RITUALISTIC APPROACH TO SONIC INTERACTION DESIGN: A POETIC FRAMEWORK FOR PARTICIPATORY SONIFICATION

Robin Morabito

Intelligent Instruments Lab,
Iceland University of the Arts,
Reykjavík, Iceland
robin19@lhi.is

Jack Armitage

Intelligent Instruments Lab,
Iceland University of the Arts,
Reykjavík, Iceland
jack@lhi.is

Thor Magnusson

Intelligent Instruments Lab,
Iceland University of the Arts,
Reykjavík, Iceland
thor.magnusson@lhi.is

ABSTRACT

While sonification is often adopted as an analytical tool to understand data, it can also be an efficient basis for the construction of an interaction model for an aesthetic sound piece. Mirroring the performative arts, a ritualistic approach in participatory sonification can take place whenever a work relies more on the outer form of the piece, than on the meaning attributed to the information communicated, to connect with an audience, losing some degrees of readability and intelligibility in the process while maintaining a reliable data-to-sound relationship. We will present a few examples that anticipate or expand the use of sonification as analytical tool to propose aesthetic approaches, accessing more complex layers of meaning in interactive design. By proposing topological, semantic, and technical perspectives, we demonstrate the functional aspects of the multimedia artwork "The Only Object They Could Retrieve From Earth's Lost Civilisation" ("The Only Object" from now on). Outcomes will be considered under the multidisciplinary framework here proposed, to conclude with possibilities and implications of a ritualistic approach to interaction design.

1. INTRODUCTION

Rituals operate via somatic, sensorial, and symbolic levels to affect individual and group identity by remarking events that are perceived as special or valuable for the communities that engage with them [1]. With the term ritual, we can identify a variety of practices, either religious (for instance all the acts administered by a priest in a Christian mass) or secular (meaning both collective non-religious events, like singing a nation's anthem before a football match, or everyday life rituals such as going out in familiar places with the same group of friends). These practices allow deep integration between different elements of the everyday life and world of the participants within coherent and shared narratives, meant to be reinforced through shared practice. As B. C. Han puts it [2], rituals bring forth a community without communication – behaviour opposed to a prevalent "communication without community" of contemporary information technologies. These elements of ritualistic and participatory features in a sound piece usually challenge our "spectatorial" attitude towards arts by introducing intimacy, closer interactions. In this paper, we examine forms of interaction design in sonification that step away from the purpose-driven, informative design of commodities, and embrace poetic dimensions or ritualistic experiences that are usually more peculiar of performed live arts. Such dimensions are firstly characterized by a counterpoint of signifier and signified, where the former gains more importance over the latter. In the concept of Han [2], signifier is the outer form, framing or appearance of a ritual. It is the dimension perceived as poetic and experienced in the context of a ritual. The signified is the discursive content, reasons, or explanation of the ritual: it is the disenchanted meaning that the ritual dresses up with the signifier. For example, the ritual of prayer in Christian culture, executed by kneeling and lowering the head with closed eyes and conjunct hands, is framed in such a way to be recognizable, yet self-fulfilling. The symbols constituting the signifier (the hands, the head, the voice tone etc.) need to be explained only in the very context where they occur; of course, the "real" or practical reason (signified) for which the head must be in such position, or the hands, or the voice tone must become thinner and monotonal, would be of scarce interest for those who engage in the ritual. After distinguishing between these two distinct levels of meaning of ritual practices, Han proposes that live arts exist in an essentially similar dichotomy: preserving the dimension of the signifier means then preserving the nature of the arts.

Although sonification does rarely fall under the definition of live art, characterized by the presence of the artist in the experience of the whole artwork [3], it can be made participatory through some level of interaction occurring between the audience and any stage of the HCI adopted. Making a sonification participatory means essentially considering the audience's presence as a pre-requisite for the sonification to occur at all; even though data might not be collected in real-time, the sonification happening in real-time and the audience's role in its execution make it conceivably equivalent to a live-act. Moreover, this process lets audiences recognize themselves and their role in the experience of the sonification, which relates to the way rituals are assimilated (see section 3). The interest for participatory, real-time sonification stems from the interest in the embodied constitution of music and its relationship with the dimension of the sacred and symbolic. Sound artists have been extensively exploring this characteristic, mirroring the "anti-spectatorial" approach that western contemporary art and performance makers adopt towards the audiences. For this purpose, participation incentivized/led by artists is usually a way to test and form new relationships with the audience, in the form of rituals.

HCI-mediated artworks search often for analogue forms of interaction, raising the question whether non-informative aspects of sonification could be reinforced and adopted to evaluate a ritualistic approach to sonification design. Sonification itself being a symbolic process, encoding abstract meta-structures in datasets into our auditory experience, it can provide a good field test for rituals and symbols. This said, holistic aspects of sonification as sound works should be considered, as this stage usually requires exploring sonic interaction design, sound semiotics and various degrees of metaphorical or freeform associations.

2. SONIFICATION IN SOUND INSTALLATIONS AND SCULPTURES

To enrich the definition of participatory sonification introduced above, we explore sonification aesthetics and consider relevant aspects in this pursuit. As Hermann and Grond have pointed out, sonification is intended as a scientific tool with artistic and aesthetic implications [4]. They envision this process to be meant to transpose, as accurately as possible, some kind of information obtainable from a dataset into multimodal sound. Ten years after this seminal article, it is time to re-evaluate the role of sonification as an artistic practice, by no mean inferior or mutilated compared to an overall informative purpose and consider it as an interdisciplinary artistic practice with peculiar technological implications.

