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Towards Participatory Design of City Soundscapes

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Abstract. Sonic environments of fast-growing urban areas are an integral part of the quality of our everyday living in cities. Due to the individual nature of the sonic experience, collecting and analyzing such experiences needs methods for gathering accurate and useful data about them. This paper describes how to incorporate the concept of soundscape into city planning processes. To achieve this, we propose creating participatory methods for gathering data from the citizens so that the data would be useful and relevant for the city planning professionals. Since the participatory planning process aims at in evolving the citizens, we suggest methods that utilize crowdsourcing, mobile technology and machine learning for presenting, workshopping, and designing soundscapes in the city context.

Keywords: Sound, design, soundscape research, communicative planning, smart cities, urban planning, tool support, crowdsourcing

1 Introduction

Urbanization and fast-growing cities have catalyzed the importance of designing urban spaces that the citizens find pleasant, homey and that support the communal style of living. Unfortunately, tools and techniques that are suited for the task are rare, and even latest research focuses on noise abatement and preserving quiet areas [1] [2] [3], overlooking the design of our everyday sonic environment.

In his famous book "The Soundscape – Our Sonic Environment and the Tuning of the World", R. Murray Schafer asked if the soundscape is something over which we have no control, or are we its composers and responsible for giving it a form [4]. The design

of an urban sonic environment soundscape should be a component of the urban planning process. In our visually orientated western culture, we tend to con-sider a city as a visual entity and the soundscape is a byproduct. Challenge in design-ing a high-quality sonic environment is the fact that different groups of people react to sounds differently [4]. Therefore, it is difficult to define a quality level for sonic environments.

This paper proposes a smart, participatory method for presenting, workshopping, and designing soundscapes in city context. The method aims at serving the above objectives in city design. From the technical perspective, the method is based on previous development, where an audio platform containing sound mixing application for soundscape design was implemented to support crowdsourcing and data collec-tion methods [5] [6]. In this phase, the research focuses on the development of the data collection, defining a common vocabulary for soundscape experience and the professional reuse of that data for planning purposes, where different stakeholders – citizens, municipal actors, and constructors – seek consensus on the designs.

The rest of this paper is structured as follows. In Section 2, we present the back-ground and motivation for this work. In Section 3, we present the problem of ex-pressing sonic memories and solutions how mobile technology could solve these issues. In Section 4, we discuss the possibilities that soundscapes offer to city plan-ning. In Section 5, we present the lessons we have learned so far in the process. In Section 6. we draw some conclusions.

2 Background and Motivation

Soundscapes. A soundscape is any acoustic environment perceived by humans [4]. The term acoustic environment refers to sound as it is received from all sound sources modified by the environment [7]. Here, a soundscape is understood as an acoustic environment perceived or experienced and/or understood by a person or persons, in a specific context.

An urban soundscape – a soundscape that represents the sonic conditions of an urban area – is a complicated, multi-layered, multi-sensory experience. It is difficult to describe or define a city soundscape, since every city as well as different parts of them differ from each other, sometimes dramatically. Just by walking a kilometer or even less, the soundscape can change from heavy traffic noise to serenity of nature sounds, and vice versa. Furthermore, every component of the city soundscape is linked to another due to the nature of soundwaves. Therefore, a soundscape is con-stantly moving, breathing, changing both as an acoustic environment and as a sonic experience.

The soundscape is not only something that surrounds us but it also includes the listener's perception of the sounds. Us humans constantly produce, modify and change the soundscape and at the same time affect each other's experience of our sonic environment. This experience is not only dependent on the sounds and compo-nents of the soundscape but the subjective evaluation of acoustic phenomena [8].

Participatory planning. Communicative or participatory planning is an approach to urban planning that aims to engage the citizens or other stakeholders into deci-sion-making [9]. The theoretical conclusion of communicative planning is that in social, open and transparent processes the citizens or other stakeholders construct more reliable and influential knowledge [10]. In the so-called "communicative turn" in urban planning since 1990s, the role of the citizens has changed from the user of the residential areas to active participants of the planning process [2]. Even though the communicative planning process emphasizes citizen's trust to decision-making in create better environments, it is not trouble-free. Stakeholders have different ap-proaches, interests and objectives, and they may not automatically serve the com-mon good. Planner's professional role is to reconcile different viewpoints and in-formation regarding planning and to offer participants an opportunity to reach a common understanding [11]. Due to a lack of systematic methods, gathering the data from the stakeholders is problematic.

