Blyth – Eastbourne – Wembury: Sonification as a compositional tool in electroacoustic music

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Abstract. Sea temperature and salinity data is used to create a musification of climate change phenomena that engages the listener from a musical and scientific point of view. The importance of musical aesthetics in sonification is discussed as well as the aesthetical considerations used for the project.

Keywords. Sonification, Musification, Climate change

1 Introduction

The use and creation of sonification regularly receives attention in scientific circles, be it as a curiosity or scientific practice. While sonification is used also for musical purposes, it remains less explored; even if the idea produces enthusiasm, the results sometimes disappoint from a musical or data understanding points of view. In both scientific and musical practices, the aesthetics of sonification is crucial for its success as an "alerting", "progress indicating", "exploration" or "artistic" method [1]. While sonification can be a powerful tool to engage audiences, it is critical that it works on a cognitive and aesthetic level as they run the risk or being unpleasant or unintelligible if not aesthetically sound. Barrass and Vickers discuss the importance of aesthetical concepts in mathematics as "truth and beauty are intertwined: beauty reveals truth and the truth is beautiful. But the point is not that mathematicians are seeking beauty for its own sake, but that the simple, that is, the beautiful, brings understanding more readily" [2].

A first aim of the project is to explore aesthetical options for the better understanding of data through sonification; a second aim is to progress towards an improved method of musical composition with sonification, also called musification.

2 Musification

Data in themselves are not information; "information is data coupled with context" [3]. As a result, sonification is only sound until it has a context. When does a sonification become a musification? If we think of music as organised sound, we need a cer-

tain degree of organisation for a sonification to become music. The organisation of sounds is the task of the composer; a composer using sonification could be described as a scientist-composer. Grond and Berger speak of musification as the use of sonification for artistic creations [4]. This definition does however not specify the role of the data in the artistic output. In fact, it is possible that a composer could produce a sonification and completely omit the fact that it is one. While a sonification should stand for itself musically, what is the interest for a composer to omit the extra-musical element of their musification? Barrass and Vickers discuss the issue: "Generally, the composer is concerned with the musical experience, rather than the revelation of compositional materials. However, when the data or algorithm is made explicit it raises the question of whether some aspect of the phenomenon can be understood by listening to the piece. When the intention of the composer shifts to the revelation of the phenomenon, the work crosses into the realm of sonification" [2]. The task for the scientist-composer is not a small one then, as they aim to produce a work that is both musically and scientifically convincing.

Data

The choice of appropriate is key to a successful sonification; we should consider it a crucial compositional choice. Not all data is equally suitable for sonification. In fact, one should be careful not to fall in the trap of "big data fetish", where one seeks the most complex data in the belief that bigger data implies higher scientific credibility [5]. Bigger datasets need to be prepared, for example by filtering for useful data or a workable number of data points. This process can be complex as the data can be difficult to understand and work with. Also, it can jeopardise the data as we reduce it. Through suitable data and mapping choices we seek to avoid a sound composition without musical structures which will be unintelligible, unpleasant and ultimately ineffective to the human ear. As Furlong explains, there "is a very large set of possible mappings but a notoriously small subset of perceptually, or cognitively, valid mappings" [3]. This is because we rely on a common "aesthetic framework", thus reducing immensely the number of valid mappings [3]. It is for that reason that the starting point for our research on musification are simple datasets, in order to explore effective mappings before moving onto more complex data.

Musical Language

The musical language employed in parameter-mapping based sonifications is often that of the Western Classical Music tradition: based on pitch, rhythm and harmony. Even when frequency rather than specific pitches are used, sonifications are often often embedded in this musical tradition. This makes sense of course, as it simplifies the understanding of the data by translating it into a language that we already partially understand. However, not all data are suited to be translated to the Western Classical Music language; other musical languages can be more suitable in certain cases. A specific language also brings a number of culturally embedded connotations which can overpower the perception of any other patterns in the data [6]. It would therefore be logical to advocate a larger range of parameters used in Classical Music as well as the use of different musical languages, for example acousmatic music. While acous-

matic music also makes use of the previous parameters, it also hinges more heavily on concepts of timbre and space, gestures and textures. A mixture of musical languages is necessary to achieve a full range of emotions and understanding, and a complete musification. For this particular project then, the author employs a mixture of acousmatic and frequency-based electronic musical languages.

Empathetic Sonification

Empathetic sonification engages the listener's brain and emotions in equal measure. The method presented in this paper consists of creating a soundscape related to the data; acousmatic music from sound sources that we acknowledge as close to the data juxtaposed with data sonification. The key to this approach is to engage with the emotional component of the information that we want to transmit. Andrea Polli emphasises the importance of an "emotional connection" to the data as "a memory aid" that can "increase the human understanding of the forces at work behind the data" when discussing her arctic sonification piece *Sonic Antarctica* [7]. These said emotions can then determine musical processes used in the piece in order to transmit them. The approach explored by the composer can be compared in some ways to use auditory icons which provide the aural equivalent of visual icons on a computer interface. Brazil and Fernström tell us that "auditory icons aim to provide an intuitive linkage between the metaphorical model worlds of computer applications by sonically representing objects and events in applications […]" [8]. An empathetic sonification uses the same process of linking the sounds heard to the data underlying them [7]. This is a similar approach as used by Natasha Barrett in a number of her works; for example *Aftershock* where she creates a sonification of rock fragmentation data and models with sound recordings of rocks [9].

