means and with a common window between 1979 and 2020. This period was selected for sonification excluding all data points before 1979 and after 2020. Based on this window, all data sets were concatenated into one data frame with several climatological and chemical features for analysis, such as ocean heat, ocean level, sea surface temperature, and various greenhouse gases including carbon dioxide, methane, nitrous oxide, CFC-11, and CFC-12 (see Fig. 2).

I conducted a visual exploration of the data to identify meaningful trends and filtered the most interesting features for my sonification (see Fig. 3). The final data set for sonification with normalized values consisted of the features of ocean heat, ocean level, sea surface temperature, and carbon dioxide, ranging from 1979 to 2020.

3.2. Synth Definitions and Data Mapping

The sonification design was based on the parameter-mapping technique, which involves mapping directly features in a data set to attributes in sound, such as pitch, to convey information [18]. I

created the sonification’s soundscape with four independent layers programmed in SuperCollider—a dedicated audio programming environment for sound synthesis and algorithmic composition. I coded a total of three layered synth definitions, and one of them was duplicated and slightly modified to improve the density and movement of the soundscape. Each layer, rather than mimicking ocean sounds, builds on an imaginative and poetic representation of oceanic currents’ qualities and the dynamic process of carbon dioxide being absorbed by the ocean. The synth definitions for each layer are called "undercurrent", "mid-current (I and II)", and "drops".

The mapping design for the four features of my dataset followed two strategies. For the *first strategy*, three data features were mapped to three synths, affecting their frequency and granular synthesis parameters, one data feature per synth, and for the *second strategy*, the remaining data feature was mapped across all synths, affecting textural-spatial sound parameters (see Fig. 4).

3.2.1. First Strategy

In this strategy, the data features **ocean heat**, **ocean temperature**, and **carbon dioxide** mapped to the synth definitions **undercurrent**, **midcurrent (I and II)**, and **drops** respectively.

The **undercurrent** symbolizes the deep currents of the ocean driving the conveyor belt, which is responsible for heat transfer between cold and warm regions, affecting globally the heating system of the planet [19]. The synth’s frequency parameter is mapped with **ocean heat** data, allowing us to perceive this overall increasing trend as shifts in pitch, taking advantage of our aural ability to discern pitch changes easily, making complex data more intuitive to understand [20]. The synth is constructed using a Feedback FM oscillator and resonant low pass filter to create a deep, resonant sound that evokes the ocean’s vast, energetic moving currents.

The **midcurrent (I and II)** represents the ocean’s role in shaping Earth’s weather. The sounds produced are both flowing and detailed, echoing the dynamic relationship between the ocean and its significant influence on weather patterns [21]. The synth is duplicated into two versions based on sine wave oscillators and mapped to **ocean temperature** data with a continuous but differentiated frequency range. In midcurrent I, I employ phase modulation to give a sense of textural fluidity and midcurrent II uses feedback mechanisms to create a deep, resonant sonic image. These mixed qualities are designed to sonically bridge both midcurrents with the undercurrent. To ensure an overall clear and rich structure, midcurrent I apply a resonant high pass filter creating a crisp contour. In midcurrent II, I use a high pass filter to clear the lower end and simultaneously match with midcurrent I and undercurrent.

Drops is mapped to **carbon dioxide** data, which modifies granular sound textures. The synth’s density and frequency are modulated by the CO2 concentration levels. The synth drops sounds like droplets falling and being absorbed by the sounding ocean created by the undercurrent and both midcurrents, creating an auditory metaphor for the ocean’s role in absorbing atmospheric carbon.

3.2.2. Second Strategy

In this strategy, the data feature **ocean level** is mapped across all synth definitions.