The key difference between musifications and data-inspired music is the purpose of using a fixed or reproducible relationship between the dataset considered and the sound work generated by it. In other words, data-inspired music (for example Cage's Atlas Eclipticalis) is meant to use data structures as a partial source of music composition, but does not have to entirely rely on it. On the other hand, sonification works tend to preserve integrity of the datasets adopted, so for them to be a basement layer upon which multiple layers of meaning can be arranged. Still, like Hermann and Grond observed, it is the interrelation between musical elements to be relevant to the human ear in order to reconstruct information. In this sense, in a purely artistic context, it is not the amount of decipherable information that matters, but the presence of underlying relationships and ratios between musical elements of the sound work, and the involvement of the audience with the piece as a condition of its existence.

Barras acknowledges an "aesthetic turn" in data visualization practices, in the way datasets made publicly available sparked interest amongst artists for material that was strictly scientific until then [5]. He notices how sonification, even if less known at the time, could also host a similar process of aesthetical transformation and become a popular mass medium for data exploration – it is sufficient for the author to replace the linguistic concept of data representation, with the non-verbal concept of functionality, to reconfigure sonification from a tool for scientific enquiry to a popular mass medium for a broad audience. To consider whether a ritualistic sonification could be conceived as social medium, we will look at Grond and Hermann's approaches to aesthetical sonification while drawing connections with the environment introduced so far.

2.1 Aesthetic approaches to participatory sonification

Grond and Hermann [4] provide a synthetic and efficient collection of documented approaches to sonification aesthetics, allowing us to reflect on sound qualities beyond the physical properties of the medium.

• attack section of the envelope: in an amplitude envelope (shaping the gain of the underlying sound wave), the attack part of the curve is the one that tends to point more at the sound source, by defining the initial nature of the sound event. This observation is particularly relevant when projecting close/distant interactions in a sonification model. A good example of a design involving this property is the mobile phone app shoogle, which associates the action shaking the phone the sound of pebble in a box, in an amount corresponding to the number of unread messages in the inbox.

• repetitions: in a sonification, repetition establishes similarity and difference. Repetition creates an inner reference between sound events, which can be experienced even by non-music educated listeners. In the same way, it can characterize interactions in a HCI by creating elements of familiarity, which can guide the user through the interaction model. Repetition is also very characterizing of rituals, as it builds connections between groups of people taking part to an event; we can expect it to have a role in facilitating cross-communication between individuals and HCI.

• conceptualization: this property is particularly important for the implication that it has in interactive sound design. According to the authors, the fact that sound can be imagined makes it a vehicle of thought just like image and language. Moreover, if sound is conceptualizable, so is its relation to the inherent pattern within data; Music for solo performer by Alvin Lucier (1965) embodies this property quite clearly. In this example, EEG real time data are converted into acoustic signals to a set of speakers, each exciting a percussive instrument. Here data are not used to make brain activity understandable, but instead underline the essence of thoughts and mental processes as implicitly dynamic.

• technological aspects: this aspect stresses the importance of the interface adopted in sonification design. Amongst the numerous sonification examples whose design is built around this approach, C. Kubisch's electric walks: though specifically designed headphones integrating receiver coils, the audience (individually) can experience a direct audification of the electromagnetic field surrounding them. In this case, technology is both the main medium and object for the sonification. In a comparable way, The Only Object's design engages with the concept of technology, while diverse kinds of sensors act as data inputs and interaction interfaces (see section 4).

• melodic and harmonic aspects: in a way related to repetitions, these features help building structures and creating distinguishable events. As we increase the degree of information entanglement in a dataset, we need equivalent sound relations to occur: the possibility of creating cross-references through melody and harmony is a property that comes in handy while attempting sonification of datasets such as complex biomolecules [6] [7]. Amongst the examples provided by Grond and Hermann on this matter, the association of melodic aspects of the sound with hierarchically complex features of the datasets is quite frequent. For the object of this paper, melodic and harmonic relationships are explored in a more "artificial way" by pairing individual data sources together to simulate higher-order harmonic and rhythmical relationships (see section 4.2 e 4.3).

• familiarity: in the notion used here, how easily we can relate to sonifications never heard before. It mostly depends on the dimensional complexity of the sonification. The more dimensions in the dataset must be considered, the less likely is the sonification to sound immediately understandable, since unrolling layered cross-references in a multidimensional dataset requires prolonged attention and participation. Audification is observed to be in general the most familiar form of sonification, as usually one-dimensional data is associated with one distinguishable sound feature.

• multimodality: it is important to remember that while listening to sound, we try to integrate multiple input streams into a coherent perception. This property can be used to produce prolonged engagement in audio-visual media,

since controlling the element of focus of a sonification we are intrinsically directing the audience attention in relation to other elements of the sensory space (and the other way around). Interesting effects can be obtained by playing with the audience's attempt to integrate multiple stimuli.