3 *Blyth – Eastbourne - Wembury*

Blyth-Eastbourne-Wembury is a stereo fixed-media piece composed as a commission for the National Union of Students (NUS) and to be played at the Eden Project in Cornwall as part of the launch of the SOS (Students Organizing Sustainability) Network. The organisation was seeking artists who engaged with issues relating to climate change and sustainability as well as encouraging their audiences to engage in these topics. For this particular performance of the piece on 9 November 2015, two speakers were placed in a bamboo hut in the jungle biome of the Eden Project. The piece is a musification of data following climate change on the British shores.

The data used for the piece describes the sea temperature and salinity on sea surface around the English coast since recordings began until 2006, it is available from CEFAS (Centre for Environment Fisheries and Aquaculture Science) [10]. Specifically, the chosen data were collected at Eastbourne since 1892 and stem from the largest and most complete dataset available (1942-46 missing). The salinity data chosen stems from Position 2 in the ferry between Harwich and Rotterdam. Max 7 was used to create oscillators and synthesisers to which the data were transmitted.

Temperature

The piece uses pitch, or rather frequency, but not the ideas of melody and harmony. The most important gesture of the work uses the average monthly temperature between 1892 and 1971 and the average monthly temperature between 1971 and 2000 (see fig. 1). We find that the latter has risen by an average of about 0.55 C°. The temperatures range in the whole data set range from 0.4 to 20.4 C°, the mean data set ranges from 5.4 to 18.3 C°. These latter values were scaled between 200 and 600 Hz, and then used for synthesis with oscillators. Consequently, the two sonified data sets produced dissonances to varying degrees depending on discrepancy found on each month. The same data are used for a number of further textures rather than gestures, where the sonification is spaced out in time and modulated to different octaves for musical effect. Although these are meant as accompaniment rather than to be directly perceived as sonification, they remain true to the data through different scaling and mappings.

Dissonances are used for their psychoacoustic effect on the listener rather than as a tonal concept. The dissonance is never resolved, augmented to almost uncomfortable levels as it is laid bare.

The aim is to produce a sense of unease and danger in the listener that reflects the emotional meaning of the data which describe climate change. The graph of the temperature data reveals a wave shape with a minimum value in February and a maximum value in July-August (Fig. 1). When sonified as described, it becomes a musically interesting gesture, particularly in relation to the maritime nature of the topic. The gesture can be perceived as a wave but also as a siren which reinforces the idea of danger and warning signal. The coincidence worked strongly in favour of the piece as the listener can make a connection between the data and their emotional response to them. Be it through serendipity, the 'sound' of the sea temperature also reflects the nature of its data; thus reinforcing the idea that some data are more appropriate to sonification than other.

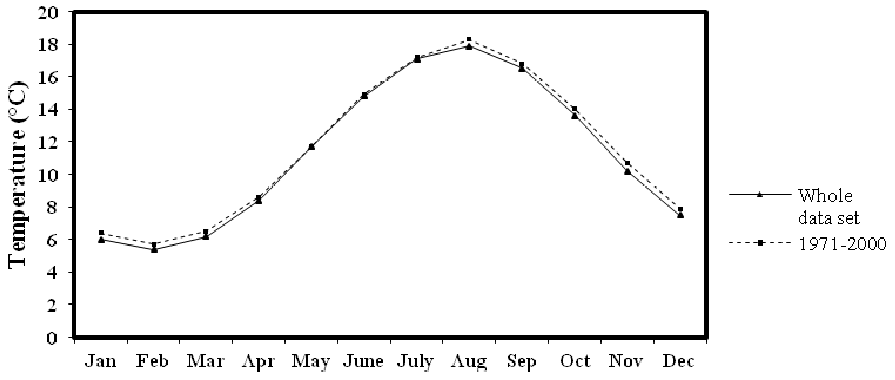

Fig. 1. Monthly averages of seawater temperature at Eastbourne for the entire data set and for 1971-2000 [8].

Salinity

Salinity data has a cyclical nature but is less regular than temperature data. It can also vary largely depending on the ferry position at which it is measured due to the flow in the English Channel. While the average rise in salinity is less pronounced than for temperature, it is still discernible. Salinity tends to be higher in winter months than summer months. The data used for sonification is the monthly average salinity in psu (Practical Salinity Units) for the year 2003 (fig. 2). It was chosen for its interesting musical gesture when sonified through simple scaling and transposition to frequency. These frequencies were then used a middle frequency for a bandpass filter applied to a noise signal. In this case, the data is used less for its inherent meaning than for its musical potential as a powerful gesture. Even if the listener does not get the same amount of emotional information as for the temperature sonification, its presence in the work still engages the listener in the data even if in a less strong manner.

