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Adaptive Soundscape Design for Liveable Urban Spaces: a Hybrid Methodology Across Environmental Acoustics and Sonic Art.

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Adaptive Soundscape Design for Liveable Urban Spaces: a Hybrid Methodology Across Environmental Acoustics and Sonic Art.

The aim of this research is to identify and implement soundscape improvement strategies in urban areas based on loudspeaker placements in the outdoor environment and the use of a computer-based system for adaptive soundscape generation, integrating sonic art practice with acoustic engineering rigour.

Keywords: sonic arts, noise pollution, soundscape, urban environment, auraldiversity, wellbeing

Background

Extending beyond the aims of noise control and mitigation, this multidisciplinary PhD studentship is an opportunity to devise, apply and analyse place and user-specific soundscape design within the built environment. The project builds on the formative work of R. Murray Schafer and the World Soundscape Project (Schafer 1993) from the 1970s and the more recent flourishing of soundscape research within the field of acoustics, such as the UK Engineering and Physical Research Council's *Noise Futures Network* (EPSRC, 2006) and the *EU COST Action TD0804 Soundscape of European Cities and Landscapes* (EU COST, 2009). One of the prompts for this PhD is the International Organization for Standardization's (ISO) adoption of the term 'soundscape', defined in part one of the soundscape standard series as the "acoustic environment as perceived or experienced and/or understood by a person or people, in context" (ISO, 2014) .

A recent review studied the last 27 years published research, and found multiple documented evidences of faster stress recovery and better self-reported health conditions related to the exposure to positive soundscapes (Aletta *et al.* 2018).

We think that an effective and meaningful implementation of soundscape standards and guidance requires robust and rounded approaches to measuring and assessing the human response to sound in all its diversity and larger effects on the urban environment. This requires new multidisciplinary research, including sonic arts practice (Lacey 2017) and sensuous urbanism (Radicchi in Wilson 2019 : 99-125), evidenced in case studies demonstrating soundscape practice and applicability in 'real-world' contexts – of which at present there are few. Moreover, this PhD project acknowledges the necessity for creative and exploratory approaches to designing contextually pertinent soundscapes and sonic interventions that can contribute to wellbeing against the backdrop of rapid urbanisation trends in cities (UNDP, 2017) and 24/7 cultural offerings (Mayor of London, 2017).

Previous research in adaptive soundscapes and sound art installations

Within soundscape research in environmental acoustics, we have found only a few papers about the effects of reshaping, restoring or treating an existing urban soundscape through the placement of active, pre-recorded sound sources in a noise polluted area which are playing back a purposely chosen soundtrack. Some of these studies have utilised natural recorded sounds like birdsongs and water features (Acloque and Schulte-Fortkamp 2011, Schulte-Fortkamp and Jordan 2016), in other cases pre-recorded music was used, (Acloque and Schulte-Fortkamp 2011, Steele *et al.* 2016). A context and site specific sound-design can account for the cultural and social specificity of a place, including the place-making design intent in case of transformation or redevelopment of a public space. To some extent, available statistics about the noise sound pressure levels in the area can also be used to adapt the sound design levels

according to a long-timescale variation (daily peaks at rush-hours, seasonal trends etc.). But the unpredictable short-timescale variation of the urban acoustic environment, like the passing by of emergency services sirens, or the odd-moments of quietness due to the cessation of roadworks, makes any given pre-determined static soundscape a sub-optimal implementation of soundscape re-design.

Conversely, an adaptive real-time soundscape generation which reacts to the variation over time of the acoustic environment in terms of level, temporal patterns and spectral content, has many more chances to be effective for diverse situations and robust against both sudden and long-term changes.

In Brighton and Hove (Lavia *et al.* 2016) a hybrid approach was tested whereby the playback material was programmed to adapt the content and sound levels at pre-determined time periods relative to known changes in the local environment with positive results. In a related project, also in Brighton and Hove (Lavia *et al.* 2012) another hybrid approach was tested, with the playback material curated in real-time through human intervention (in-situ musician), again with positive results.