We want now to consider this aesthetic framework transversally across sonification works, and experiment with it in a ritual context, meaning in particular participatory and collective. If the engagement becomes the main concern of the sonification, we can mostly bypass the need for readability and intelligibility and focus on semantical implications of the properties here reported. By making collective participation necessary for the functioning of the sonification system proposed in this paper, we want to enclose the artwork to the domain of rituals. Hermann's and Hunt's definition of interactive sonification [8] and KatieAnna Wolf's work on personalized interactive sonification [9] provide a solid starting point to support such statement, however not entirely aligned with it. While the former sees interactive sonification as a virtual musical instrument, played primarily to learn more about the data, the latter tries to reconcile the role of sonification in music performance presenting it as a medium to enrich audience members' experience of music. We find that both these representations might not suffice the pursuit for a collective, participatory experience of sonification definable as ritualistic. On one hand, we want to valorise sonification as a compositional technique not motivated by the meaning of the underlying data (signified), but rather by taking advantage of its aesthetic peculiarities as patterns in time to enable a deeper symbolic relation with the art piece (signifier). On the other hand, we also want this experience to be collective, for which Wolf's personalized approach to interactive sonification seems inappropriate. In order to picture the kind of task at hand, we need to explore the way sound rituals are experienced in the context of sound practices.

3. PHENOMENOLOGY OF SOUND RITUALS

Both religious and secular rituals can be pictured as self-reinforcing events repeated over time, with high symbolic and patterned behaviour [10]. Additionally, rituals reflect group identity through artefacts, scripts, performance roles and audiences [11].

The individual role in ritual activities can vary: some rituals are highly scripted, meaning less individual expression is allowed; unscripted rituals are instead characterized by the freedom of taking part in them or not [12]. Ritual behaviour is closely related to the experience of magical, mystical and mythical [13], taking place in a circular time, experienced mostly as self-referential and requiring full immersion to be accessible, as observed by Han [1]. A discussion focused on sound rituals stemming from these points has been proposed by Morley [14], examining music in the context of the earliest known manifestations of symbolic and religious activity (rituals) during the Upper Palaeolithic, broadly spanning from 50,000 to 12,000 years ago. In doing so, Morley unfolds structural and phenomenological properties of music and religious rituals, drawing a number of comparisons between them and assessing the high degree of entanglement they share. In particular, few amongst these comparable properties seem particularly relevant to clarify how the two are related and relatable, to ultimately try to include them into our ritual sonification design.

Firstly, in many cultures conceptions of music are mostly inseparable from conceptions of rituals and religion [15]; "ritual" and "performances" are virtually synonyms in these contexts. Secondly, both engage with the dimensions of magic and mysticism; music is often conceived as a medium for the transformation of boundaries between sacred and profane, between forms and discursive content, probably because of its role in many societies' rituals. Additionally, both are highly symbolic languages with no fixed meaning; performance and perception of music are characterized by a "floating intentionality", which reflects in rituals as "bounded ambiguity" [16]. Finally, both hold the power to stimulate powerful emotional reactions, and reciprocal reinforcement occurs between them. A further aspect of music often overlooked by modern western culture is its interdependency with the concept of presence mentioned before. Begbie (2000) observes that thinking of a music work as constituted only by sound patterns heard or codified in a score is "artificial and inadequate" for it also consists of actions, making it "temporally constituted and situated" [17]. It can be argued that this contextual aspect of "embodied" music is largely underrepresented in literature as it is in western culture.

In a way, the interest for embodied aspects of music departs from the initial purpose of sonification, which relates to the scientific pursuit for transparency, of rendering all the information contained in the data. In the arts, we often seek to embrace the mystery with multiple layers of meaning, a feature that we see in ritual practices. In this process, information is encoded in such a way to make it partially invisible, accessible only through practice-specific rituals in the arts (and rarely with the pursuit for objectivity). Han conceives rituals as composed of two layers, the sacred one outside (the one that is experienced collectively and mostly as forms, whose meaning is represented by the signifier, main constituent of ritual) and the informative one inside (that is the practical reality of the ritual, analytically cut into its individual components, or "meaning" of the ritual, called signified). In the arts, the focus on forms requires for the informative side to be less accessible in order for audiences to experience the artwork: otherwise, often knowing the physical and mechanical causes for the "magic" would essentially vanish it. Han observes that the pursuit for transparency in the arts destroys them by exposing the profane encased inside the sacred (see section 5). We want then to discuss sound rituals with attention to the signifier and its possible relationships with specific aesthetical properties, rather than with the signified. We will sketch few useful guidelines for ritual sonification design in the process. Such approach might be of interest for sonification researchers and sound artists, for facilitating the reconnection of a highly technical task with a broader perspective on agency of audiences and the collective experience of sound pieces.

The last point to introduce is the relationship between music and time, as it strongly reflects the above-mentioned relation with rituals. It is known that the experience of music affects one's perception of time [18] [19]: considering the temporary and situated aspect of music, which we have seen not limited to score and sound properties, but also actions bound to the concept of presence [17], we can point at the unique way a sound practice intersects religious practices by performing a similar manipulation of time. We will discuss presence in section 4.5; for now, it suffices to conclude saying that while these dimensions might seem hard to detect in a sonification, they do actually affect the holistic experience of it as a sound work and allow us to expand the sonification field by interfering with the way these dimensions are presented and accessible to audiences.

