Research Article

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A Soundwalk in the heart of Poblenou superblock in Barcelona: Preliminary study of the acoustic events

https://doi.org/10.1515/noise-2021-0016
Received Dec 12, 2020; accepted Apr 08, 2021

Abstract: The Poblenou Superblock, in Barcelona, is a crucial element in the development of the new city-planning within the framework of the Superblock (Superilles) concept, whose principal aim is to recover the cultural, economic and social exchanges once produced in streets and squares. People living in urban areas need a lower traffic density, more green spaces and cleaner air in order to restore the previous uses of public spaces in their day-today lives. The urban actions conducted at this Superblock to change its uses were completed about 3 years ago, and neighbours and workers have already taken over the new spaces. In an interdisciplinary work on urban planning and acoustics, we detail the preliminary results of the acoustic events found in the recordings in a soundwalk in the heart of the Poblenou Superblock. Fifteen people evaluate and record sound fragments with the Hush City App application, in order to establish comparisons between the different points of the route, observe the spaces arranged for people and perceive the soundscape. Meanwhile, several acoustic technicians record 5-min long audios in the different stops designed for the soundwalk. The points chosen to make the recordings are very different from each other, some of them in the middle of gardens and others are on pacific streets and finally, we also wanted to include Superblock borders where the traffic is still very present. The results of our study were promising and have encouraged us to further investigate acoustics events in superblocks and include all the perceptual information provided by the Hush City App.

Keywords: Superblock, acoustic event, soundscape, soundwalk, Hush City App

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1 Introduction

Several studies have depicted that noise is currently one of the worst environmental pollutants that affects citizen's health, mainly in urban areas [1, 2]. Nevertheless, noise perceptions vary substantially between individuals and the perception of a noisier environment increases also with age [3]. In this respect, the soundscape concept, firstly introduced by Michael Southworth in the 1960s, considers how the acoustic environment is perceived by humans in context [4].

Soundscape research, where several investigators from different socio-cultural backgrounds and also different disciplines are involved [5] becomes a very efficient tool, because several dimension are explored by means of using different perspectives, obtaining a deeper understanding of the soundscape perception. The results show that urban soundscapes can be characterized by soundmarks, and that soundscape perceptions are dominated by what we call acoustic comfort, as well as visual images and even day lighting; reverberance does not lead to a consistent preference judgements [6]. Soundscape descriptors have been also used to develop predictive models of perceived affective quality [7].

In soundscape studies, the method of soundwalking was explored by Murray Schafer in the 1970s in the framework of the World Soundscape Project (WSP). Schafer wanted to explore the relationship between humans and the sounds of their environment and what happens when the sounds change [8]. A soundwalk is defined as "any excursion whose main purpose is listening to the environment" [9, 10]. During a soundwalk, the participants in the walk can assess the acoustic environment and their feedback can potentially feed back into urban design and planning and policy making [11]. Radicchi [12] has widely developed the methods of soundwalking applying to the co-design process of the cities with the collaboration of citizens [13] even as a method to raise acoustic awareness among children [14] and the public at large by using the Hush City App mobile application [15]. Similar performances can be found in [16].

In order to restore everyday use of some parts of the city to the citizens, the everyday use of some parts of the city, Barcelona launched the Superblock project (*Superilla* in Catalan). The project, consisting of several urban actuations, refers to an architectural concept that creates blocks in the middle of the city in an aim to decrease air and noise pollution, and promote an inclusive and sustainable neighbourhood. The superblock is a place for cultural and social exchange, where people can meet and children can play [17].

The main objectives of the Superblock proposal are (according to [18]): *i)* a more sustainable mobility integrating new bus and bicycle points; *ii)* the revitalisation of the public space promoting new uses of the street; *iii)* promoting biodiversity and urban greenery creating new community spaces with trees and birds; *iv)* the integration of governance processes involving citizens in the definition and development of the project.

The soundwalk under study took place in the heart of the Poblenou Superblock, and it was designed by Dr. Radicchi, who also led the citizens in a walk round the streets of Barcelona. Moreover, while Dr. Radicchi gave details about the experience to the participants, La Salle team recorded longer pieces of audio (around 5 minutes each) of each of the soundwalk stops, in order to gather more raw acoustic data for posterior analysis. In this paper, we conduct a first analysis of the 5-min audios collected in the Poblenou soundwalk, detailing the main acoustic events found in the different locations with a preliminary analysis of the number of occurrences and their duration.