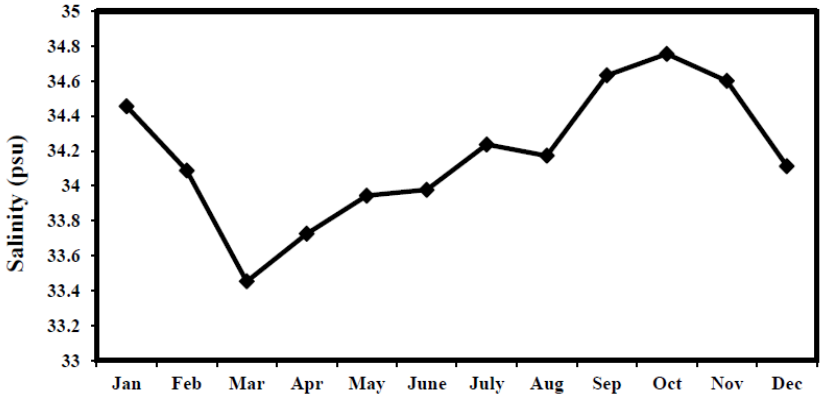

Fig. 2. Salinity at position P2 on the ferry route between from Harwich to Rotterdam for the year 2003.

Soundscape

The sonification elements are combined with a soundscape which in itself reflects the information from the temperature and salinity data. The acousmatic soundscape is composed of sound recordings from Wembury Beach in Wembury, Devon (UK) and Barbican Harbour in Plymouth (UK). Table 1 describes the sounds used; fig. 3 shows the progression from environmental sounds to human sounds in a coastal setting. This sound progression is also found in the piece; it begins with the recording of a river stream, before witnessing an increasing amount of human interaction with the environment such as walking, before evolving into a soundscape of human activity on the harbour. The natural-human progression ultimately reflects the information we gain from the datasets discussed: an increasing human influence on nature and resulting climate change.

TABLE I: SOUND SOURCES FOR THE ACOUSMATIC SOUNDSCAPE

Sound	Description
River	River stream
Waves	Incoming waves
Wind	Wind noises
Birds	Bird noises
Walking on sand	Walking on the beach
Walking in water	Walking in the river stream (all Wembury Beach, Wembury, UK)
Gravel	Dropping stones and gravel in bucket filled with water
	Dragging stones and gravel across the bottom of a bucket filled with water
Urinating	Urinating on Wembury Beach
Humans	Human activity on Barbican Harbour
Cars	Cars driving by on Barbican Harbour (both Plymouth, UK)

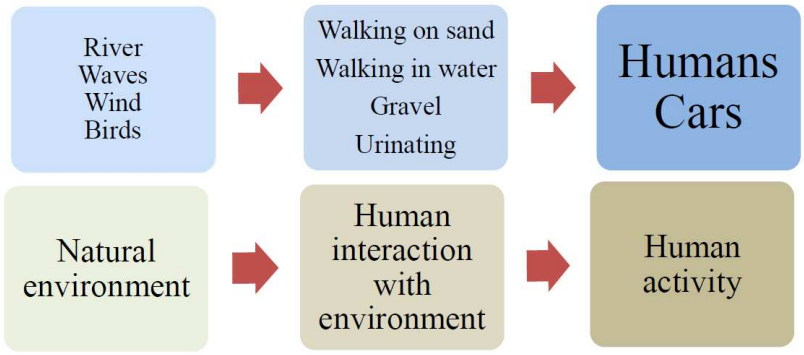

Fig. 3. Progression of recorded sounds from the natural environment without human interaction to a human.

4 Concluding Remarks

Our research looks at sonification as a compositional tool. This paper shows that musical elements and aesthetics of a sonification have a strong influence on the understanding of data. However, data can also shape a musical work through sonification. Patterns in data can create gestures and a larger musical structure but the nature of the data can also signify more than its extra-musical meanings as they dictate the nature of the music; in this case sea-related sonified data sounding like sirens and juxtaposed with maritime landscapes. The theme of climate change influences the progression in sound sources and musical transformations in the composition.

Practical work on musification clearly shows that the deep understanding of the data

by the composer is a needed prerequisite since it allows the composer to make informed decisions when reducing and compressing datasets. Without a sufficient knowledge of the scientific subject, the composer can just transmit the immediate, apparent information conveyed in the raw data. In our case, for instance, the understanding of the sources of variability in the temperature dataset (i.e., daily, seasonal, etc.) allowed an apparently simple data pre-treatment (i.e., choice of monthly averages) that proved very effective. It has also allowed us to choose and apply appropriate musical languages to express the emotional content of the data. In conclusion, sonification can be a powerful and useful tool for composition in electroacoustic music; not only can one convey a meaning or emotion through music, the music itself becomes the meaning of the data. A successful musification demands a thorough understanding of both the tool and the data it is applied to.

Supplementary Materials
To hear the full piece please visit
https://soundcloud.com/nuria-bonet/blyth-eastbourne-wembury

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