The challenge in incorporating soundscape design in the participatory city plan-ning process is that where buildings and plots have edges, soundwaves travel from one area to another as long as they have faded out. This means that there is no empty space or clean canvas when it comes to soundscapes. Introducing new buildings, streets, parks or changing the structure of the city in any way does affect the sound-scape but it is hard for the public to imagine the changes that can be quite unpredict-able sometimes. These changes are dependent on surface materials, structures and shapes of the buildings, the amount of traffic or people, and machinery such as air conditioning that are included in the city structures. Furthermore, animals, weather conditions, speed limits, special events and thousands of other little things change what the city sounds like.

Photography, maps, drawings and nowadays 3D models give us a living and accu-rate impression of a space or scenery. There is no corresponding method in sonogra-phy to describe the environment as well as any visual image can [4]. On linguistic side, we face the same problem: there is a lack of lexicalized terms and vocabulary for describing sounds [8].

Soundscapes in participatory planning. Describing a sound consists of the emo-tion and experience of the sound. A soundscape can be experienced negatively, posi-tively or something in between and this is dependent on experiences, personal histo-ry, and preferences [12]. Therefore when the citizens are asked what they would like their sonic environment to sound like, the answers cannot be anything else than quite imprecise.

From an urban planning perspective, the soundscape is mainly studied as an acoustic space and the research focuses on noise abatement, noise pollution and protection of quiet areas. Noise levels are measured in decibels, which is important when the target is to reduce the overall noise level in urban areas. The importance of this approach is unquestionable as well as the fact that noise causes health problems, annoyance and lowers the inhabitants' positive relationship to their habitat [13] [14]. Yet measuring decibels does not tell much about the information or the individual's emotional experience of the sound in question [4].

Ever since composer and environmentalist R. Murray Schafer started his "World Soundscape Project" and stated that there should be a subject which we would call

"acoustic design" [4], dozens of researchers from various fields of science have searched for a solution for designing and creating a better soundscape. Designing a sonic environment is a multi-disciplinary process that requires the knowledge and involvement of various professionals from planning, architecture, acoustics, noise abatement and so on. There are no official guidelines on how the design process should be carried out and how the involvement of different stakeholders should be done. The latest research shows that there is a need for more detailed and structured guidelines for soundscape planning [15]. The stakeholders should be involved during the whole planning process and that an appropriate engagement process with a rele-vant panel of representatives is crucial to the successful identification of the issues [1].

The current trend in soundscape research is to move from understanding towards designing the environments. There is a rapid expansion of research and the aim of this work is to provide policy-makers and practitioners with operative tools, stand-ards and methods [3] [16] [17]. Wide range of research has been done in the field of noise abatement, noise monitoring, prediction models and auralization [18] [2] [19]. Kang et al. have proposed a model, which profiles recorded soundscapes, applies linear regression to soundscape profiles to predict suitable perceptual attributes re-lated to each soundscape, and finally visualize perceptual attributes as layers in geo-graphical maps (soundscape maps) [2]. While Kang would use a grid of small sen-sors to collect soundscapes, Zappatore would rely on crowdsourcing and mobile phones [19]. In Zappatore's approach, mobile devices would be used as recording decibel meters. Recordings, location info, info about user's perception about noise pollution, and other sensor data from a mobile device will be uploaded into backend service. Recordings are analyzed and visualized as noise maps. With all this research there is a common goal to understand how acoustic environments are perceived and thus enhance the sonic environment of urban areas.

Incorporating the concept of soundscape into the planning process is a fairly new idea. Soundscape expertise is not included in the planners' profession and training the planners is probably the first step towards better sonic environments [12]. Due to the individual nature of the sonic experience, the second step would be creating methods for gathering accurate and useful data. This paper aims to define how to incorporate the concept of soundscape into planning processes. This contains creat-ing participatory methods for gathering data from the citizens so that the data would be useful and relevant for the city planning professionals.

3 Supporting the sonic memory with audio tools

In everyday listening, we focus on gathering relevant information about our environment. We sort, evaluate and describe the sounds according to our hedonic judgement and with spontaneous association. [3] Therefore, any public discussion about sonic environment rarely offers nothing more quite overall data. To assist this conversation we have created a mobile soundscape mixing application [4] in which the soundscape can be divided into pieces and re-arranged. In order to see how this changes the communication we ran a test to compare the different ways of expressing sonic experiences.

3.1 Mobile mixing tools

The idea of the mobile mixing tools was to create an easy and simple method for anyone to create and share their opinions about sonic environments. Our mobile soundscape mixing application is a part of an audio platform (Fig. 1). This platform consists of an audio digital asset management system (ADAM), a management application, and mobile applications. Soundscape management (soundscape mixing application), NFC tag management and audio story management applications (audio story sharing application) will run on smartphones. The admin console (management application) will run on the workstation's web browser. The data management and data storage modules (ADAM) run on application and database servers, which could be separate physical or virtual servers or one server combining both roles. The platform is modular so that a user can pick up only those mobile applications that they need. ADAM contains functionalities to manage the assets and an interface for the management application and mobile applications over the Internet. The management application is an administration console for managing the audio files and users.