This paper is structured as follows. A short soundwalk state of the art is described in Section 2. The Superblock project is detailed in Section 3. The soundwalk proposal realised for the study is explained in Section 4. A first approach to the results is described in Section 5 and finally the conclusions in Section 7.

2 Soundscape evaluation: Soundwalk state of the art

Human happiness is related, among other issues, to city urbanism [19]. The city is a 'device for hapiness', as Montgomery passionately argues. All urban noises contribute to the image of the city; in fact, only noise sources that provoke discomfort due to their intensity or the fact that they blur the perception of the most representative sounds of the city should be limited [20]. There is a clear relation between the components of a good mental health and a thriving city; the latter depends on the good mental health of its population [21]. Almost a 50% of the world population is is currently living in cities, and for this reason, urban planners, architects and other citymakers have an important role in this design [22], even integrating noise mapping techniques [23]. People living in quiet areas do not suffer the negative health effects [24], and similarly quiet areas tend to benefit the health of those who visit them regularly.

In this sense, the acoustic comfort evaluation in urban open public spaces is a key issue to support this healthy city design [25]. Several considerable differences have been found between the subjective evaluation of sound levels and the acoustic conform evaluation. The latter is much more complex; furthermore, people tend to show more tolerance in terms of acoustic comfort depending on the sound source type. And we should take into account that the social context of the noise exposure is a co-determinant of noise annoyance [26].

Schafer [27] suggests that we suffer from acoustical overload and are less able to hear the nuances and subtleties of sound. Our task, he maintains, is to listen, analyze and make distinctions in spite of sound pollution. Westerkamp [9] defines a soundwalk as any excursion whose main purpose is listening to the environment. It consists of exposing our ears to every sound around us no matter where we are. Both Schafer [27] and Westerkamp [9] were pioneers in soundscape research.

A systematic soundwalk has advantages for quantitatively and qualitatively evaluating soundscapes as multimodal experiences, which can compensate the lack of laboratory experiences [20, 22]. It allows us to gather both subjective responses but also objective measurements for soundscapes, even using them as a tool the interpretation of a soundscape. Smartphones can be used as a relatively inexpensive device for audio measurements and for recording the soundscape of a place [16]. Different mobile apps are available in the market, such as: Hush city, City Soundscape, MoSart, Audiospook, among others. For an overview, see [28].

The individual soundwalk [29] has advantages for measuring diverse subjective response. Nevertheless, soundwalk in group is an active way of participation in the soundscape evaluation [30], where the essential aim is to encourage participants to listen discriminately and conduct critical judgements about the sounds heard, and also about their contribution to the balance (or imbalance) of the sonic environment. Usually, at the end of all the soundwalks, participants are asked to fill in a questionnaire about the location and the characteristics of the stops and stations, but also to evaluate the other locations walked between stops. The feedback given in that questionnaires should be taken into account as a qualitative indicator to design

urban places. Only a holistic understanding of the soundscape is obtained merging quantitative and qualitative data of the walk and results can then be used to improve the acoustic environments [11].

Moreover, soundwalks performed by youngers are also an educational method to show children the importance of living in healthy sonic environments and to involve them in soundscape analyses and evaluation [14].

In this sense, and to improve standaritzation, there is a need to develop a common language of concepts and terms, about the outdoor acoustic environment that can provide fundamentals for a clear communication across the several disciplines involved in soundscape [31].

The combination of the citizen science paradigm together with a novel mobile application – the Hush City App – [28] satisfies the goal of involving people in identifying, assessing and planning urban quiet areas.

The Hush City App [15] is a mobile application designed to identify and find quiet areas within or nearby urban areas. Data collected with the app is linked in real time to the Hush City Map, a web-based open access map. Each dataset captured with the app in the quiet areas contains an audio recording, a photo, a sound pressure value and a perceptual responses, which helps the users to identify, access and evaluate everyday quiet areas in their neighbourhoods, and thus contribute to their protection and planning by municipalities.

This App has been used in the Poblenou Superblock soundwalk and data collected will be analysed in further work.

