The City Soundscape and the Brain

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Abstract

This paper will discuss the integration of sonificationin urban design and planning. Being both temporal and polyphonic in nature, soundcan assist in the representation of the multiple temporal flows whichcontribute to the urban dynamic of a city. Thus we propose a 'sonified' urban masterplan to represent the city in time as well as space, allowing us to better compose urban flows such as movement. First, we introduce the Sonified Urban Masterplan tool, and describe how it can be used to sonify the multiple layers of graphical information used in urban design and planning. Then, we describe how we can use sound to represent different urban systems, before explaining the generation of a Sonified Urban Masterplan for the city of Paris. Through adiscussion ofthe various reactions received from members of the general public, we conclude with the different advantages of the integration of sonification in urban design and planning.

Keywords: Urban design and planning, urban sound cartography, sonification, urban rhythm, Rhythmanalysis

1. Introducing Urban Rhythm

The city is a dynamic organism consisting of a number of urban flows, including environmental, transport, and activity flows. We can call these spatio-temporal relationships 'urban rhythms'. Urban rhythms, as described by philosopher Henri Lefebvre, can be observed everywhere where there is an interaction between a space, a time and an energy. (Lefebvre 2004) However, in order to be analysed, these rhythms must first be captured through some sort of spatio-temporal representation technique.

The analysis of urban rhythm, named Rhythmnalysisby Lefebvre, can be used as a way of understanding the city. The city, as a collective organiser of our spatio-temporal movements, can be seen as a composer of our social and cultural rhythms. However, these urban rhythms are also subjected to the larger rhythms of the environment, such as the seasons and the tides. In fact, we can see our lives in terms of different types of rhythms at various time scales, which occuron a yearly, monthly, weekly or daily basis. The routine of everyday working life – the cycle of leaving home to go to work in the morning and returning in the evening - is an urban rhythm familiar to many of us.

Many urban problems can be attributed to a failure to appropriately design in space for our desired temporal outcomes. For example urban sprawl, combined with an inadequate provision of public transport infrastructure, has contributed to an over-reliance on the motor vehicle. This has lead to traffic jams and excessive commuting times,as well as a lack of urban activity and undesirable pedestrian experiences. The problem of urban sustainability can thus be viewed as a rhythmic one and addressing it calls for a more temporal approach to urban design. (Adhitya 2013)

It is not surprising that urban design is primarily concerned with the spatial organisation of built form, considering its reliance on visual representation techniques. The problem of the graphic urban masterplan is that it is static in nature, as well as limited in the amount of information that can be portrayed - too much visual information becomes illegible and thus incomprehensible. Sound, however, has several advantages which graphic representation lacks - it is both temporal and polyphonic in nature. It is thus well adapted to the representation of temporal information, such as the multiple temporal flows of a polyphonic urban system. In fact, audition has been noted to play a greater role in the cognition of simultaneous streams of temporal data. Sonification is a relatively recent technique which involves the representation of data through auditory means (Kramer 1994).

Thus in this paper, we explore the potential for sonification in the representation and analysis of urban design and planning. In our attempt to integrate sound in the urban planning process, we explore the sonification of urban cartography, which would allow the visual information of an urban masterplan to be heard as well as seen. We discuss the development of a Sonified Urban Masterplan tool – the "SUM" tool –which enables us to articulate various urban systems– environment, transport, form, activity, and design - in time as well as space. As a case study, we apply it to the city of Paris and obtain the reactions of both the general public and urban professionals. From their feedback, we discuss the effectiveness of sonification in the representation of the urban system and the understanding of one's rhythmic experience in it.

2. Background: Urban sound cartography

Existing urban sound cartography involves the integration of information concerning the acoustic environment with its geographical location, whether quantitative noise levels (in dB) or more qualitative soundscape recordings. This can involve geo-localised environmental sensing from official sources (e.g. Eyes on Earth - NoiseWatch[1]) or collaborative databases involving crowd-sourced data from geo-localised mobile sensing devices (e.g. NoiseTube[2] and Le MontreVerte[3]).