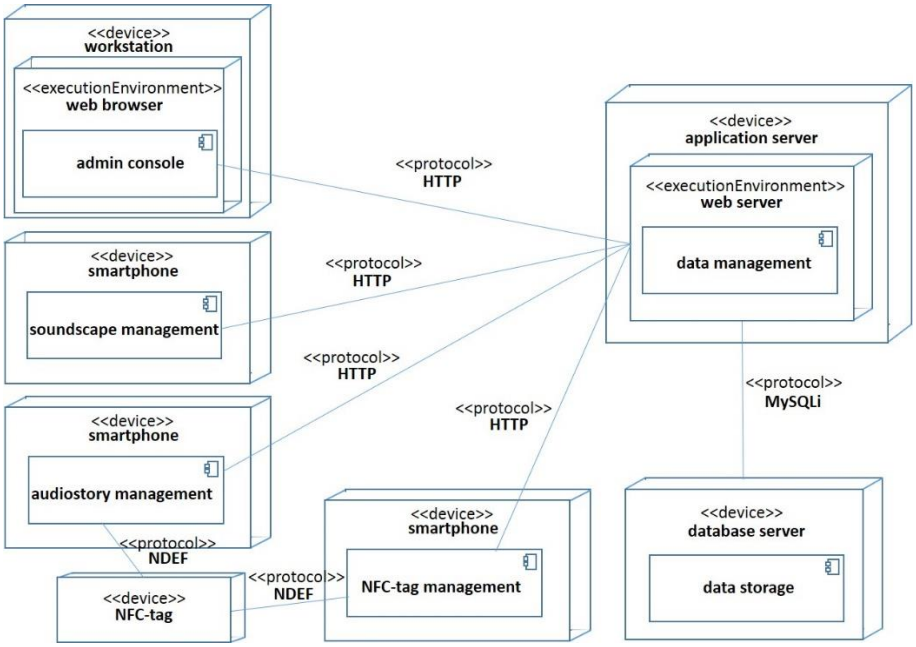

Fig. 1. Audio Platform deployment View

We developed a soundscape mixing application called SoundSpace to increase user interaction by developing soundscapes from building blocks stored in ADAM [20]. The SoundSpace tool allows the user to test and play with soundscape elements [5]. The user can search audio files from ADAM, and listen to sounds before selecting them to create a soundscape segment by segment (Fig. 2). SoundSpace then plays the audio

files together by looping them and thus giving an audible example of different kinds of soundscapes.