Following the proposed method, to map one feature across all synths to create unity in the sound structure and fluidity through

		SYNTHS				
		Undercurrent	Mid-current I	Mid-current II	Drops	
SOUND PARAMETERS	Frequency	Ocean Heat	Ocean Temperature	Ocean Temperature	CO2	
	Granular density	X	X	X	CO2	
	Reverb mix	Ocean Level	Ocean Level	Ocean Level	X	
	Reverb room	Ocean Level	Ocean Level	Ocean Level	X	
	Resonant low pass filter RQ	Ocean Level	X	X	X	
	Resonant high pass filter RQ	X	Ocean Level	X	X	
	High pass filter resonant modulation	X	X	Ocean Level	X	
	Delay time	X	X	X	Ocean Level	
	Delay decay time	X	X	X	Ocean Level	
	Panning position	X	X	X	Ocean Level	
	Amplitude	Ocean Level	Ocean Level	Ocean Level	Ocean Level	

Figure 4: Table showing how data features are mapped to sound parameters for each specific synth.

data mapping, I chose **ocean level** data to modulate textural-spatial sound parameters. The data modulates parameters such as **reverb mix, amplitude, reverb room, resonant low or high pass filter rq, high pass filter resonant modulation, delay time, delay decay time, and panning position** to create a dynamic interaction between all synth in the sonification. By implementing this strategy, the sonification creates a dynamic sonorous relation that reflects on the interplay between ocean level variations and the other data features heat, temperature, and carbon dioxide.

3.3. Music Composition

To create the piece “I am the Ocean”, I analyzed the previously described aesthetic sonification under musical parameters. This was an explorative process that allowed me to imagine methods of translating the sonification’s auditory information into a musical narrative, extracting from the sonification musical form, densities, and sound gestures, along with rhythmic and melodic potential motives, and other musical elements.

This approach aligns with the concept of musification within a compositional framework, as detailed by Filella [22] in her thesis "Data Sonification in Creative Practice." Filella showcases through multiple artworks how data sonification can be organized into musical structures to convey emotional intentions exploring this concept in various performance modalities. Similarly, Morawitz [23] discusses his work "On the Extinction of a Species," how he employs spoken narratives, field recordings, cultural sounds, and both abstract and sonification-derived sounds, to create a multilayered narrative based on acousmatic techniques. Building on these perspectives, the application of sonification for compositional purposes requires an analysis of the sonic qualities of the sonification to be used as a musical material.

Expanding upon this approach, I analyzed my aesthetic sonification to be used as material for composition, further exploring the narrative inside the sonification in connection to my artistic intention. Some of the most representative translations that can be easily identifiable in my composition are:

- In the first movement of the piece, the strings dynamically transition between bowing with pressure in the lower registers and light bowing on high harmonic positions. This interaction between the cello and double bass mirrors the undercurrent and midcurrent sounds, simulating the ocean currents and creating a wave-like pattern. The pitch development throughout this section reflects the ascending trends in the data, culminating the section with an accelerated modulation on the low frequencies which reflects the data’s exponential growth.

- Throughout the composition, saxophones, and voice fluctuate between melodic and textural material, with variations of resonant harmonic clusters and subtle microtonal divergences. These variations echo the fluid dynamics captured by the mid-current synths, symbolizing the complex relation between the ocean and weather patterns and the unsettling realities of climate change.
- From the second movement until the end of the composition, areas of rhythmic articulations intensify, gaining presence and density, inspired by the evolving granularity corresponding to variations in CO₂ levels as sonified with the 'Drops' synth.

3.4. Contemporary Aesthetics

The contemporary aesthetic that informs my work resonates with the innovative sounds and compositional techniques by artists such as Pierluigi Billone, Klaus Lang, Jexper Holmen, and Francisco Lopez. These artists' approaches influenced my research process and artistic creation, particularly in sound design, detailed notation, and the exploration of textural and melodic structures.

Pierluigi Billone's exploration of the relationship between sound practice, sound thought, and our technologically transformed reality deeply influenced my integration of sound design and sonification as an instrument for performance. Billone's composition "Face" [24] exemplifies his ability to juxtapose contrasting atmospheres, where non-pitched, loud, short, and sharp sounds coexist with sustained, muffled, and atmospheric textures. This concept of opposing yet coexisting materialities has influenced my composition, allowing for the emergence of melodic movements from complex textural backgrounds, more in detail in section 3.2.3.

Klaus Lang's manipulation of time as musical material, explored by Wilson [25] through the concept of fragility, has led me to examine resonant spaces within my orchestration under a magnifying glass, searching for the limits and belongings of instrumental possibilities within my ensemble. Lang's idea of time as music material being perceived through sound [25] has encouraged me to construct my piece the concept of attentive listening (explored on section 3.2.2 and 3.2.4) and use it as a technique for the development of the narrative while in performance.