However, urban designers and planners are responsible for analysing and designing for many urban rhythms which cannot always be heard, ranging from environmental, transport and activity flows, to urban morphology and design. In determining where and how we spend our time, the urban structure inevitably plays a role in composing our everyday urban rhythms. The spatial composition of built form and the temporal connections between them, determine the flow of people and their relative activities, whether commuting, working, or recreational. How can we therefore represent these rhythms of movement and activity, in

1. European Environment Agency (EEA) http://www.eyeonearth.org/en-us/Pages/Learn-More.aspx [Accessed May 2013]
2. http://www.noisetube.net/#&panel1-3 [Accessed May 2013]
3. http://www.lemonde-des-plantes.com/montre-verte/ [Accessed May 2013]

order to better understand the dynamic of a place, and the way in which we spend our time? Through image sonification, in which data has a position in time as well as space, the representation of urban rhythms is possible.

3. Methodology: A Sonified Urban Masterplan

With the objective to integrate sound into the urban design and planning process, a tool for the sonification of the urban masterplan was developedin collaboration with Dr. Mika Kuuskankare[4] at Ircam-Centre Pompidou, Paris.[5] The SUM tool is an image sonification tool which can be used to transform graphics into sound, towards the creation of audio-visual maps.

Existing image-sound tools, such as Xenakis' UPIC[6] and its modern equivalent of HighC[7], were intended for graphic music composition and consist of a single image layer read along a single time line from left to right. However, in order to sonify the multi-layered, spatio-temporal structure of the urban system, we required a tool which could support the sonification of multiple graphic maps and their lecture from multiple directions and speeds. For analytical purposes, it had to be able to transform existing images, and for design purposes it should be possible to create new ones.

The SUM tool was thus specifically designed to support this multi-dimensional structure. Developed within the visual computer-aided composition environment of PWGL[8], it provides a flexible environment for both sound design and graphic composition. It allows both the importation of raster images, such as existing masterplans, as well as the creation of vector objects for the development of future urban designs. It also allows the definition of any number of spatio-temporal paths of varying speed, for the representation the various urban flows of interest.

4. Sibelius Academy
5. Adhitya, Kuuskankare (2011)
6. Xenakis (1977)
7. Baudel(2008), Available from: http://highc.org/
8. Laurson (2009)

The SUM tool translates image into sound through the processes of image rasterisation and parameter-mapping, as shown in Figure 1. After first rasterising the images along our vector paths of interest[9], the graphic parameters (RGB colour values) are obtained. These are then converted into sound parameters according to a sound design strategy defined by the user, generating an Urban Sonic Code.

Figure 1. Urban sonification process – from image to sound.

The sound design strategy is crucial to the effective acoustic communication of the data concerned. In our sonification of urban rhythms, we seek to represent a number of urban systems– environment, transport, activity, urban form and its design elements. Thus, in order to be able to identify and differentiate between each urban system, we must consider bothhow and what we hear.

Drawing on theories of acoustic perception and cognition, our 'urban sonic code' thus consists of a combination of soundscape recordings and acoustic modelling techniques, depending on the nature of the urban data. Iconic sounds were used whenever possible in order to assist learning through semantic association[10] (e.g. a church bell associated with a church). When objects are not associated with ecological sounds, sounding objects were created.[11] In order to distinguish between each system, we have associated each with a different timbre like the different sections of an orchestra: strings for transportation; brass for environment; woodwind for activity; and percussion for urban form and design elements. The idea was that when played together, due to their timbrel differences, an 'urban orchestra' would result.

9. according to Bresenham's line algorithm, Bresenham (1965)
10. Hermann et.al (2011)
11. Rocchesso, Fontana (2003) Available from: http://www.soundobject.org

4. Application: Playing Paris

The SUM tool was then used to generate a Sonified Urban Masterplan for the city of Paris. After generating an image dataset for each urban system of interest –environment; transportation; activity; urban form; and urban design -the colour-coded data was translated into sound using the SUM tool. The composition of one path could be listened to over time, such as the evolution of a linear experience, as well as its simultaneous relationship to other paths, such as the different lines of the transport system. The set of audio-visual maps could also be played together, such that their interrelationships could be heard. As an example, we sonified all the systems along a specific street in central Paris, Boulevard de Sébastopol, as shown in Figure 2 below.