However, only two papers by the lead author have covered the impact of making the playback ambient responsive -and adaptive - to the environment through an algorithmic approach.

These papers cover the research I carried out in the lab of Architettura Sonora between 2009 and 2010 with a multidisciplinary team (Cobianchi and Brusci 2010, Licitra *et al.* 2010). The system architecture developed at the time was employing: a database of site-specific and original soundtracks composed by a sound artist; a custom software developed in Max/MSP responsible for applying spatial and spectral processing to them during the playback according to the changes in the acoustic environment captured with

an array of microphones; multichannel audio amplifiers; a series of architectural loudspeakers visually integrated with the landscape.

The creation of the user and site-specific compositional database was a key stage to guarantee the integration of the augmented soundscape with the pre-existing one and the acceptance of new sounds as not alarming or alien. The database entries were designed by a sound artist considering the story of the place, the typical users, and the purpose of the intervention (most case studies were urban parks where the quietness and the restoration effects were sought). There was a total of about 20 different tracks, each with a duration between 30 and 60 minutes, to provide enough variety as well as adaptation capacity to the different environmental "rhythms".

This system was temporarily installed in different urban settings in Rome and Milan, as well as implemented in a garden nearby a trafficked road in Florence that we developed as our outdoor lab and called "the Sonic Garden", with encouraging results (Licitra *et al.* 2010).

On a path which runs in parallel to the soundscape studies within environmental acoustics I`ve found instead more artistic dialogues with the city environment such as the sonic art installation "Time Piece" by Max Neuhaus at the Whitney Museum in New York in 1983 (LaBelle 2015 :158), which augmented the soundscape with a delayed and pitch shifted reproduction of the acoustic environment as picked up by microphones along the avenue, following a "time keeping" cycle of 20 min. The resonant architecture of "Le Cylindre Sonore" by Bernhard Leitner for the Parc de la Villette in Paris in 1987 (Lacey 2017 :150), creates a semi-enclosed space of electroacoustic sounds within an urban park. The ambitious "Southgate" system of 156 speakers 'seamlessly embedded in the everyday infrastructure' in a shopping district in Melbourne in 1991 (ibid:152)

has been extensively used to play local composers` works before being decommissioned in 2006. Odland`s and Auinger`s “Harmonic Bridge” in North Adams, Massachusetts (ibid:162), was installed in 1998 and is composed of two aluminium resonators installed near the roadway which respond to the traffic noise and feed with their resonances a couple of speakers embedded in concrete boxes in the underpass where people can enjoy the traffic re-composition with its inner hidden harmony.

Bill Fontana`s monumental installations “Sound Island” (1994) and “White Sound” (2011), aimed to bring the ocean into the city, by playing a live feed of rolling waves through dozens of loudspeakers installed respectively at l`Arc de Triomphe in Paris and along Euston Road in London, at a sound pressure level competing with the traffic noise and thus capable of spectral masking (ibid :164).

Hellstrom`s sound art installation “Sonic Space” in Stockholm Mariatorget city park in 2010 (Hellström 2012), in contrast, plays sounds recorded in a nature reserve at a level which makes them subtle but still able to trigger informational masking.

Many other installations are reviewed in (Lacey 2017: 141-174) and in (Cerwen G. in Aletta and Xiao 2018 :23-45).

Most of these installations don`t necessarily have an acoustic masking intent, but they force the public space users to re-consider and re-negotiate their relationship with the space, and also with other users who are experiencing the space at the same time, either because of the intrinsic social pull of sound and music, or because of the call to interaction built in the installation itself through the use of sensors and interactive software. I trust this effect is not of lesser importance in shaping the perception of the urban environment and in determining the quality of our experience as city dwellers.