Jexper Holmen's method of developing extremely detailed passages that highlight micro-nuances in sound has been instrumental in my approach to composition, as listened on his composition "Intend" [26]. I use this technique in my scores, where structural repetitions are written with probabilistic variations by changing small details in playing instructions of sound structure, allowing for the amplification of subtle sonic details.

Moreover, inspired by Solomos' analysis of Francisco López artwork [27], my sound design creates a symbolic representation of the ocean, as explained in section 3.2.1, based on the conceptual "wilderness and chaotic nature" he finds by comparing López filed recording pieces with Xenakis artworks.

3.5. Orchestration

The music was written for a six-piece ensemble made up of voice, electronics, cello, double bass, and alto and tenor saxophone. The composition takes advantage of the acoustic instruments' capacity for extended techniques for integrating the sonification's electronic timbres into a flexible and cohesive sound environment. This not only deepens the performers' connection with the data but also

aims to potentially extend this embodied sound-data relation to the audience.

The background of the musicians was a mix of classical and experimental contemporary players, all of them capable of reading music, knowledgeable in extended techniques, and experienced improvisers which especially involves listening and readiness for change and reaction. These allowed me to compose using their attentive listening skill to create a self-conducting piece and craft an environment of musical awareness. Through the creation of this environment, the performance immersed the audience in a space that facilitated an emotional connection to the music, which significantly enhanced the possibility for engagement with the intention of the project.

3.6. Blending

It was important for the composition that the sounding environment was inviting and attractive for the audience to maximize attention. One of the biggest challenges this presented was to make the sonification's electronic sounds resonate with the acoustic instruments. Failing to do so would risk dispersing the audience's attention, as they might struggle to make sense of the sounds rather than focusing and immersing themselves in the intended message of the music.

To overcome this difficulty, I explored similarities between the sonification's electronic textures and textures of extended techniques within the orchestration of my composition. To this end, I focused on finding spaces of resonance between instruments based on musical materiality and instrumental technical possibilities. This method enhanced a dynamic flow between melodic and textural elements through the idea of an "orchestral transversion", where musical elements emerge and disappear into rich clouds of slow-mutating textural sounds while shifting instrumentation, in a similar technique as described by Chernovianenko [28] through the term "sonoristics."

3.7. Scoring for Performance

To navigate the complexities of integrating sonification into music composition while ensuring the meaning of the data is conveyed as intended, I employed a mixed notation approach. This methodology combines detailed formal notation with graphic scores (see Fig. 5 and Fig. 6), allowing for an extremely controlled manipulation of musical materials alongside graphic abstraction, which stimulates creative input from the performer within specific and designed musical constraints. The blend of notations sought to use the performer as an instrument of affectivization through the struggle this balance creates in a musical context.

This technique was applied with a cautiously designed vertical balance in mind, encouraging structured yet dynamic interactions within the orchestration. This balance was crucial for ensuring a cohesive narrative throughout different sections of the composition. It allowed for both, to keep the performer playing the composition and not to improvise based on their habits, and to help the performer release the tension built because of the extreme focus the detailed composed passages required. Furthermore, graphic scoring played a fundamental role in captivating performers and the audience in the music. Brøndum [29] discusses how graphic notation allows the performer a deeper involvement with the musical material and to contribute creatively to the music, creating a sense of ownership that increases engagement that can be extended to the audience.

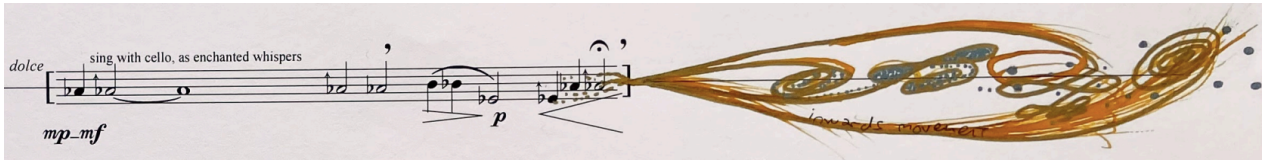


Figure 5: Example of mixed techniques notation.