3 The superblocks project

The Superblock project presents a new model of mobility that restructures the uses of the typical urban road network [17]. It provides several types of solutions to the main urban mobility problems and improves both the availability and the quality of public space for citizens. In order to achieve these goals, two essential changes should be made: *i)* the modification of uses of the basic road network and *ii)* the change of several routes of transport around the area under study. This project was designed by Salvador Rueda, who conceived and designed the Superblock idea around 30 years ago. Since then, the authorities have been working the project and it has been widely developed. Rueda states that the time needed to take a short trip by car is very similar to the time that it takes by walking, and that cars take up around the 85% of the public space, while his idea of the Superblock design should reduce this value to around 25% [32].

The Superblocks planned and developed in Barcelona's grid plan are composed of 9 blocks, thus forming a square of 400 m by 400 m. The roads remaining inside are usually closed to motorised vehicles, and preference is given to pedestrians to use the public space. The inner streets are also used for residential traffic, services, emergency vehicles and vehicles with requirements under special circumstances. The roads in the perimeter are used for motorised traffic, and serve as the basic roads in the zone.

Nowadays, the Superblocks project is emerging as an interdisciplinary solution to renew the use of the public space, taking into account both planning and mobility, and also limiting the presence of private motorised vehicles in order to somehow return the public space to citizens' life. The relevance of this space to the life of people is the basis of the philosophy of the Superblocks idea; each part of the grid has universal accessibility, citizen safety is increased due to the speed limit restrictions (mainly 10 km/h), and also the comfort of the neighbours is improved, as well as the quality of life of residents and visitors. The application of the project has also shown that new uses of public spaces have enhanced the social cohesion and the economic activity in the zones under study.

The idea of the Superblocks project is currently being analysed and developed in several Spanish cities, not only in Barcelona, which, incidentally, has recently launched a more ambitious second stage[1]. The city of Vitoria-Gasteiz is also involved in the development of this idea, and was the winner of the European Green Capital Prize 2012 and Plan for Mobility and Public Space, and also has been rated Best Practice by Un-Habitat. Other cities as El Prat, Viladecans, A Coruña and Ferrol are also working on that idea.

4 Soundwalk proposal

The soundwalk proposal focused on Poblenou neighbourhood, which in recent decades has been transformed from an industrial area into a trendy residential and business district, with still several parts of free ground to built. In these circumstances, the changes promoted by the Superblocks concept can be understood as new developments for everyday life today but also for future uses of that Superblock.

1 *cat.elpais.com/cat/2020/11/11/catalunya/1605089383_655216.html* [in Catalan]

