Combined sound- and lightwalks.
A novel, mixed method to assess sound and artificial light of the urban environment at night.

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Abstract
In line with the 2030 Agenda for Sustainable Development, cities in Europe have implemented policies for addressing economic, social and environmental sustainability. Noise and light pollution can be regarded as challenges to sustainability, due to the detrimental effects they can have on human health, wellbeing and the environment. Increasing levels of noise and light pollution in cities can lead to the loss of quietness and darkness, two qualities of the urban environment, that European policies attempt to protect. Most approaches to noise and light pollution reduction apply quantitative indicators and methods. A literature scrutiny showed a tendency to overlook human perception as a criterion for assessing sound and light phenomena and their interplay. Against this backdrop, this contribution presents a novel mixed method for assessing sound and artificial light of the urban environment at night -- the combined sound- and lightwalks – that was envisioned in the attempt to fill this gap of knowledge. It outlines a case study where a combined sound- and lightwalk was conducted in 2019 in the Friederichshain neighbourhood in East Berlin. It illustrates materials and methods applied, explaining how acoustic and light components of the environment were assessed during the walk, by collecting perceptual responses and quantitative measurements. It presents the results and the study limitations. In conclusion it discusses how integrating qualitative perspectives and using citizen-generated data, planners and policy makers could make progress towards the creation of more inclusive and sustainable approaches for the protection of urban quiet and dark areas at night.

Keywords
night walking; artificial light, sound

Introduction

In 2015, the 2030 Agenda for Sustainable Development was adopted as a plan of action for people, the planet and prosperity, that includes 17 Sustainable Development Goals (UN 2015). Specifically, the Sustainable Development Goals 3 and 11 are targeted at addressing health and well-being and at building sustainable cities and communities. In recent years, the European Commission has also increased its programs on urban sustainability. Particularly, the Priority Objective 8 of the 7th Environmental Action Programme, entitled *Sustainable Cities: Working together for Common Solutions* is designed to promote the sustainability of European cities so that all Europeans are "living well, within the limits of the planet" (EC 2014). Accordingly, European cities have implemented policies for addressing sustainability and their performances have been under scrutiny by the European Commission, accounting for economic, social and territorial impact (EC 2020).

Nowadays, sound and artificial light can constitute environmental challenges, given the detrimental effects they can have on our health, well-being and the urban environment, however they are rather understudied in urban planning (Radicchi et al. 2020). Road traffic noise, for example, is the second worst environmental stressor after air pollution in Europe, affecting over 125 million people every year (EEA 2020). Prolonged exposure to excessive noise can constitute a health risk, leading to premature death, cardiovascular disease, sleep disturbance, hearing loss and cognitive impairment (WHO 2018). Similarly, the increase of artificial light at night has negative impacts, including the disappearance of dark skies, which can cause a disruption to the daily cycle of night and day, potentially inducing sleep diseases and weakening of the immune system (Wartmann et al. 2019, Meier 2016).

Increasing levels of noise and light pollution in cities are leading to the loss of quietness and darkness, two qualities of the urban environment, whose importance for health and well-being is reflected at the policy level (e.g. EC 2002). However, literature review shows that traditional approaches to study noise and light pollution present methodological limits. On the one hand, quantitative measurements are usually applied for assessing sound and artificial light of the urban environment at night, overlooking how sound and light phenomena are perceived. On the other hand, the interplay between light and noise pollution is rather understudied in urban studies and planning, despite significant commonalities occurring between the sound and light phenomena. Light and sound are both natural and artificial physical entities, which can be objectively measurable as well as subjectively interpreted, both being processed by the brain. Light and sound are ephemeral phenomena changing over time, and, under specific circumstances, they can be potential

pollutants, impacting the environment and human health[1] (Figure 1). The scientific interest for combined research on sound and artificial light arose in recent years (Radicchi et al. 2016, Radicchi and Henckel 2017, Meier and Henckel 2017), leading to the experimentation of a novel, mixed method for assessing sound and artificial light of the urban environment at night: the combined sound- and lightwalks[2].