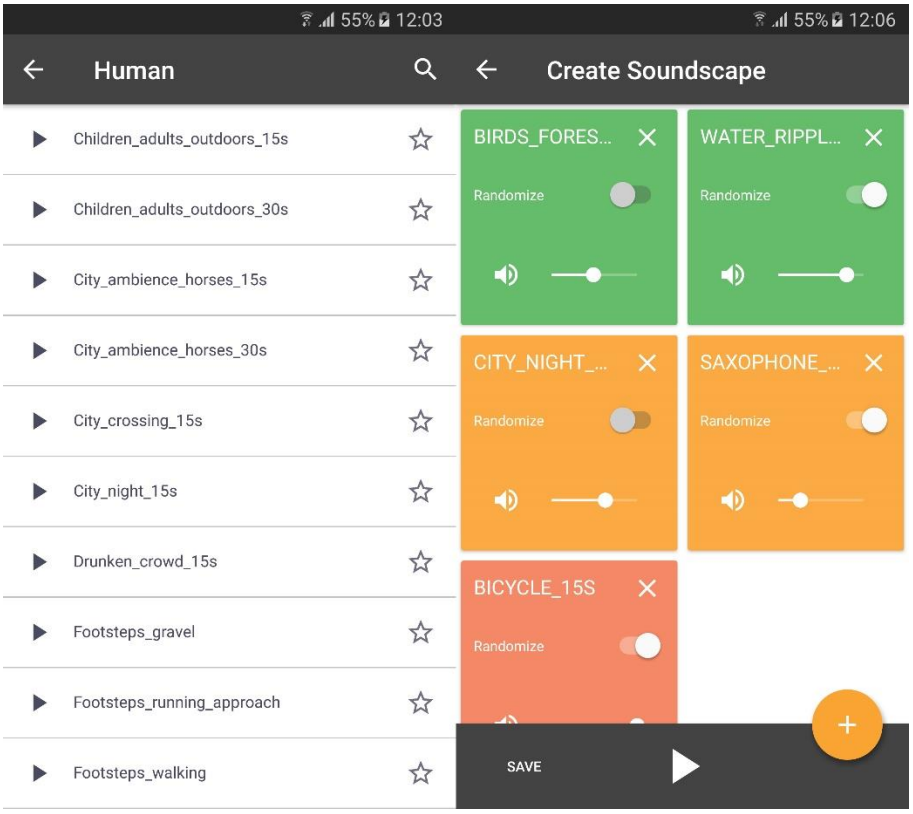

Fig. 2. The SoundSpace tool's user View

Such audio platform can be used in the participatory planning process in many ways. The mobile application could be offered for the citizens for free use and ask them to upload the kind of soundscapes they prefer. This could be done as a general enquiry or for a specific location. ADAM could be used to store and share uploaded soundscapes.

3.2 Sonic memory and useful data

To observe how a mobile tool that creates hearable opinions affects the ways a person describes ones impressions about soundscapes we ran a test with group of university students. The aim of the test was to study the following topics:

1. How well a person is able to recall a soundscape after a while.
2. What kind of verbalization/vocabulary the participants use to describe the sounds they heard.

3. Is there a difference between recollections that are memorized and written down, and memorized with the sonic mobile tools.

3.2.1 Method

Participants. The voluntary test group of 18 university students from Information and Communications Technology Department of Metropolia University of Applied Sciences.

Material. First soundscape resembled an urban nature environment (Fig. 3) and consisted four sound files from the sound collection:

- Finnish birds singing
- A summer forest ambience with mild wind and birds
- Lapping of light waves
- Distant discussion noise

The volume of the water sounds and discussion sounds were lower to make them more distant.

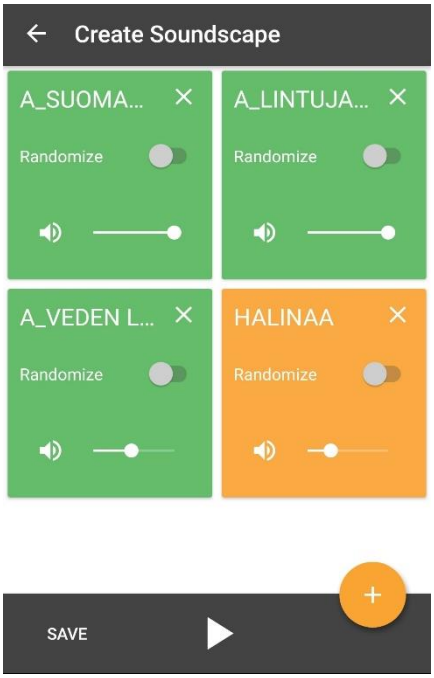

Fig. 3. Nature soundscape setup

This soundscape could be called a 'hi-fi' soundscape as R. Murray Schafer defines [4]. In a hi-fi soundscape the background noise is low and even quieter and distant sounds can be heard. The listener is able to separate sounds from each other. On the

contrary, in a lo-fi soundscape an individual sound disappears into a flood noise and only the most dominant and loudest sounds can be recognized.

The second ‘lo-fi’ soundscape sounded like a busy city with people and traffic (Fig. 4). This soundscape also consisted four sound files:

- Street noise with low frequency traffic sounds, tram rumbling and people walking and talking
- City humming and a tram passing by
- A motorcycle passing by
- A person walking by from a close distance with high heels

The volume of the street noise, city humming and the motorcycle was adjusted to lower to create a more balanced soundscape.

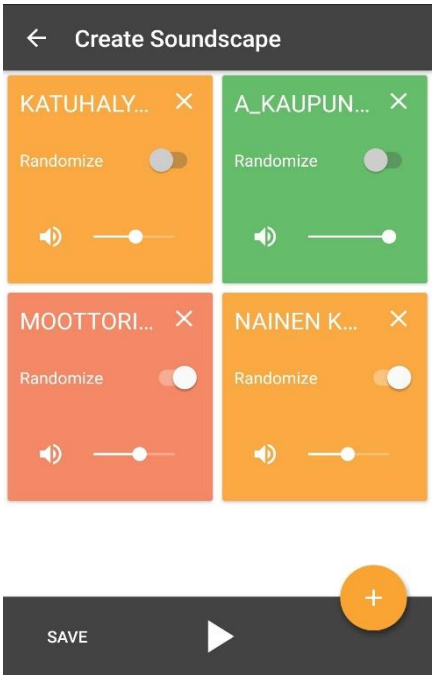

Fig. 4. City soundscape setup

Schafer also presented a classification of the soundscape elements [4]:

- Keynote: ambient sounds (such as wind, traffic, humming, etc.) which are not actively listened because they are filtered out cognitively.
- Soundmark: a sonic landmark; a sound which is characteristic of a place.
- Sound signal: a foreground sound that is listened actively. These sounds usually carry a signal with a message (car horn, dog barking, etc.).