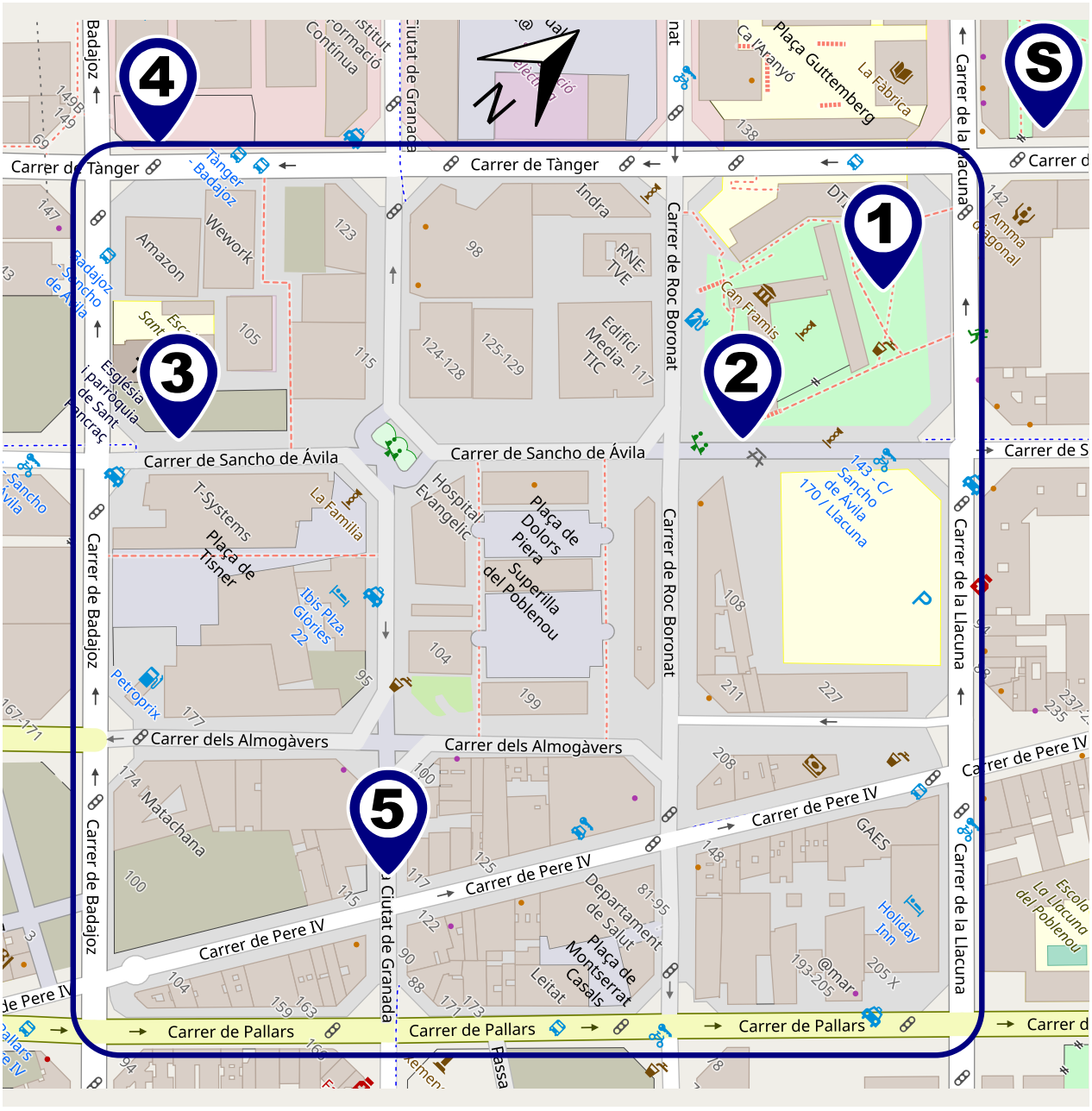


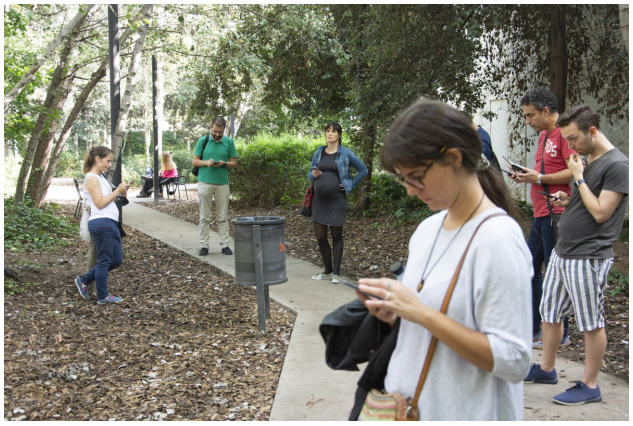
Figure 1: Image illustrating the soundwalk route held in Barcelona on September 27th. Poblenou Superblock is marked with a blue frame, and the soundwalk's stops are indicated with numbered markers. (Map Source: OpenStreetMap 2020)

The soundwalk planning is depicted in Figure 1. The soundwalk starts in the inner block space (Ada Byron Square, see point **S** in the Figure), where where all participants are introduced to the methodology of the study.. The starting point, which is not actually in the Superblock itself, was chosen as it was considered a quiet area near the first street of the Superblock. The proposal for this soundwalk consists in a guided walk through the Poblenou Superblock with stops at five listening points (as depicted in Figure 1). At each location, the participants are invited to *actively* listen in silence to the environment for around 1-3 minutes, and afterwards assess the location using the Hush City App [15] (see all the stops of the soundwalk in Figure 2).

The first listening point **1** is inside the Superblock, in a green area between the Museum Can Framis and a road (see Figure 1). The second listening point (number **2** in Figure 1) is located between this museum and the *Escola Flor de Maig* School. This street has been pedestrianized, so the street place has turned into a public space for citizens. Tables, sculptures and a playground has been set in that corner.