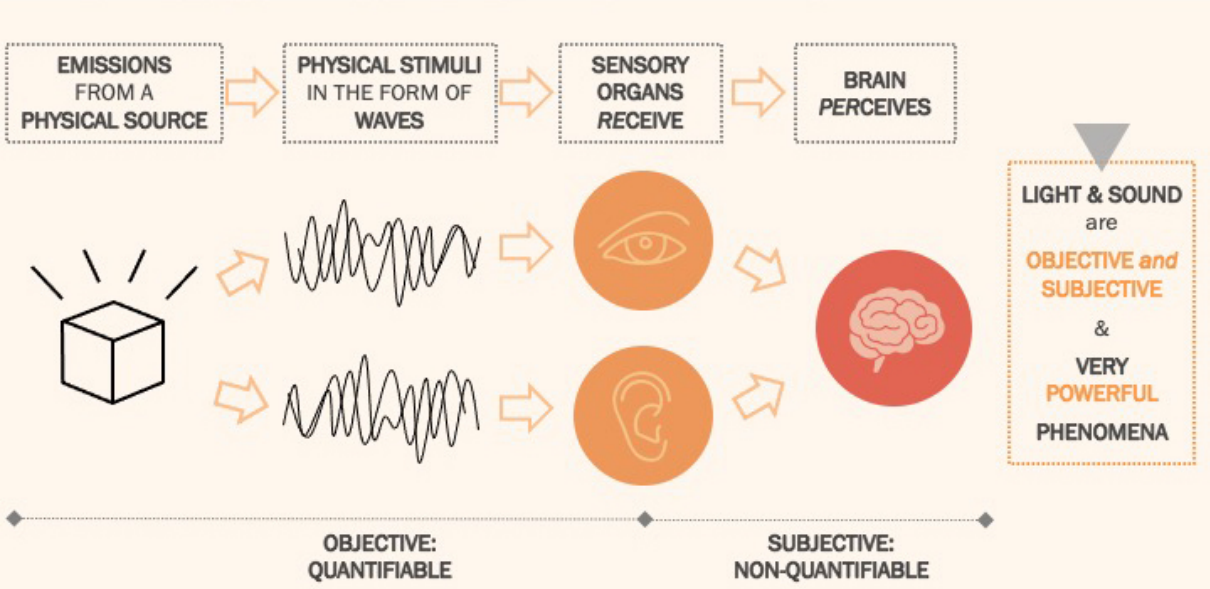

Figure 1: Diagram illustrating the commonalities between light and sound. Image source: Radicchi A, Meier J, Dietrich H (2016).

Combined sound- and lightwalks can be considered examples of "sense walking", a method introduced in the 1950s and 1960s to "investigate and analyse how we understand, experience and utilize spaces" by focusing on sensory information gained through one or more senses. More in general, walking, as a mode of exploring the world, belongs to the history of mankind: the Bedolina Map - one of the most ancient topographic maps carved in stone during the late Bronze Age and the Iron Age (1000-200 BC) - depicts walking routes from one place to another (Careri 2002, Radicchi 2017). In modern times, especially during the 19th and 20th centuries, walking in cities was acknowledged as a creative, reflective and sometimes subversive way of exploring and understanding the city (Benjamin 1982, Hessel

[1] Concerning the differences, light pollution is the negative *by-production* of the intended activity itself, i.e. the provision of artificial illumination. Conversely, noise is the *by-product* of activities, which are not intentionally implemented to produce noise pollution.

[2] The experimentation was conducted by the author, an architect-urbanist and soundscape scholar (Antonella Radicchi) and by the author's colleague, an artificial light scholar (Dietrich Henckel). Together, they first experimented with the combined sound- and lightwalks, within the framework of the design studio "Light- and Soundscapes of the Urban Night – Berlin/Firenze", which they co-taught at the Technical University in Berlin in 2016-2017. Then, they further tested this method at the XXXII Italian Congress of Geographers, where they guided a combined sound- and lightwalk in the Celio neighbourhood in Rome (Radicchi and Henckel 2018).