The soundscape examples contained a keynote and several sound signals. To avoid too strong associations to real existing places there were no soundmarks. Tram sound is distinctive to some cities but still it is associated to several places around the globe.

Procedure. The participants first listened to two soundscape audio files in a classroom from loudspeakers. The participants were instructed to concentrate on listening and not to take notes or do anything else while listening. Both sound files were approximately 1.5 minutes long.

After 12 days, the test group was gathered in a classroom and divided randomly into to two groups. The first group stayed in the classroom and the second one was guided to another classroom. All the participants used their personal laptop to open an online form. Both groups were also given Android phones with the mobile mixing tool or instructions how to install the application to their own Android phone.

Group 1 was asked to create the two earlier heard soundscapes with the mobile mixing tool as well as they could one by one. They were then asked to take a screenshot of the soundscape created and evaluate how well they succeeded in building the same soundscape they had heard. Finally, the participants were asked how well they thought they remembered the soundscapes, if they found the application easy to use and if it helped them to remember the soundscapes.

Group 2 was asked to memorize and write down what sounds the two soundscapes contained one by one. Then the participants were asked how well they thought they remembered the soundscapes by memorizing. After this they were given the mobile devices and asked to test the mobile mixing tools. Then they were asked if they found the application easy to use and if they thought it would have helped them to remember the soundscapes.

3.2.2 Analysis

The two test groups both used approximately 40-60 minutes to complete the task and. The mobile mixing tool worked well and 84% of the participants evaluated it as easy to use. Only one participant found it difficult to remember the soundscapes well. Of the the18 participants, 14 remembered the listening order of the soundscapes somehow incorrectly. The nature environment soundscape was the first but most of the participants described the city soundscape as the first one. All the participants remembered that the other soundscape was somehow related to nature environment. Two did not describe a city environment at all, two described as some other kind of engine, and vehicle related sound source.

Group 1 was asked to build the soundscapes with the software. Five of the group thought they remembered the soundscapes well and four quite well.

The nature soundscape was easier to remember and most of the participants had picked the exact sounds that they heard 12 days earlier (Fig. 5). All the soundscapes the participants created sounded like a forest with birds. Seven of them had also the water sound in some form. None of the participants either heard or remembered the distant discussion sounds but this can also be due to the classroom listening conditions.

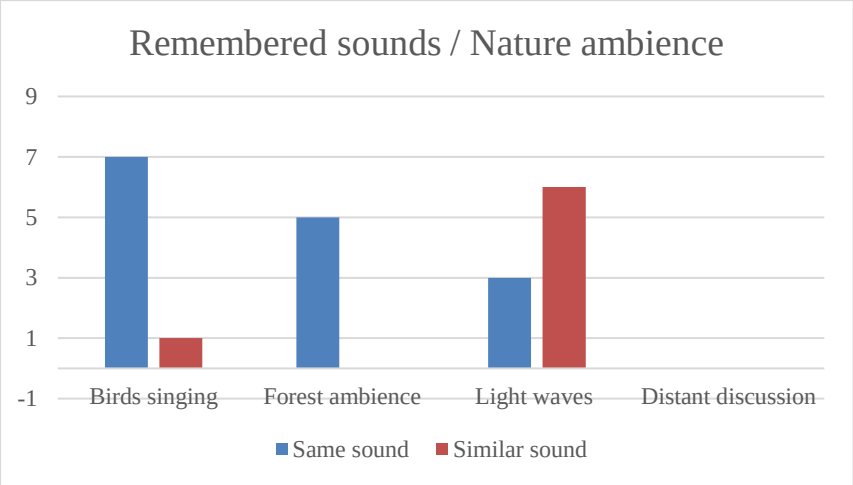

Fig. 5. Sounds picked from the sound database compared to the original soundscape number 1

The city soundscape is more complicated to perceive because there are several sounds constantly overlapping. There is also an overall background noise, the keynote sound, masking the more quiet sounds. The participants remembered the sound signals such as footsteps and tram passing. These were probably the most distinguishable sounds in this soundscape example. From the city soundscape eight of nine were able to pick at least one sound from the library that was exactly similar with the original soundscape (Fig. 6).