The third listening point **3** is located in an office area, just close to Ibis Barcelona Hotel. Minor tactical urbanism-oriented interventions have been made, by means of re-surfacing the ground and installing benches and tables, where one can find office workers having lunch. The fourth stop **4** is located in the border of the Superblock, just close to a high traffic road where road traffic noise is the predominant in the soundscape. The final point **5** is close to one of the access areas to the Superblock. The road traffic noise is here also quite relevant.

(a) Starting point **S**



(b) Stop **1**

(c) Stop **2**

(d) Stop **3**

(e) Stop **4**

(f) Stop **5**

Figure 2: Picture of the participants of the soundwalk in the different listening points (©pictures by La Salle BCN).

5 Preliminary results on audio analysis

In this section we will describe the preliminary results gathered using the raw acoustic data that we collected simultaneously to the course of the soundwalk. The raw acoustic data analyzed in this paper was collected during the soundwalk, using a hand-held recorder zoom H5 and a tripod to collect 5-min large pieces of audio of all and each of the stops of the soundwalk. The final goal was to have a larger amount of acoustic data available to describe the different events occurring in Poblenou Superblock.

5.1 Metrics and annotation

These results include the evaluation of the different types of events occurred during the soundwalk and registered by our team, their duration, but also their Signal-to-Noise ratio (SNR) and its impact on the Level A-weighted equivalent ΔL_{Aeq}. The events have been manually labelled by experts. The SNR computes the ratio between the signal and the noise, which means that evaluates the salience of the event with respect to its surrounding soud. The impact on the L_{Aeq} value is computed as the difference between the equivalent level at a certain time frame and the same value excluding the event under study. Both the SNR evaluation and the impact have been detailed in our preliminary work by Orga [33].

The annotation process has been conducted manually, following the criteria defined by the Research Group on Media Technologies, which can be found in [34] and [33]. The audio pieces are listened to by experts, who manually annotate all the events that they can identify. The other events are listed as *complex*, which means that there is an event in that piece of audio, but the annotator could not identify which was the source of the noise.

The manually labelled events include the following categories: *step* (people walking), *bird* (birds singing), *bark* (dogs barking), *cmplx* (non-identifiable sound), *peop* (people talking), *wind* (wind sound to the microphone), *brak* (brakes of cars/motorbikes) and *horn* (horns mainly from cars).

5.2 Event annotations analysis

The first evaluation is shown in Figure 3, which shows both the SNR and the impact of the acoustic events in the five stops. It can be observed that stops **1** and **2** present the lowest median values, around 0.5 dB and 1 dB of SNR, being the latter the second lowest value of SNR measured during the soundwalk. The events on these two first stops present low impact values with low deviation.