4. DESIGN OF RITUAL SPACES

In this section, we present the design of a participatory "ritualistic" sonification, discussing the piece "The Only Object They Could Retrieve from Earth's Lost Civilization" as a demonstration of the concepts introduced in this paper and explore the results obtained. This work, presented on May 17th, 2022, in Dynjandi Hall, Reykjavík, consists of a dark, empty room except for an object (Figure 1) at the centre of it, illuminated by two spotlights. The object (a tower-like sculpture of scrap plastic and PCB parts melted together), is presented as "the only relic that a post-human interplanetary civilization could find on the radioactive planet Earth", and the visual aesthetic choices of material and appearances vaguely refer to popular culture of cyborgs, while also tapping into the western fear of nuclear physics. Embedded in the object, three distance sensors, two light dependent resistors (LDRs) and one motion sensor disposed around it communicate with a Bela board [20] on the inside (Figure 2). The sensor board runs a Pure Data (PD) [21] generative sound patch, involving two FM synthesizers used mainly as percussive and pad-like instruments, and a sequencer. The sonification of distance, light and motion data takes place with ritual phenomenological theories in mind, and involves exploring the relationships between the six data streams with the sounds and time events produced in PD (Figure 3). Lastly, the speaker system is hidden to confuse location and spatialization of sound sources, creating a more diffused sound environment. It is a participatory sonification as it requires the audience to engage with the object for it to take place at all, and its focuses not on intelligibility or readability, but the constitution of a symbolically interesting musical environment, while avoiding the aesthetic trap of randomness. It can be seen as a sonification of space since the source data are related to spatial properties, where sensor-sound mappings are coherently associated and, in most part, noticeable by the audience: this way allows familiarity to emerge without having to completely disclose the sonification mechanism.

4.1 Sonification as social medium

The observation and concerns expressed by Han [1] in relation to the loss of social aspects of rituals in our societies, and the aesthetic observations of Barras [5], have motivated the attempt to engage in a deeper discussion about the occurrence of rituals in sound interaction design and in
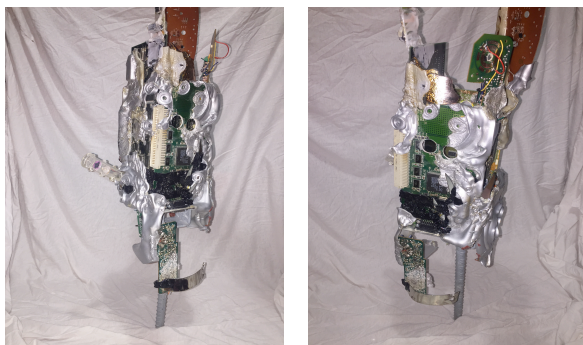

Figure 1: Two sides of the early form of the sculpture, to be positioned at the center of the space. The holes on the surface host the ultrasonic distance sensors.

relation to this piece. Having acknowledged the potential of sonification as a complex multimodal symbolic design process, and recognized the possibility for a critical perspective on the methods, aims and outcomes involved, we ask:

• Is it possible to conceive sonification as a social medium?

• If rituals are disappearing across western sound practices too, how can sonification help the audiences to rediscover the poetry of the signifier?

On the inside, The Last Object plays with these questions while an unaware audience experiences it. On the outside, the piece tries to embody the very philosophy proposed by Han of a community without communication, displaying symbolic sonic relations (meaningful only in the context of the ritual constituted around it) affected in their status by the sole presence of bodies around the sculpture. At the same time this feeling clashes with an abnormal and intimidating idea of human technology by displaying what might be left of it in the future. Although a signified, here represented and motivated as a "warning to humanity," is of course traceable in the work, it is not the focus of this discussion. We want instead to examine the role of the signifier, embodied as the form of the artwork, in the engagement with the audience. To do so, we will consider morphological aspects of this sonification which relate to the HCI adopted and the interactions built so far with users/audience, but also symbolic choices in the sound design reflecting what we have called a ritualistic approach.

4.2 Input space

The initial technical stage of the work is the input space, which refers to the type of input data that we want to consider in this context and the sections of the HCI that detect them, before being sent to the Pure Data software for the actual sonification process. Card, Mackinlay and Robertson [22] consider the role of input devices in human-machine communication, being input devices meant to engage in dialogue with computers and machines. This communication must be conducted in ways that are specific to the context, hence designing a human-machine interface is somehow the design of artificial languages – with the direct consequence of having to deal with symbols that the language expresses. As they put it, there are mainly two criteria that can be used to evaluate an input device:

• Expressiveness: related to the resolution and scaling of input devices, it implies dealing with how the input values are represented in the output. For our purpose, it is useful to consider it as a scale that predicts how much of the input values can be represented amongst the output projection, or how much the input can convey of the "exact" meaning of the information received. In The Last Object, this criterion is mostly affected by sensor resolution: the three distance sensors used, emitting ultrasonic pulses at regular interval, with distance measured according to the time it takes for the echo of each pulse to be received, were somewhat noisy in the setup adopted (see below). This has implied a limited expressiveness, meaning that less of the original input values could be successfully included in the output stream. Given it was not an informative sonification, interpolating and filtering the input values, together with de-synchronizing the ultrasonic pulses, has shown to be sufficient to stabilize the output response and give a feeling of "smoothness" between the readings.
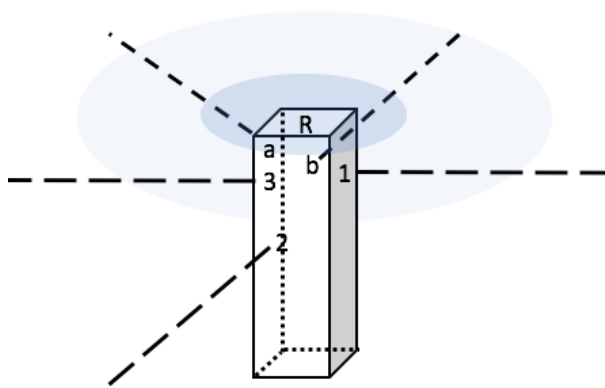
Figure 2: Illustration of the 3D placement of six sensors around the surface of the sculpture, approximated as a parallelepiped. Numbers are ultrasonic distance sensors (HC-SR04), lowercase letters are photoresistors, and R is a microwave radar sensor (RCWL-0516).