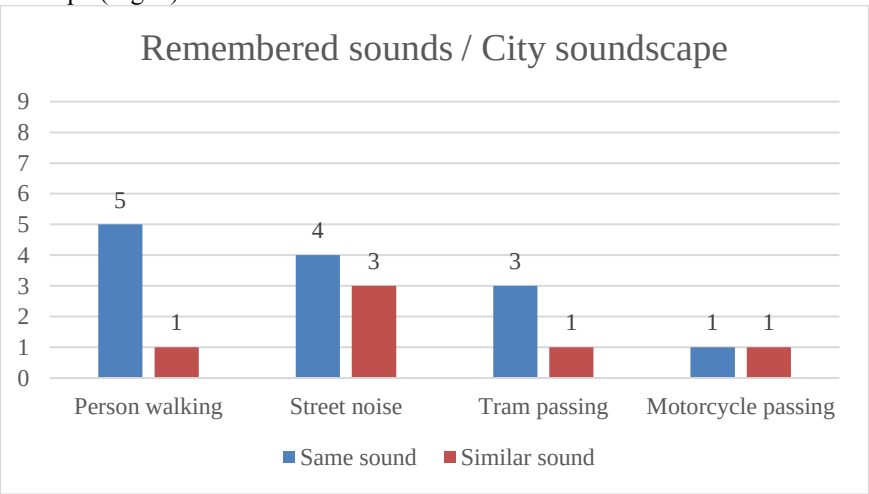

Fig. 6. Sounds picked from the sound database compared to the original soundscape number 2

Group 2 described the soundscapes as well as they remembered with no help of mobile tools. Only one participant thought it was difficult to remember the soundscapes

well. Even though the participants were asked to list the sounds of each soundscape as precisely as possible the number of sounds mentioned varied from 1-5. Average amount of sounds described was 2,7.

The key elements of the nature soundscape had been memorized well. Compared to group 1 there is not much difference (Fig. 7). Eight participants mentioned birds, seven mentioned water sounds and five referred to nature or forest sound.

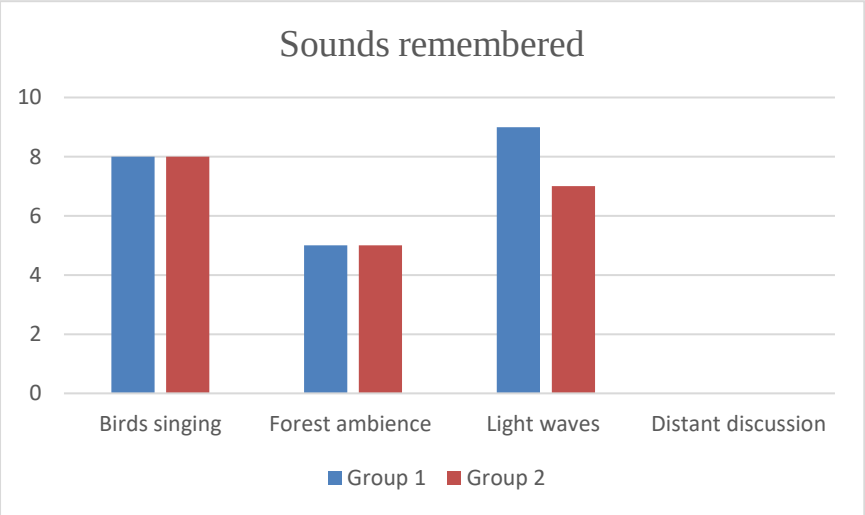

Fig. 7. Key sound elements of the nature soundscape remembered. Comparison between group 1 and group 2.

The difference occurs in expression and verbalization. Where group 1 was able to express their recollection with full soundscapes, group 2 used simple words such as “bird singing”, “wind” or “forest sounds”. Some participants verbalized the soundscape as sounds events such as “fishing on a rowing boat” or “nature scenery”. Some had associated the water to a spring, others to waves or water lapping.

The city soundscape seemed to be more difficult to remember and describe accurately (Fig. 8). Only two mentioned walking sounds, five referred to street noise, two had picked up a tram or a train and only one mentioned a motor vehicle.