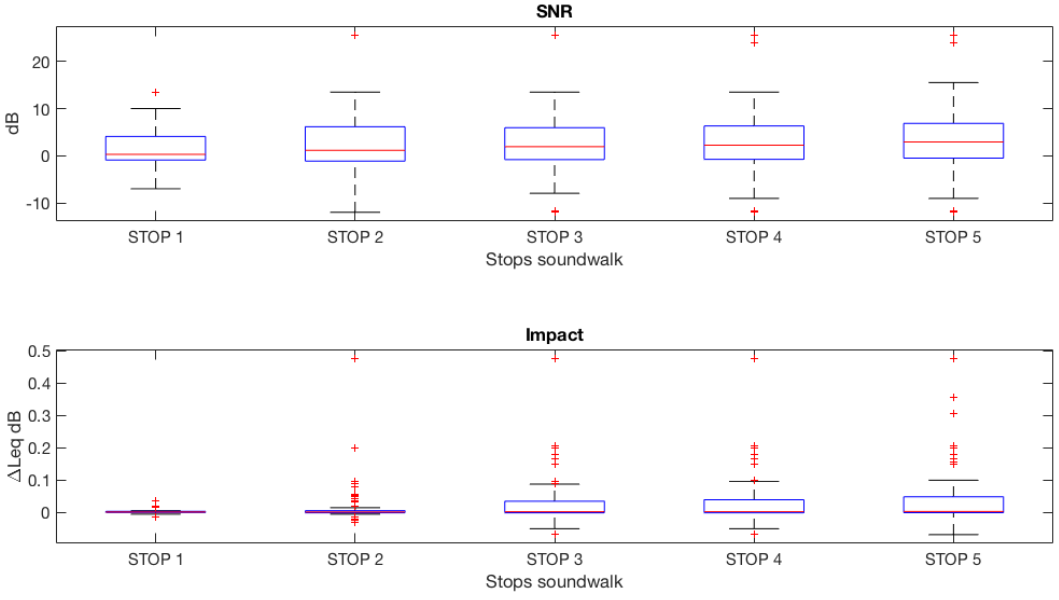


Figure 3: SNR and Impact of all the labelled events in the Poblenou Superblock soundwalk. Stop 1 presents 76 events, Stop 2 presents 75 events, Stop 3 presents 27 events, Stop 4 presents 14 events and Stop 5 presents 26 events.

Table 1: Mean and total duration (s) of the events in each stop of the soundwalk.

		Stop 1	Stop 2	Stop 3	Stop 4	Stop 5
step	Mean	0.12	0.31	-	-	-
	Total	0.58	0.62	-	-	-
bird	Mean	0.30	0.32	0.84	-	0.82
	Total	6.65	13.88	0.84	-	0.82
bark	Mean	0.58	-	-	-	-
	Total	14.41	-	-	-	-
cmplx	Mean	0.98	0.54	-	-	3.05
	Total	8.83	2.16	-	-	6.10
peop	Mean	2.49	3.01	-	2.51	3.55
	Total	2.49	3.01	-	2.51	10.66
wind	Mean	0.91	4.72	8.65	5.84	7.93
	Total	12.78	108.58	207.59	40.87	79.33
brak	Mean	-	1.62	-	2.58	1.99
	Total	-	6.47	-	5.17	7.97
horn	Mean	-	-	0.55	0.42	0.75
	Total	-	-	1.11	0.42	2.99

Stops **4** and **5** present higher SNR values, around 4.5 dB and 5 dB, and also higher impact for all the events detected, even with some non-negligible outliers in the boxplot figures. Finally, stop **3** presents values in-between the two groups. Despite individual impacts being low (around 0.1 dB some of them), the idea of the aggregated impact for several events occurring in the same time frame changes this perception. Summing up several contributions we can reach to relevant impacts in the same measurement window.

According to Figure 1, stops **1**, **2** and **3** are located within the border of the Superblock; stop **4** is outside and stop **5** corresponds to an access. The higher impact events are located close to the borders or directly beyond, whereas the ones with less impact occur in the heart of the Superblock. Considering the details given in Table 1, the sounds related to traffic and city noise (horns, vehicle noise and brakes) are mainly detected on the edges or outside the Superblock. The stops where lower impact events occur also contain birdsong, which is usually associated with quiet environments. Both people and wind are events that appear very commonly, nearly in all locations.

5.3 Time-evolution and Impact Analysis

Another analysis carried out on the data recorded during the Poblenou soundwalk was the observation of the temporal evolution of the five sequences recorded at the five stops. In Figure 4 you can see the different nature of the soundscape of all the stops, as well as the clear predominance of the wind from the second one until the end of the soundwalk.

The predominance of the natural sounds sources such as birds or dogs is particularly clear in the first stage, such as *birds* or *dogs*, uniformly distributed over time. It should also be noted that there is a clearer distribution of traffic noise, in the second, fourth and fifth stops, with *brakes* and even *horns*.

Figure 5 shows all the events labeled during the 5 stops of the soundwalk where the axis represents the SNR ratio and the duration of the event and the diameter of the point is the impact value, as defined in [33]. Due to the wide range of impact values, the diameter is charted following a piecewise function. Events shown in Figure 5 can be separated between events with a duration below one second (*bird*, *cmpx*, *bark*, *step* and *horn*) and over one second (*wind*, *bark* and *peop*).

Long-lasting events wind and bark present SNR values which are higher than 0 dB and higher impact. Wind is the event with highest SNR and impact meanwhile people present high impact and with a SNR lower than 0 dB. Short-lasting events have a reduced impact compared to the above one second and maintains similar SNR. Bark and horn presents a SNR above 0 dB meanwhile step and complex have an impact around 0 dB. Birds shows a wide range of SNR from −10 dB to +10 dB and lowest impact.