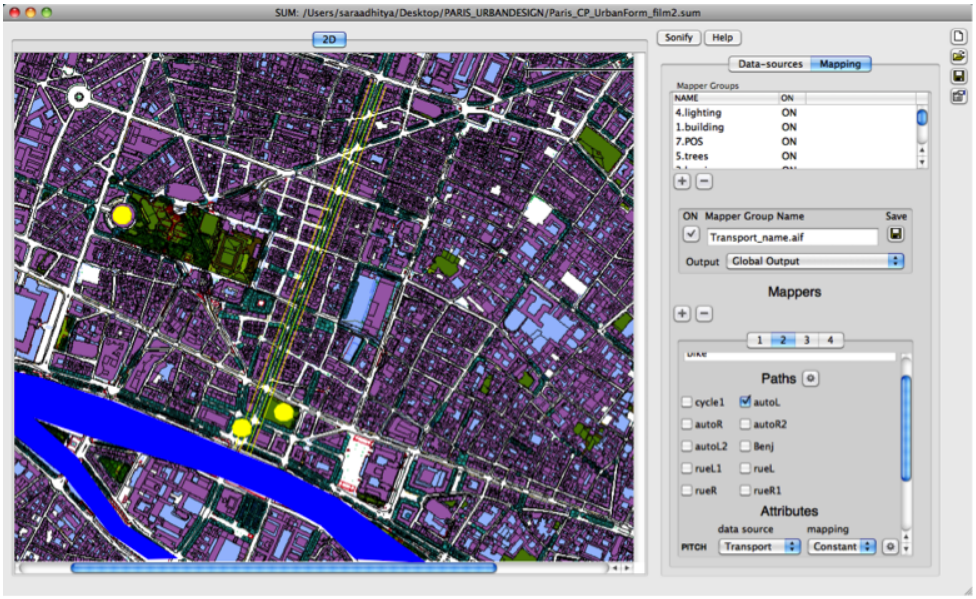

Figure 2. Sonification of Boulevard de Sébastopol, Paris, in the SUM tool.

In order to test the effectiveness of SUM as an urban representation tool, we presented the urban sonic code and resulting sonification to 25 members of the general public[12] in the form of a video. As to be expected, the effectiveness of the acoustic communication depended on the listener. The spatio-temporal connection between image and sound was well-received.[13] However, while there was ready acceptance of the iconic sounds, the more

12. non architects, urban designers or planners
13. Adhitya (2013) '*One can easily assimilate the visual data presented as (s)he follows the structured relationships between them!*' Subject xx.

abstract sounds received mixed reactions, with some participants more receptive to the abstract mapping than others.[14] With little training prior to the viewing of the video, this is not surprising, and can be improved in the future with further training of the urban sonic code.

5. Results: Listening to Paris

The Sonified Urban Masterplan of Paris attracted a range of responses when presented to the 25 members of the general public, who were not urban professionals. Their feedback to the communicative power of SUM will be discussed below, including its ability to provoke feelings of emotion and recognition; represent temporality and movement; communicate urban data; and increase rhythmic awareness through embodied experience.

Evoking a range of emotional responses,SUM was recognized as a tool '*capable of triggering powerful emotions*'.[15] Aesthetically, the sonification was described as a '*...natural and almost playful data representation*'[16], with several participants referring to it as a '*musical composition*'.[17] Intellectually, SUM inspired an interest in listening to other places, the curiosity to interpret more paths,and the desire to learn more about the composition of the city. The sonification was also reported to have succeeded in igniting the memory and provoking feelings of recognition.[18] Those who were already familiar with the area claimed that the sonification helped to 'transport' them to the place represented and 'relive' their experiences with greater awareness.[19] To those who were not familiar with it, the sonification was said to have helped them imagine what it would be like to be there.[20]

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14. Ibid. '*Of course, some mappings are easier to interpret with no training, while for others I would need some more experience*' Subject xviii.
15. Ibid. Subject xxi.
16. Ibid. Subject xx.
17. Ibid. 'like listening to a piece of music'. Subject i.
18. Ibid. '*I lived in the area for 6 years and the analysis of Bld Sebastopol feels very familiar - many of the sounds evoke emotional feelings as they mimic the real sound*' Subject xvii.
19. Ibid. *'As the examples in the video are about places I've been to, I feel transported there and biking down Boulevard de Sebastopol but in a more aware fashion than I would normally do*.' Subject vii.
20. Ibid. '*Looking at the map and listening to the music simultaneously provoked visualisation of the journey*.' Subject iv.