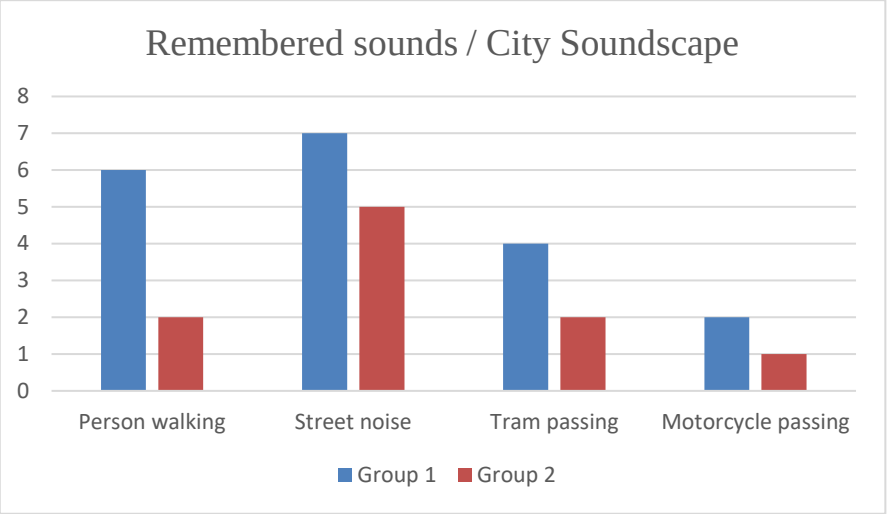

Fig. 8. Key sound elements of the city soundscape remembered. Comparison between group 1 and group 2.

The verbalization was more varied than with the nature soundscape. None of the participants mentioned street noise but used expressions like “city sounds” or “city noise”. Two participant mentioned human voices and one participant described the soundscape as “metro tunnel”.

After testing the mixing tools 55% of the group 2 thought that it would have helped them to remember the soundscapes. The participants knew at the beginning of the test that they will continue the task a week later. This probably affected the way they concentrated to listening. In a natural situation we listen to our environment more carelessly and therefore most of the sounds leave unnoticed.

With more simple hi-fi soundscapes there did not seem to be much difference between the two test groups’ recollections. The second soundscape contained more sounds element and the group 2 remembered and described the sounds much less than what can be heard from the group 1’s soundscapes. From the answers of the group 2 it can be observed that free verbal expression creates a remarkable possibility for misinterpretation and misunderstanding.

4 Mobile mixing tools and participatory methods

Since the participatory planning process aims to involve the citizens and utilize their knowledge about the area in question, the crowdsourcing requires methods and technology for gathering accurate and comparable data that is usable for the planning professionals. Our platform offers a user-friendly and smart method for the citizens or other stakeholders to discuss express and share ideas and opinions about soundscapes.

The soundscape design process and platform described here is based on three cornerstones:

1. Citizens of all ages can participate in the design process with mobile tools that are easy to use and offer a real hearable version of the soundscape in question. The citizens can express their opinion not only with words but also with sonic data.
2. The mobile tool gathers data from the design process. This data contains information about the sounds the citizen chose, deleted, and listened and so on. The data can be processed for various purposes.
3. The interaction with the citizens, the data that is collected and the sound components where the soundscapes are built from are such that they are equivalent to the real sonic environment and can be used later in the planning process.

4.1 Expressing opinions with mobile tools

A sound can be described with numerous ways and sounds, sound sources and sound events are easily mixed up and used illogically. In the urban area context the soundscape is most likely dense and noisy which makes is difficult to remember, describe and separate all the various sound elements. With the mixing tool, it is possible to create a common method for expressing and discussing about sounds.

To incorporate soundscape design into the city planning it needs to be considered in every step of the planning process [1]. In most cases, the data that has been collected from the citizens during the planning process is based on written or oral opinions and feedback. Expressing a sonic experience is a complicated task and the result most likely leaves possibilities for misunderstanding. As R. M. Schafer writes: “To report one’s impression of sound one must employ sound” [4]. This means that by representing sonic examples of the soundscapes and changing its components both citizens and the decision-makers can express their sonic ideas more specifically. By creating or modifying soundscapes element by element the user is creating a hearable opinion but also offering data by choosing and not choosing sounds.

4.2 Smart data collection and sharing

In the new soundscape mixing prototypes, we need to collect and save two types of data in addition to audio data: logging data and metadata. Logging data will contain all user interaction with the application: what audio files user selected, in which order, which audio files were removed, how individual audio files were configured (for example volume level), how often user listened the soundscape created, etc. All these events will be time-stamped and saved into log storage, which is linked to the final soundscape file.

Soundscape-related metadata needs to be enhanced. So far, we have defined mainly metadata, which is compatible with unqualified Dublin Core [21]. We need also metadata that defines the structure of soundscape, i.e. what audio files are needed and how they are configured. Maybe we need metadata, which describes better the soundscape, i.e. adjective describing what kind of soundscape user has created and

user's emotions related soundscape. One possibility is to define metadata describing if some audio files are a mandatory part of the soundscape. When the user has finalized the soundscape, then we need to upload soundscape file, related log file and metadata into ADAM. This means that also ADAM needs to be modified. Storing soundscape file, related log file and metadata into ADAM, enables detailed analysis of user interaction and behavior, and soundscape content.