• Effectiveness: related to a series of points of merit that the authors connect with the capacity of the input to convey the intended meaning with felicity. Amongst these points there are mostly two that can be relevant for the input design for The Last Object:

• footprint: the space taken by the input device, which has to be reasonable both in a physical, tangible way, but also within the topology of the HCI design. In other words, input device should connect to the output devices with the minimal distance possible. To maximize the effects of this point, sensor spatialisation has played a crucial role: each sensor points mostly outward from the centre of the object, increasing the space where interaction occurs without increasing the input space footprint. This spatialisation has also functioned as a musical score, where sound events are organised according to their occurrence in space rather than their succession in time (Figure. 4). All this works to optimise where the interaction occurs as much as possible, limiting topological interferences of each input.

• bandwidth: the human action sensed, relative to the device's own bandwidth and the application's precision requirements. Regarding expressiveness, we know that precision requirements had to be compromised early in the design stage, but we can reflect on the human and device bandwidth in relation to the scope of the expected interaction. This means that we can consider the bandwidth of actual detectable human movements, then the bandwidth of the sensors themselves, and predict or prepare interactions accordingly – an approach that leaves a large freedom of movement and form, simplifying as much as possible the nature of interactions (front-back, light-dark etc.) while using
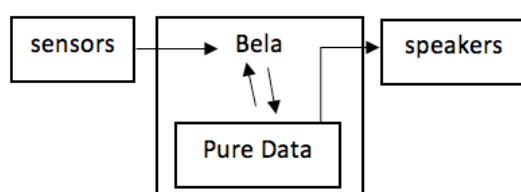

Figure 3: Schematic representation of relationships between the technological elements involved in the sound sculpture interaction

as much bandwidth as possible. This approach lets us foresee possible choreographic implications, which will be explored in the future.

While this approach sets some fundamental points in input space design that are related to the task at hand, it suffers from a lack of communicability in the artistic environment. Since semantic approaches tend to consider only design of interactive commodities [22] [23], we want to be able to evaluate the aesthetic dimension of symbols also in the input spaces of interactive artworks.

4.3 Sensed context

For this case, sensors characterize the input space in what Gray and Salber call a sensed context [24], referring to the level at which acquisition of information from the surrounding environment occurs. The information of interest presents few relevant characteristics:

• Is accessible via sensors;

• Captures properties of real-life phenomena, and;

• Can extend application functionality or affect positively the existing functionality.

This type of information relates sensors to phenomena in space-time. It implies considering timeliness and accuracy of sensed information, and whether identity of entities across phenomena can be determinable through it. Hence, two problems arise: a sampling problem (being able to approximate the right space-time location of events) and an identity problem (being able to distinguish different events occurring). We described The Only Object as a sonification of space. To overcome both sampling and identity problems, a constructive approach is addressing spatial and temporal locations non-linearly, making "sweet spots" more available across larger space-time areas than noisy, quasi-random soundscapes. This creates easily reachable checkpoints in time and space, for audiences to orient themselves in the sonification. It also reduces the need for overly accurate sampling, since it creates extended contexts in which meaning can be spontaneously generated by its relationship with checkpointed sound forms, and at the same time moves the problem of identity on the level of having to "map" the geography of sound to find morphological replicable structures of interest, rather than having to rely on the computer to sort out which gesture means what symbol. As mentioned before, this approach consists in sculpting the sensed context according to the input space with the idea of increasing the familiarity with the sonification. Non-readability helps in this pursuit by wrapping the direct correlation of data values with sound outcomes into a sort of password protected ritual artefact. The audience knows that their presence and movement in the space surrounding the sculpture affects the way sound is produced and unfolds in time, but they do not need to know the direct amount of the correlation nor notice the actual data stream underneath the sonification artefact. Such approach implies two considerations: it cannot be applied when sonifying for data exploration, and there must be ways for the relationship data-sound to be manifested.