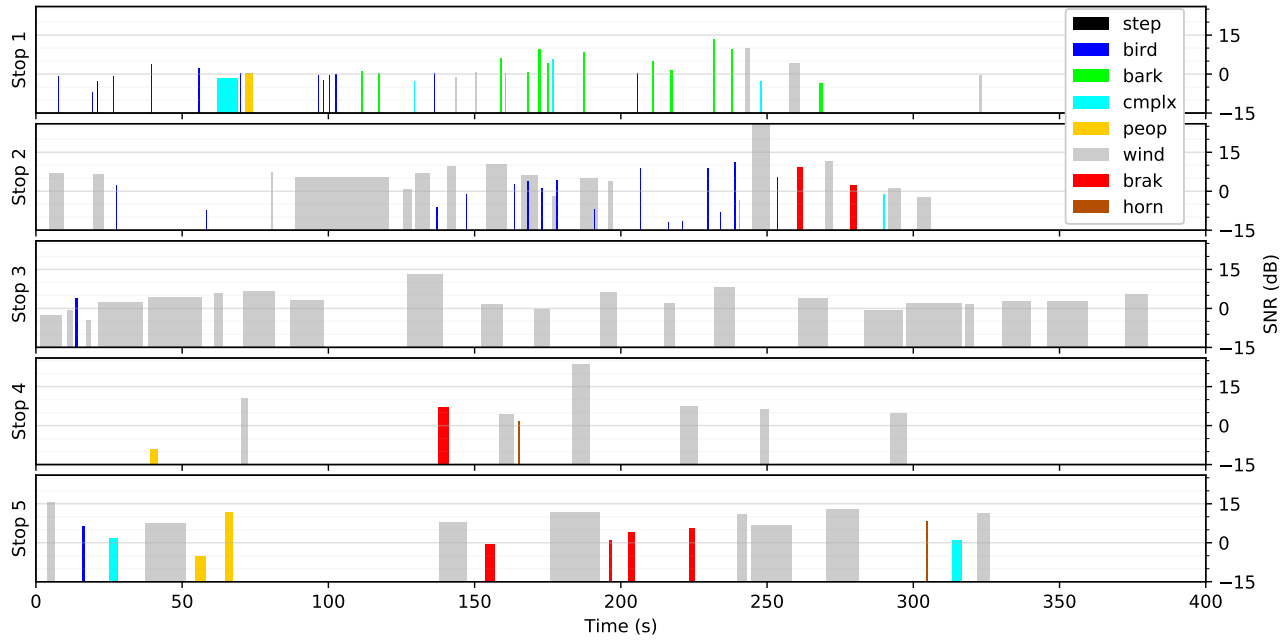


Figure 4: Events plot for each of the 5 stops during the recorded time.