Figure 6: Example of detailed notation.

During the performance of "I am the Ocean," the ensemble's dynamic interplay transformed the sonification into an emotional expression enhancing the affectivization of data perceptualization. The music, composed to emulate self-conducting dynamics in chamber music, crafted a deep, attentive listening among performers, which helped in navigating the piece's complex narrative and delivering the artistic intent through emotional expression to the audience. A crucial element was that the performers had access to the complete score while performing, enabling them to be fully aware of each other's parts. This allowed the musicians to either move the music forward or stay longer in specific areas encouraging further musical development.

This approach created a collective perception of the sound, allowing for a fluid and adaptive performance. The interplay between detailed and graphic notation created a performance that was technically challenging and also explorative. Through this method, the performance served as the embodiment of the project's intent—blending data, sound, and emotion into a narrative that drove the audience toward awareness and engagement with the pressing issues of climate change by focusing on ocean data.

3.8. Sonification Object as an Instrument

Another crucial strategy for maintaining musical fluidity and creating unity in the ensemble's sound was turning the sonification into a performative instrument. This was achieved by sampling the sonification's synth definitions and then performing live with these samples. This capacity to operate the samples in real-time during performance gave the piece a dynamic and fluid quality, allowing a live conversation between the digital and the acoustic.

This instrumental implementation of my aesthetic sonification was inspired by the concept of interactive sonification, where the use of sound in an embodied human-machine interactive system provides information about the data being processed or the interaction itself [30]. In their 2019 study, Wolf and Fiebrink [31] explored the application of interactive sonification using digital music instruments in live music performances. Their research focused on how audience members can control, in real-time, the mapping configurations between performers' gestures and the resulting sound synthesis, creating a sonification instrument for the

audience which increases the audience's engagement and understanding of the performance's musical structure through dynamic interaction. In the case of "I am the Ocean", the performer is the only one with control of the sonification as an instrument, who uses it for a nuanced and controlled musical expression rather than data exploration, getting the instrument closer to professional musical practice.

To harness the sonorous interactiveness of this instrument, the composition was structured into sections based on organized arrays of samples. Each section had a series of instructions with possibilities for changing the sounds, aiming to establish a controlled development of the composed material for the performer. The samples were quickly loaded and made available to play by the performer before and during the performance. To manipulate the sounds, the performer chooses between pitch shifts based on designed gestures, distortion, and filtering. The performer could also change envelopes of triggered samples and overlay sounds controlling densities, creating tension, or resolving as instructed. As a recursive technique, drones were dispatched with varying filters and effects over time to create tensioning and resolving intervals in the vertical structure of the orchestration over sub-sections of the composition.

This implementation enabled the use of the sonification object as an instrument, enhancing the symbolic meaning of the music and amplifying its emotional impact, ensuring the musification was coherent with the original sound design. Moreover, having this instrument as part of my orchestration influenced the composition's structure, as the possible musical development was anchored to the potential for the sound development of the instrument. Through this integration, sonification became an active part of the musical narrative, shaping the composition and being shaped by the ensemble's collective expression.

4. PERCEPTIONS OF THE MUSIC

The composition was recorded in February 2022 by the ensemble described in section 3.2.1. The following April, I conducted a feedback session among musicians studying for the Advanced Postgraduate Diploma at the Rhythmic Music Conservatory (RMC) in Denmark. The goal of conducting this session at the RMC was to have an expert audience working with sound aesthetics and composition to evaluate if my artistic intention with this project was archived through my compositional outcome. There were a total of ten participants. All of them are professional musicians and artistic researchers with previous knowledge of my projects. However, none of them had heard the music before.

After a brief presentation of my project, I explained that the feedback session was going to have two sections; first, the participants were going to listen to the music and engage in a free writing exercise, writing down any thought that came to their mind while listening to the music, and second, I was going to openly discuss

with the participants what they experienced while listening to it, trying to decode the compositional methods linked to the data and my artistic intention.