Modelling the sensed context information according to the input space seems to be a constructive approach to participatory interactive sonifications. Moreover, blurring the dataset's representation seems to make symbolic information more accessible, possibly because of the reduced frequency of drastic changes, of for their coincidentally better placement. It would be interesting to see whether reducing sonification

readability, even with non-sensory captured information, can help enhancing the accessibility of holistic symbols carrying meaning from the sonification. The next stage to be considered is the level of engagement we want to attribute to the interaction that will shape the actual sound movements in time.
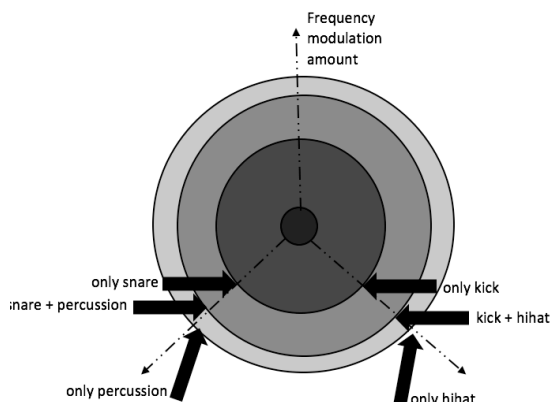

Figure 4: Example of one data-sound event interaction, sequenced in space, stylized as seen from above. Concentric circular areas represent progressively further radiuses from the sculpture. Drum patterns are organized in such way to be accessible by moving along two of the arrows and all concentric circles; transition states are allowed between them as well. The third arrow quantifies the noisy character of the percussions, by increasing the harmonicity and modulation index of the synth.

4.4 Morphology of engagement

Interaction with the sound system is a fundamental point of this work. Examples of interactive music compositions or performances are well documented [25], but here we are interested in the expanded field of interaction involving the audience. Bringing the audience ahead as the main composer of the music produced with the sonification is also not a new idea: a remarkable example is Tweetscapes [26], a project that sonified and visualised Twitter data from Germany or in German language in real-time. The sounds were based on a fixed but consistent sound database, assigned randomly to each new hashtag encountered but then reproducibly associated to them. This can be seen as a participatory sonification, since the audience contribution is necessary for the sonification to take place; it is, in other words, motor and object of the sonification. Tweetscapes speaks to a mostly unaware audience: one could even say that tweet posting is "out of control" for a limited number of individuals that experienced the artwork. While The Only Object also uses data from sensors both as object for the sonification and as parameters for interacting with it, the audience's presence determines also the form of awareness there developed.

As computing technology becomes more ubiquitous, anything could become an interface and engage with displayed information in public space. However, the diversification of contemporary information technology has made it available beyond screens and interfaces, allowing for

subtler representation of data. This idea reconnects with rituals characteristics of presenting symbols that invite participation, without forcing it. Also, it introduces the concept of calm technology [27], enabling the communication of relevant information in a subtle and unobtrusive way. While this technology is intended to blend sonification processes in interactive commodities, it serves also the purpose of enabling an invitation to an interaction, rather than formulating this interrelationship as a "requirement" or a direct instruction. In The Only Object, the audience is invited to take part in the artwork by a narrative that pictures the artefact (sculpture) as meaningless, according to the future body-less civilization that retrieves it, but at the same time wants to stimulate curiosity of contemporary, embodied humans to interact with the space surrounding it.

There is then a strong aesthetic value to the participatory sonification realised, reflecting the idea of information decoration [28], adopted in the context of home commodities that implement sonification in their design: information framed this way will result as appealing to novice users, while still unfold multiple semantic possibilities to the user which will have spent more time around it. The choice for such subtle sonification is not casual at all. Since one of the themes of the artwork is recurrence in time and the experience of presence (see section 4.5), keeping the audience around the piece long enough for them to engage with it is a challenging task that finds in calm technology a suitable approach. Furthermore, interconnected components between art pieces and HCI have been studied by Jeon, Fiebrink, Edmonds and Herath [29], by relating interactivity with the degree of acknowledgment of prior responses by the HCI. Quoting Edmonds [30], it is possible to refine a taxonomy of participants' engagement with artworks:

• static: the art object does not change by input from the audience/spectator;

• dynamic-passive: an internal mechanism enables the art object to change in response to environmental changes;

• dynamic-interactive: the audience has active role in affecting the changes of the art object;

• dynamic-interactive (varying): human agent or software agent can change the original specification of the art object (including for instance machine learning); satisfies the definition of "full interactivity" as the system can reference each response to a context already exchanged.

The Only Object's interaction design falls somewhere around dynamic interactive engagement type, reinforcing as well the participatory aspect of the sonification system adopted. The illusion for a full interactivity, or better the illusion of context, is given by arbitrarily "preparing" the auditory scene of the piece, placing tactical auditory checkpoints in the input space (see fig. 4). As similar sound mesostructures emerge in dynamic but recognizable ways in each checkpoint, the exploration of liminal spaces between them becomes favourable, enhanced by continuous real-time synthesis. To loosely design the interaction occurring in each of these areas (or spatial locations), sensors readings are used in the synthesis and sequencing stage associated to multiple properties each. Furthermore, mathematical relationships between them are explored to categorize even more the effect of each interaction with the sonification system. For instance, each sensor might relate to a different qualitative property of sound events (timbre, articulation, duration, pitch etc.) but the sum of pairs or triplets of them might be associated to the unfolding of the event in time (pitch sequence, distribution of events, groups of notes); of course a number of different and

analogously interesting combinations can be attempted in this stage, however multimodality and some level of redundancy have already shown to be effective in the dynamic-interactive design of the piece.