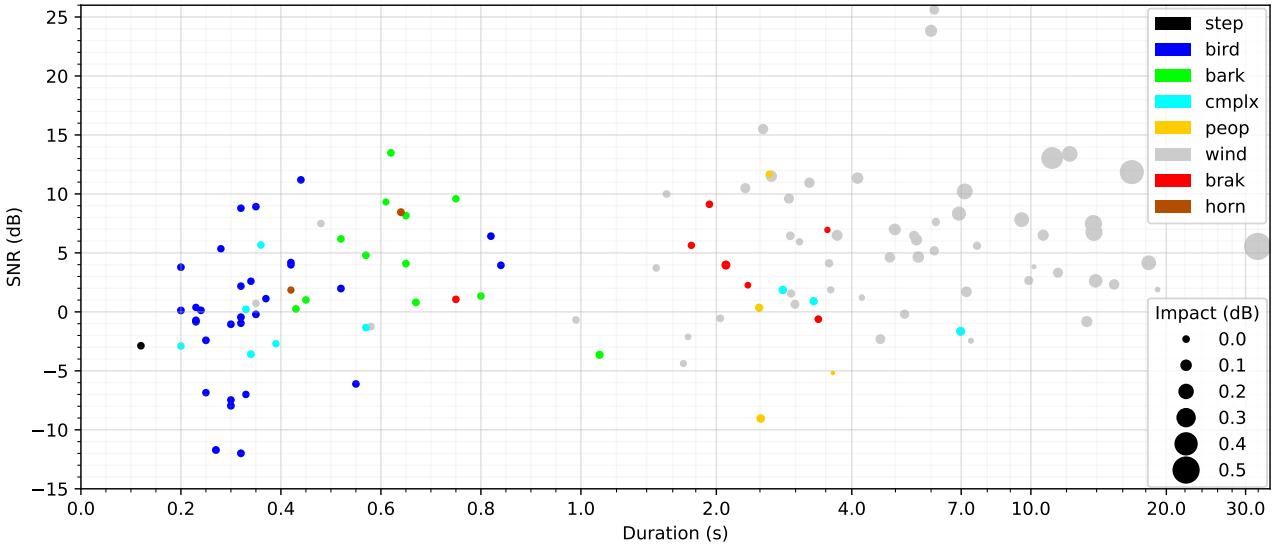


Figure 5: SNR, Impact and duration of all the events.

6 Discussion

The preliminary results presented in this article suggest that it could be interesting to carry out exhaustive studies with the data collected by the Hush City App, in contrast with the data collected by the Barcelona City Council on street noise, with special attention to data from the noise in the Poblenou superblock environment. From the previous analyzes, we already know that these are pedestrianized spaces adapted to prioritize the citizen in their use, but the comparison with all the objective acoustic measurements carried out by the sensors of the Barcelona city network would add, not only information, but also an homogeneous criterion to the data that citizens kindly provide us. The final objective is to ensure that all the methods of capturing subjective data from citizens can be taken into account in future urban designs, by means of complementing the acoustic measurements that the technicians gather in the locations under study.

To achieve this objective, any regulation that supports the standardization of the data collection method would be helpful. In this sense, the ISO 12913 series [35] on soundscape was developed to achieve a broad international consensus to establish a common basis between disciplines and professions that start from their interest in soundscape. Of all the variety of forms of data collection that the ISO describes, both the soundwalk and the questionnaire are two of the key elements to develop the soundscape estudies. We consider in the future to expand the coverage of the experiments in the superblocks project in Barcelona to include in more detail other elements of information gathering, such as the personal interview with the citizen or binaural measures.

7 Conclusions

This first study of the events recorded during the Poblenou soundwalk leads us to an in-a-nutshell description of the acoustic activity of the area. We see that it is an area frequented by pedestrians, since one of the events detected in most of the stops is people talking. There is also an abundance of natural sounds, such as wind and birdsong; the latter especially in areas that had already been detected as quiet area, e.g. parks or pedestrianised areas of the Superblock.

Traffic-related noises are restricted to soundwalk stops that are tangential to streets with traffic, not interior Superblock streets where actuations have been performed. Finally, a relevant element to highlight is that some of these events have a non-negligible ΔL_{Aeq} acoustic impact, although in this article they are only measured individually. The most relevant correspond to the areas with more traffic, which are next to areas with many motorised vehicles.

This preliminary work about acoustic and event analysis gives our interdisciplinary team a baseline that will allow us to face the holistic analysis with the data obtained from the participants of the soundwalk, gathered thanks to the Hush City App [15]. The incorporation of perceptual data and sensations of users to this pre-analysed data coming from acoustic measurements and recordings, and the posterior annotation and analysis of the events will add value to the global vision of the acoustic environment of the Poblenou Superblock.

Acknowledgement: The Hush City soundwalk in Barcelona was part of the 2019 Global Program of Hush City soundwalks, developed by Dr. Antonella Radicchi. The Global Program was organized as a dissemination activity of the Hush City Mobile Lab project (2018-2020), which received funding from the HEAD-Genuit Foundation. The Hush City app was invented by Dr. Antonella Radicchi.

Funding information: The first version of the Hush City app received funding from the Marie Curie Actions Program of the European Union's Seventh Framework Programme (under REA grant agreement no. 600209 TU Berlin – IPODI). The second version of the Hush City app received funding from the HEADGenuit Foundation (research grant P-17/08-W). The research that led to this contribution has been conducted partially thanks to funding from Secretaria d'Universitats i Recerca from the Departament d'Empresa i Coneixement (Generalitat de Catalunya) and Universitat Ramon Llull, under the grant 2020-URL-Proj-054 (Rosa MaAlsina-Pages).

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest: The authors state no conflict of interest.

Data Availability Statement: Data used for this publication has been independently collected by La Salle researchers during the soundwalk. This data does not belong to the Hush City database.

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