Research team

The research for the current project “Liveable Listenable Cities: human-centred

planning and appraisal of applied soundscape design for an auraldiverse population" is being conducted by: Mattia Cobianchi, MPhil/PhD Student, Goldsmiths, University of London and Senior Transducer Engineer at Bowers & Wilkins.

And supervised by a collaborative team comprising: Lead Supervisor: John Levack Drever, Professor of Acoustic Ecology & Sound Art and Head of Soundscape SIG, Co-Head of Sound Practice Research, ambassador for ICE (Invention, Creativity and Experience), Goldsmiths, University of London; Second Supervisor: Jonathan Freeman, Professor of Psychology, Goldsmiths, University of London and Managing Director of i2 media research, which specialises in digital consumer research; Co-Supervisor: Lisa Lavia, Managing Director of The Noise Abatement Society (NAS), PhD Student for Project DeStress on Soundscape and Wellbeing, Heriot-Watt University.

Methodology and areas of investigation

In an effort to take advantage of the possibilities afforded by the soundscape approach within environmental acoustics as well as by soundscape composition within sonic art practice, this research will follow a criss-crossing path between scientific rigour and artistic leaps.

System development

This stage involves the development of the adaptive software, soundscape composition and audio system design and installation.

The adaptive software needs to process in time the data acquired from a microphone array and output a multichannel audio stream. I will start by considering "adaptivity" as an acoustic response to the unwanted sounds, but I will also investigate other forms of adaptation to external stimuli and inputs (weather, users` presence etc.). A key concept is the definition of "unwanted sounds", since these will be very context and user

specific, thus some parametric control will be built in the software to allow at a later stage the definition of “unwanted” through quantities measured in-situ. Alternatively, we could implement a form of direct end-user interaction to allow the users to influence in real-time the behaviour of the system.

Current processing power on consumer computers allows the possibility of teaming up the processing and morphing of pre-composed soundscape blocks with real time synthesis of masking sounds, pattern recognition, as well as the re-use of noise and sound sources “found” in the acoustic environment as compositional blocks, to imbue them with new meaning and scope.

In this context, we would like to implement the soundscape composition as a co-creation process with the local communities to engage them in an active stand about which are the sounds that they regard as “unwanted” and which are instead the ones they would like to be more present. One potential dilemma we can already predict at this stage is if - and when - some sounds should be present (and potentially valorized, or “augmented”, instead of masked) even if the users don`t “prefer” them, because they “belong” to the place. This issue also falls within a current discourse in sound studies about the role of sonic art installations in educating citizens on how to listen to the ‘spirit of the place’ (Lacey 2016).

We also acknowledge the danger of the “uncanny valley“ effect (https://en.wikipedia.org/wiki/Uncanny_valley), where any introduced sounds which are realistic enough to fool our perception at first, suggest an expected sound source or event that has generated that sound, but then other sensory cues or further investigation by the user disattend this expectation, creating frightening and/or uncomfortable feelings. Possible strategies to avoid this I think may be the careful study of aural-visual

interactions and the location and spatialization of familiar introduced sounds in places consistent with a plausible source, or in places which do not encourage any further investigation.

I will first implement and test the adaptive system in a laboratory environment to assess under controlled conditions some basic users` responses via surveys and questionnaires to investigate the qualitative experience of the users as well as the change of descriptors like vibrancy, pleasantness and eventfulness (Aletta and Kang 2016). In terms of soundscape rendering and assessment of aural-visual interactions, full Virtual Reality headsets with head tracking, binaural audio as well as Ambisonic loudspeakers systems and video projection systems are all options we are considering, but since there is not yet an international standard available, a review of the most recent ecological validity studies is in order, for what concerns level, spatial attributes, descriptors consistency, cross-modal interactions etc. See for example Maffei *et al.* 2015, Sudarsono *et al.* 2016, Hermida Cadena *et al.* 2017, Hong *et al.* 2017, Campos *et al.* 2018.