At this point, we could discuss the nature of the difference between a sensed-interactive sound work, and a participatory sonification as presented here. Usually, sonification is assumed to be mostly focused on data representation; refusing this assumption has the effect of blurring the boundaries between disciplines. For instance, how does a Parameter Mapping Sonification (PMS) of distance sensors differ from an interactive sound work adopting distance sensors? As mentioned above, in this case sensors' data are both sonified and used to control the interaction occurring with it. We have also mentioned that a critical difference between data-based music and any kind of sonification is that in the second case all data relationships are potentially portrayed in the sonification. This feature can already help identifying a work as a sonification rather than a data-inspired or data-controlled piece: the intention of preserving the dataset and presenting it in its entirety arguably distinguishes between interactive sound works and sonifications of sensory inputs, even though the sonification might not be made with informative purposes. The Only Object collects and groups distance values to produce variable-length sequences of timed events: this peculiarity helps distinguishing between sensory inputs as real-time controllers (audience's movements activate and affect sound synthesis parameters) and sensory inputs as data to be sonified (non real-time collections of values stored and furthermore manipulated) within this work. Even though both functions adopt the same data sources, one stage sonifies them ex-novo into times and pitches, the other works as a controller over the sonification parameters.

4.5 Presence as temporal dimension of the sonification

Having examined the HCI interaction design, input space and sensed context of an artwork constructed around these principles, we need to define a common language that can address time in a ritualistic sonification design. For this purpose, we dive in the concept of presence considered as relevant both in ritualistic and musical practices. Acknowledging that music works do not exist exclusively as scripted sound patterns [17], but also as actions that can be understood only as temporary and situated, moves the dialogue from properties of sound to the concept of presence in music. In particular, it questions how this field can be transposed, within the sonification framework, to the phenomenology of rituals.

From a Western music perspective, one way of engaging in this discussion is emphasizing that music shares with ritual practices a main feature which is direct participation (despite in our music tradition, "participant" and "audience" are usually two different things). It is hard to overcome the apparent separation between the sound source (performed or not) and the audience (passively experiencing the source, or whose response is considered hierarchically inferior to the one coming from the source). Partially because of this, but also because of the evidence of music traditions built around the opposite concept [15], attention has been drawn to participation as necessary mean for the process of music execution, as it is for religious rituals. Western sound art is trying to get in touch with this participatory dimension by engaging in forms of interaction that rely on audience participation to the piece. In doing so, sound sculptures and sound installations are gradually embracing ritualistic approaches, looking for immersive, somatic experiences; moreover, as practices they are also characterized by a more prominent extension in space, rather than in time. In a way, withdrawing from the pursuit of sequential time nourishes itself the acknowledgment of the "presence." This sense of immersion guides the establishments of micro-rituals, which sculpt the sonic environment into a shared territory of change: the poetic effect of the interaction is what The Only Object relies on.

This experience fits within the idea that sonification can be considered an intermedia compositional technique. Under this light, it can be adopted to create sound works with no informative purpose at all, but with a deep level of user interactivity favouring symbolic connections with the dataset. Familiarizing with these forms is the easiest way to make these connections visible and engaging in micro-rituals with the piece.

5. DISCUSSION: ON TRANSPARENCY AND POETRY

We want to conclude with some final observations on the realization process of this piece, which can have practical implications for a ritualistic approach to participatory sonification. We have suggested that unawareness plays a role in audience building a mystical connection with the artwork - an activity that characterizes ritual practices as well. This allowed us to apply the idea that sonification can be used as a social medium, and we also propose a critical perspective on how this social medium might be used outside constructive and playful experiments. In a globalized world that pushes for delocalization, dispersion, diffusion of information, the interfaces we use tend to reflect this schizophrenic tendency. In a strictly pragmatic sense, sonification is already necessary to mediate between the exponential technical developments flooding the arts since the middle 20th century, and limited human capabilities of perceiving and processing information over time. A ritual methodology for sonification can foster information decoration and calm technology as principles for constructive and collective uses of HCI in the arts as in science. It must make aesthetics non-colonisable by the economy that pushes for consumption and production for profit and tends to commodify technological artefacts.

Sonifications with informative purposes are somehow shielded from this critique because they fully embody the scientific mantras of reproducibility and intelligibility (or transparency, using Han's terminology). What we want to underline instead is how inadequate this can be in an artistic context, where sonification can be performed primarily for aesthetic reasons. In this field, the pursuit for transparency can easily be driven into a compulsive mentality of producing a work as a self-fulfilling act. This mindset justifies the over-analysis of artistic sonifications in terms of information availability rather than information decoration, eclipsing alternative approaches. Implementing audience participation as a requisite for sonification can help mitigate over-analysis by modelling a favourable communal environment to experience information as a ritual act. This approach requires that the symbols and the encoding we decide to use sustain the idea of mystery, or valorise the signifier above the signified. It also means seeing a sonification as a poetic work, rather than as an analytical task. Since the aim becomes not to make information

intelligible, but to build symbolic relationships between the elements involved, the main task should be to accompany and favour the development of rituals amongst these elements and the audience. For this purpose, we should perhaps focus on further aspects of the sonification framework that transcend the technique itself.

6. CONCLUSION

In this paper, we have explored participatory sonifications to introduce ritual sound practices occurring in that context. We have presented a prototyped artwork, The Only Object, to propose transversal approaches to ritualistic design of participatory sonification. As we framed sonification's role as data-sound encoder of complex meanings, we have illustrated ways to valorise the form (signifier) of a particular sonification ritual rather than its content (signified), hoping to shed a light on the interrelationship occurring between HCI, interaction model, sound design and holistic narrative of a sonification piece. Finally, we have expressed concern for the commodification of sound and called for a critical take on disappearance of ritual from sound practices, including sonification.