2012) by means of diverse practices such as "aural flânerie" (Boutin 2015), "nightwalks" (Beaumont 2015), and the Situationist *dérive* (Debord 1958, McCartney 2014). Walking as a sensing tool for environmental assessment and design can be found in the work of Kevin Lynch: in "A Walk Around the Block" Lynch and Rivkin focused on perception and memory of streetscapes (Banerjee and Southworth 1990, Jacks 2004). In the 1960s, the Swiss theorist and planner Lucius Burckardt established a new discipline, the so-called: "Promenadology", aimed at studying the landscape through walking, using the senses as tools of investigation (Licata and Schmitz 2019). Similarly, "sense walks" use one particular sense at a time to focus on everyday urban life, and soundwalks, lightwalks and smellwalks (Henshaw 2014) can be considered as examples of sense walking (Radicchi 2017). Another type of "sense walks" are "time walks […] which aim at increasing our attention towards the spatio-temporal aspects of the environment, making us discover hidden and unsuspected rhythmic structures and helping us appreciate their aesthetic potential" (Mayr and Radicchi 2013).

Soundwalks are the most advanced type of "sense walks" both in theory and practice. They were first practiced by Michael Southworth in Boston in 1967 (Southworth 1969), and subsequently formalized by Murray Schafer in the 1970s within the context of the World Soundscape Project (Schafer 1977). However, the German-Canadian composer and musician Hildegard Westerkamp significantly contributed to popularize the soundwalks as "excursion[s] whose main purpose is listening to the environment [by giving] our ears priority" (Westerkamp 1974) and since the 1970s practitioners have experimented with soundwalks within different disciplines (McCartney 2014). More recently, soundwalks have been introduced as a participatory method to assess the quality of the acoustic environment of cities in soundscape research and urban planning (Adams et al. 2008, Aletta 2016, Brook and Schulte-Fortkamp 2016, Radicchi 2017, ISO 2018). Conversely, lightwalks have a relatively younger history as a method to assess the nocturnal environment. They have been applied to sensitize people to light pollution and only recently to collect data about people's perception of different light environments, under various degrees of natural darkness (Schwendinger 2013, Henckel 2018, Krop-Benesch 2018).

In 2016, combined sound- and lightwalks were firstly envisioned by the author and a colleague as walks occurring in the time-space of the night[3] and focusing on two senses at a time (i.e. hearing and vision). Theory and practice of soundwalks were taken as a reference

[3] For lightwalks the night is the obvious time-space, whereas for soundwalks the night is rather underrepresented (McCartney and Gabriele 2001). In general, the temporal dimension, and especially the night (Shaw 2018), plays a quite neglected role in "sense walks", although natural and artificial environments, routines and practices significantly change at day and night, as time lapse-based research shows.

to position the combined sound- and lightwalks. A combined sound- and lightwalk was defined as any excursion whose main purpose is listening to the environment and looking at its artificially lit components. As a methodological reference, it was taken the "4 Variations" framework, which indicates how to perform silent soundwalks, commented soundwalks with "simple evaluation points", "solo soundwalks" and "soundwalks with complex evaluation points" (Radicchi 2017).

Against this backdrop, this contribution presents a combined sound- and lightwalk, that was conducted in Berlin to assess sound and artificial light of the urban environment in the Friederichshain neighbourhood. It describes materials and methods of the study, explaining how the six participants in the walk were guided along a predefined path composed of four stations, and how sound and artificial light was combinedly assessed by means of perceptual responses and quantitative measurements. It presents the data analysis' results, that highlight the potential of the method for the integration of a qualitative perspective in the assessment of sound and artificial light at night. In conclusion limitations of this study and recommendations for future research are addressed. Specifically, suggestions include how integrating qualitative perspectives from combined research fields and using citizen-generated data could help to inform planners and policy makers about how to create more inclusive and sustainable planning and policies for the protection of both urban quiet and dark areas at night.