At a second stage, I will design and supervise the installation of two outdoor systems for the in-situ testing of two bespoke sound installations in contrasting outdoor locations in the city of Brighton and Hove or London. The only difference from the laboratory environment is that this time we will need to face the challenges of a public space in terms of health and safety, installation practicalities on a large surface area, environmental reliability of the outdoor speakers, vandalism and sabotage etc. The encouraging experience of the Brighton beach tunnel experiment (Easteal *et al.* 2014) suggests that long term installations of this kind are feasible and sustainable.

Auraldiversity and inclusivity

We should pay attention at all stages of the research to the inclusion of subjects from the auraldiverse population in the range of potential users who can benefit from this approach. Auraldiverse subjects, i.e. subjects who temporarily or permanently do not exhibit 'normal hearing', are well defined by J. L. Drever in contrast to auraltypical people, or subjects with an 'otologically normal hearing' (Drever 2017), following a shift in perspective from classical otology. This new definition brings to the fore the socio-cultural implications of the different degrees in between perfect hearing and deafness, by challenging the assumptions made by subjects with a normal hearing about the pleasantness and acceptability of a specific acoustic environment. The auraltypical population may tend, unknowingly, to impose their understanding of normal hearing on others as correct and natural. However, a wide range of vulnerable auraldiverse subgroups including, but not limited to, infants and children, dementia sufferers, the visually impaired, hearing aid users and those with hyperacusis and hyperacute hearing in Autism Spectrum Disorder may as a result suffer serious physical, mental and emotional discomfort in situations that may be acceptable or comfortable for the auraltypical population. While in an ideal case scenario the augmented soundscape would constitute an improvement for both the auraltypical and the auraldiverse groups of people, this may not be possible, and we will be called to make a situated judgement to choose a reasonable and justified compromise.

In-situ testing and behavioural observations

The final stage of the research consists in the presentation of two bespoke sound installations in contrasting outdoor locations in the city of Brighton and Hove or London.

Further to the possibilities already discussed within a laboratory testing context, in terms of assessment of users` responses to soundscape modifications in outdoor locations, we intend to take advantage of a combined approach that uses in sequence behavioural observations, open ended question interviews and self-reported surveys. This chronology should help ensure that participants' rationalisation process does not affect their natural behavioural responses.

Recognising the difficulty in assessing human responses to sound using traditional participatory or self-reporting survey techniques, recent studies (Lavia *et al.* 2012, 2016, Lepore *et al.* 2016) have successfully employed non-participatory and observational behavioural observations: finding that changes in human behaviour "can manifest as rates of behaviour, directions of behaviour, or as entirely new behaviours, which can be measured in appropriately ethically approved non-participatory observation studies to quantify these changes" (Lavia et al in Aletta and Xiao 2018 :86). This is an alternative and promising approach.

Traditional self-reported noise survey methods, using questionnaires or interviews require participants to consciously rationalise their response to sound at a specific point in time. This can be problematic as the human perceptual response to sound is mainly unconscious, emotional and context based (e.g. people can like or dislike the same sound depending on the context in which it is heard, associated activities being performed, resting states and expectations). While convenient for researchers and practitioners, the limitations of self-reported survey methods risk biasing the answers to the questions while non-participatory methods can be cost-prohibitive to conduct and present many ethical challenges (ibid).

Conclusion

To create liveable cities which minimize the negative consequences of noise pollution, robust methods are needed to: accurately identify, collect and analyse objective and subjective data regarding the causal links between the quality of the acoustic environment and people's subjective response, and make sound studies comparable for particular use cases. This sonic arts PhD will explore the impact on people of soundscape composition, going beyond previous studies, along a continuum from passive noise control, to classic subtle natural soundscape composition (e.g. birdsongs and water sounds), towards more compositional and art intervention approaches. This project will help evidence how 'the world of social sciences increasingly enters into resonance with the art world to contribute to a socio-aesthetic of the sonic world.' (Thibaud in Guillebaud 2017 :225) thereby helping to improve citizens' wellbeing.

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