7. ACKNOWLEDGMENT

8. REFERENCES

[1] C. Bell, *Ritual. Perspective and Dimensions*, New York, USA: Oxford University Press, 1997.

[2] B. Han, *The Disappearance of Rituals: A Topology of the Present*, Cambridge, UK: Polity Press, 2020.

[3] L. Loke, G. P. Khut, and A. B. Kocaballi, "Bodily Experience and Imagination: Designing Ritual Interactions for Participatory Live-Art Contexts," *DIS 2012*, Newcastle, UK, 2012, pp. 779-788.

[4] F. Grond, T. Hermann, "Aesthetic strategies in sonification," *AI and Society*, vol. 27, no. 2, pp. 213-222, 2012.

[5] S. Barras, "The aesthetic turn in sonification towards a social and cultural medium," *AI and Society*, vol. 27, no. 2, pp. 177-181.

[6] T. Giesa, D. I. Spivak, and M. J. Buehler, "Reoccurring patterns in hierarchical protein materials and music: The power of analogies," *BioNanoScience*, vol. 1, no. 4, pp. 153-161, 2011.

[7] C. Yu, Z, Quin, F. J. Martinez-Martinez, and M. J. Buehler, "A Self-Consistent Sonification Method to Translate Amino Acid Sequences into Musical Compositions and Applications in Protein Design Using Artificial Intelligence," *ACS Nano*, vol. 13, no. 7, pp. 7471-7482, 2019.

[8] T. Hermann, A. Hunt, "An introduction to interactive sonification," *IEEE Multimedia*, vol. 12, no. 2, pp. 20-24, 2005.

[9] K. Wolf, R. Fiebrink, "Personalised interactive sonification of performance data," *Journal on Multimodal User Interfaces*, vol. 13, pp. 245-265, 2019.

[10] E. Rothenbuhler, *Ritual Communication: from Everyday Conversation to Mediated Ceremony*, SAGE Publications, 1998.

[11] R. Rappaport, "Ritual, Sanctity, and Cybernetics," *American Anthropologist*, vol. 73, no. 1, pp. 59-76, 1971.

[12] K. R. Campbell, *Performance ritual and the design of mobile devices*, University of Canberra, 2016.

[13] D. W. Rook, "The Ritual Dimension of Consumer Behaviour," *The Journal of Consumer Research*, vol. 12, no. 3, pp. 251-264, 1985.

[14] I. Morley, "Music and ritual: Parallels and practice, and the upper palaeolithic," in *Becoming Human: Innovation in Prehistoric Material and Spiritual Culture*, Cambridge, UK: Cambridge University Press, 2009, pp. 159-175.

[15] R. Schechner, *The Future of Ritual: writings on culture and performance*, New York, USA: Routledge, 1993.

[16] I. Cross, "Is music the most important thing we ever did? Music, development and evolution," in *Music, Mind and Science,* Seoul, South Korea: Seoul National University Press, 1999, pp. 10-39.

[17] J. S. Begbie, *Theology, Music and Time*, Cambridge, UK: Cambridge University Press, 2000.

[18] J. J. Kellaris, "Music and Consumers," in *Handbook of consumer psychology*, -: Taylor & Francis, 2008, pp. 837-856.

[19] J. Tenney, L. Polansky, "Temporal Gestalt Perception in Music," in *Journal of Music Theory*, vol. 24, no. 2, pp. 205-241, 1980

[20] https://bela.io/.

[21] https://puredata.info/.

[22] S. K. Card, J. D. Mackinlay, and G. G. Robertson, "The design space of input devices," in *CHI '90 Proceedings*, Seattle, USA, 1990, pp. 117-124.

[23] S. K. Card, J. D. Mackinlay, and G. G. Robertson, "A Semantic Analysis of the Design Space of Input Devices," in *Human-Computer Interaction*, vol. 5, pp. 145-190, 1990

[24] P. Gray, D. Salber, "Modelling and Using Sensed Context Information in the Design of Interactive Applications," in *8ᵗʰ IFIP International Conference,* Toronto, Canada, 2001, pp. 317-336.

[25] V. Goudarzi, A. M. Gioti, "Engagement and interaction in participatory sound art," in *Proceedings of the SMC, 2016*, Budapest, Hungary, 2016.

[26] http://heavylistening.com/tweetscapes/.

[27] A. Case, *Calm Technology. Principles and Patterns for Non-Intrusive Design*, Sebastopol, USA: O'Reilly, 2016.

[28] S. Bakker, R. van den Berg, S. Pijnappel, and E. van den Hoven, "Sounds Like Home: Sonification and Physical Interaction in the Periphery and Center of the Attention," in *Proceedings of ISon 2010*, Stockholm, Sweden, 2010, pp. 55-58.

[29] M. Jeon, R. Fiebrink, E. A. Edmonds, D. Herath, "From rituals to magic: Interactive art and HCI of the past, present, and future," *International Journal of Human-Computer Studies*, vol. 131, pp. 108-119, 2019.

[30] E. Edmonds, "The Art of Interaction: What HCI Can Learn from Interactive Art," *Synthesis Lectures on Human-Centered Informatics*, vol. 11, no. 1, pp. 1-73, 2018.