The ability of sonification to represent travel and movement in a more experiential way was also recognised, through its inherent temporality and capacity to give a sense of timing.[21] The speed of the path was reported to help with one's understanding of distances, as well as the necessary travel time, which is difficult to judge from spatial representation alone.[22] The sonification canal so be seen to have been successful in 'embodying' movement, with a cyclist, for example,able to recognize familiar rhythms of travelling down a road at a certain speed.[23] This included rhythmic qualities of density, repetition, and variation.

SUM was said to reveal a number of urban 'dimensions' not normally revealed in the graphic urban masterplan, including the plurality of a city. This included how the city was used by its' inhabitants, and the change of activities over time, described by one participant as the 'life' of the city: '*The fact that the city is alive, that there are things that happen and change, that walking in a street you can see many different things from one square to the other and discover things.*'[24] In doing so, the sonification was able to communicate the social dimension of a city, rather than simply its physical urban structure,and was celebrated for providing a 'much deeper experience' than just looking at a map.[25]

Last but not least, other practical advantages of sound in urban representation were acknowledged. Not restricted to physical scale, sound was able to represent the smaller-scaled details difficult to communicate on a map. As described by one participant, including such information would easily make the graphic masterplan '*very noisy and impossible to communicate with*'.[26] In addition to scale, this was largely attributed to the polyphonic nature of sound: '*While visually you can only focus on one thing, aurally you can have more than one input.*'[27] Sound also contributed to aiding the legibility of the map by avoiding '*... frequent references to the legend.*'[28] Sonification was celebrated for enhancing the graphic plan, making it more 'informative' and 'enriching' through another layer of representation.

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21. Ibid. '*It was more experiential than just looking at a graphical plan, gave me a sense of timing of a place in a similar way to physical travel.*' Subject xxii.
22. Ibid. '*The pre-set pace also allows me to have an idea of distances. With a purely graphic map it is often hard to judge how long it would actually take me to walk or bike from one place to another - especially for an unfamiliar city.*' Subject vii.
23. Ibid. '*As a biker I did have some awareness that fitted well to the rhythms represented...*' Subject iii.
24. Ibid. Subject xviii.
25. Ibid. Subject vii.
26. Ibid. Subject xvii.
27. Ibid. Subject x.
28. Ibid. Subject vii.

6. Conclusion: SUM and urban representation

The richness of the responses received with respect to the first application of the Sonified Urban Masterplan of Paris, demonstrates the great potential of sonification in urban representation. These initial responses demonstrate the ability of sound to communicate urban movement, experience and rhythm, on both an emotional, aesthetic and intellectual level. This was confirmed by feelings of recognition reported by those familiar with the area. The polyphonic dimension of sound was celebrated for its ability to communicate the plurality of the city often lost in the graphic plan, including its social dimension, while its temporality allowed one to understand the rhythms of the various urban systems over time. For some, it was an introduction to the invisible rhythms of urban composition more often than not ignored on a conscious level.[29] For others, it provided a way of capturing lived experiences that the static masterplan could not. In both cases, sonification can be seen to have increased awareness of the effect of the urban structure on the resulting urban dynamic.[30] Through the act of listening, not only to the soundscape but to one's embodied experience, we hope to deepen our understanding of the urban composition on our urban rhythms, towards the design of more enjoyable and sustainable experiences in the future.

> 'Listening to the transposition in sound of the monuments, offices, markets, trees of Boulevard Sebastopol opened me up to the possibility that this manner of interpreting the urban dimension may in fact help to develop a deeper understanding of the city in which I live.'[31]

29. Ibid. '*... I'm not even aware of it while I'm walking in the city itself. I'll go through crowded places and more silent areas but will not perceive the inherent rhythm consciously.*'Subject xiv.
30. Ibid. '*New and repeated sounds drew my attention to the variety and placing of different aspects of the city, and made me realise that these might be more intentional and "beautifully" placed than I had first realised!*' Subject xxii.
31. Ibid. Subject xiii.

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