Out of ten participants, eight were able to understand the symbolic meaning of the music with a certain level of data abstraction and the relation to my project's intention, one was not able to understand the composition linked to the data or the concept of aesthetic sonification into musification, and one did not engage in the session. Some excerpts of the free-writing text were:

Participant 1: *“Your creation speaks to a very calm place in my soul. The sonic structures are moving in many directions yet together. What you try to communicate was clear to me; we are in this together, alone and together.”*

Participant 2: *“A nostalgic, contemplative, and overwhelming space. The immensity of a crisis, tension, and need for action.”*

Participant 3: *“Lament like music, temple and spiritual (so beautiful).”*

Participant 4: *“Ocean-like, powerful, forceful, and quasi-aggressive force. It is very active. It feels like the smallest sounds have been amplified. It feels very close and extremely present. A powerful experience.”*

Participant 5: *“Music that is alive! Waves. Spirits. Love. Silence. Tears and sorrows and the loss of someone. Fragility. Presence and intensity.”*

The overall feedback was positive as the audience understood the compositional outcome, my intention with the piece, and the encoded meaning of the data. The imagery collected from their free-writing texts shows a strong affectivization of the data, which aligns with my artistic intention. During the session, I engaged with the participants in vivid discussions about the political implications of music in global pressing issues and the context of activism.

5. CONCLUSIONS

In this paper, I described my process of using the sonification object as an interface for musical composition and performance, applying contemporary aesthetics and techniques for the creation of my composition “I am the Ocean”. The paper adds to the literature on using sonification beyond its role in data analysis, exploring its value in artistic expression and narrative within a musical context. It investigates the potential of musification for audience engagement in our current climate crises through the affectivization of data. It also reflects on the importance of keeping the artistic intention in focus via diverse compositional tools while being mindful of the balance between data affectivization and its effectiveness in information transfer, in alignment with the previously mentioned artistic intention.

In “I am the Ocean,” I nurtured a symbolic abstraction of climate change data focusing on its aesthetic treatment, aiming to create a composition that engages the audience in climate change discussions. A key method in this project was the aestheticization of sonification, which facilitated the translation of the sonification under musical parameters for analysis, and its transformation into a musical instrument for performance. The integration of mixed notation techniques proved instrumental in communicating the composition's narrative and maintaining the ensemble's

focus enhancing the audience engagement. This approach, blending detailed musical notation with graphic scores, allowed me to compose a piece that was precise, technically challenging, and exploratory at the same time, which built on a symbiotic engagement between the performers and the audience.

The paper also described a method for building a cohesive sound in the ensemble, where one of the central aspects was to investigate resonant structures within the orchestration to blend acoustic and electronic sounds. I also took advantage of fluctuating between textural spaces and melodic passages, creating space for orchestral transversion. Additionally, I described how to use the sonification object as an instrument for live professional performance and how to blend the electronic sounds of the sonification with an acoustic ensemble. Consequently, the sonification instrument served as an interface for performance and brought flexibility for ensemble performance and cohesion in the ensemble's sound. This approach highlights the versatility of sonification in music composition and live performance, further exploring the relation between the data, performers, and audience.

Lastly, I conclude from the feedback session developed in section 4., that the creation of aesthetic sonification and its further manipulation for musification shows a clear potential for audience engagement under a defined artistic intent. Furthermore, the potential of sonification objects as interfaces in artistic application demonstrates their flexibility to bridge data, sound, and emotion in a narrative that engages and inspires the audience. As I look forward to future developments of my sonification projects, the exploration of aesthetic spaces, particularly through AI systems, promises to further enrich this dialogue, creating access to data exploration via diverse intentionalities.

6. ACKNOWLEDGMENT

I would like to thank Calum Builder, Johannes Nästesjö, Valeria Mircapillo, Jūra Elena Šedytė, and Ida Nørby for their professional dedication to my music. I am also grateful to Gianluca Elia, Professors Torben Snækkestad and Jacob Anderskov, and Lotte Anker for their invaluable support and sharing of knowledge, and to the Rhythmic Music Conservatory in Copenhagen for creating an inspiring space for artistic research in Denmark. Finally, I thank Dr. Thor Magnusson for his mentorship and encouragement, and my colleagues at the Intelligent Instruments Lab for their collaborative support and critical insights into my work.

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