4.3 Communicative planning process and soundscape design

Cities already able to smartly collect data about the locations of different soundscapes and what are the citizens' opinions about them. What is missing is the detailed data of the sounds that these locations contain. The application could also be used for demonstrating the effects of noise or other planned changes in the soundscape. The citizens could then modify or test different variations of these changes and express their opinions about it. This would, for example, give a possibility to define tolerable limits for certain sounds of suggested sounds that could be added or removed from the soundscape.

Cities arrange workshops and exhibitions as part of the interaction with the citizens. The audio platform could be available in an exhibition as audio-only or in later parts of the planning process combined with visual models of the area. Also, the soundscapes created by the citizens could be shared in exhibitions. One of the participatory methods used in city planning is guided walks in the location. Since the soundscape mixing application is mobile the soundscapes could be built on the location where the actual visual environment is fully available.

The further development will be about the data collection, recording and storing of the soundscapes and implementing them into augmented and virtual spaces. We have already developed new soundscape mixing prototypes, which address some of these possibilities. However, we need to further develop also ADAM to support all requirements.

5 Towards smart urban soundscape design

Urban areas are under a great interest at the moment. The planning methods and technologies are developing quickly but at the same time the process is becoming more and more complicated and multi-dimensional. Designing a soundscape is not a separate process from the rest of the planning process, and not least because the sonic environment is largely a result of material and living environment. Therefore it is important to think how the soundscape design process could be truly incorporated into to planning process and how it could benefit from other current inventions in the planning research.

Depending on the planned area in question, various professionals are involved in the planning process. Yet in most of the cases, the planning is presented visually but it can be a picture, map, model, 3D model etc. If the soundscape would be designed alongside

with the visual and other environment there would need to be possibilities to transfer the soundscape design data from system to another. This is possible if visual environment planning platforms can be expanded to include audio elements.

In the method presented here ADAM has so far been designed to interact with mobile applications and management application. Thus, we have developed REST APIs for authentication, content search, content download, and content upload. Now it seems that we need to exchange information also with other IT systems, such as map based and 3D model based city planning systems. This means at least that we need to revisit existing APIs to enable searching and downloading soundscape files and related metadata. However, this approach is limited in the sense that it enables soundscape transfer to one direction only and requires that other IT systems probably need to be modified to access ADAM.

If we want to transfer soundscapes from a system to another we need a clear understanding or possibly a standard of the structure of urban soundscapes. As described earlier there is a great deal of theoretical information about soundscapes and various methods for analyzing and structuring them. These theoretical and technological inventions are an important part of the process that aim to create a smart working method for designing soundscapes. The method described here needs this knowledge in order to success.

Storing soundscape structure and other new metadata enables also new possibilities for analyzing data. Collecting soundscapes and the metadata with them would create in a long run knowledge about sonic experiences and opinions about soundscapes. This could be facilitated by using smart crowdsourcing methods for gathering soundscape data. Larger collected data would open a possibility to use Machine Learning approach for example. With machine learning, it would be possible to predict problematic sound components from urban soundscapes.

These are just few examples of co-operations and combinations that smart and structured audio data collection would open. Combining sound and picture would be a step towards a more comprehensive environmental planning process. Sonic environment affects the visual environment and vice versa. By adding audio to visual representations, the citizens would get a more realistic impression of the changes planned in their living environment.

6 Conclusions

Our experience of the world is a combination of our five senses but still our environment is mainly designed visually. It has been acknowledged that our sonic environment has a significant effect on our well-being and living conditions but due to the predominance of the visual planning, the methods of designing soundscapes are underdeveloped. There is a lack of comparable data of the citizens' sonic experiences, methods of collecting the data smartly and knowledge of how to implement the data into planning processes. A sonic experience contains a lot of tacit information that we have no words for. Writing down what an environment sounds like is a subjective interpretation and verbalization of something that we usually do not express that

carefully. Therefore, we need a different kind of tools for interaction, expression and explanations.

In this paper, we have presented a concept for smart data collection of sonic experiences and methods for implementing them into city planning. The project aims to develop a method that could be transferred internationally to any city planning process. Furthermore, creating smart and standardized methods for data collection would open the possibility to use a machine learning approach for data analysis. This would create common knowledge about sonic experience and basis for the real design of soundscapes.

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