A combined sound- and lightwalk in Berlin

The combined sound- and lightwalk presented in this contribution was conducted on November 28th 2019 in Berlin within the context of the 2019 Conference *Stadt Nach Acht – International Nightlife*. The walk was aimed at assessing the quality of sound and artificial light of the urban environment in the area under investigation, by means of questionnaires and measurement tools. The walk took place in the evening of a weekday from 7 PM to 8:30 PM in the Friederichshain neighbourhood in East Berlin. This neighbourhood belongs to the district of Kreuzberg-Friedrichshain, that has undergone vast changes in the urban and social structure, becoming one of the most fashionable areas of Berlin for young people, hipsters, night-life lovers and the international ex-pat community. Fifteen participants signed-up for the sound- and lightwalk, and six people attended the activity, including a vision-impaired person, suffering from low vision.

The route (Figure 2) of this combined sound- and lightwalk was predefined by the walk leaders and it comprised four stations, where the participants were asked to make

observations and collect data about the acoustic and light quality, by replying to a questionnaire.

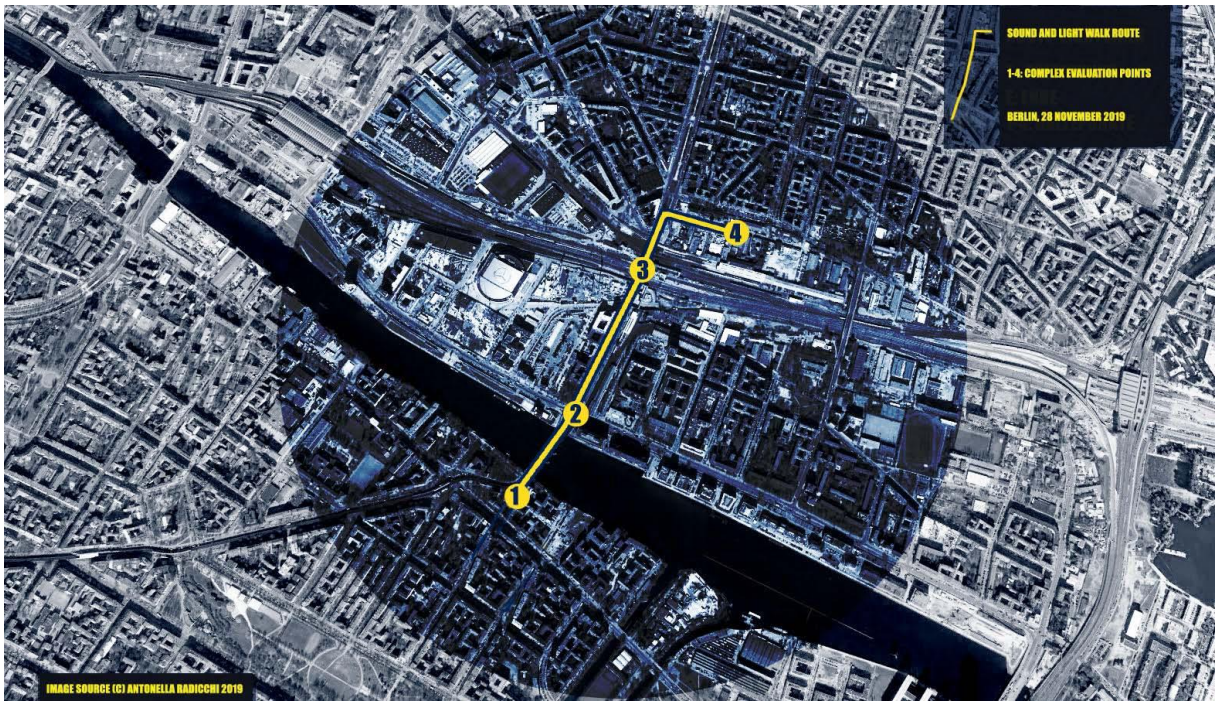

Figure 2: Map illustrating the Berlin sound- and lightwalk route and the four stations. Station (1) Schlesische Str./ Falckensteinstr.. Station (2) Am Oberbaum/Stralauer Allee. Station (3) Warschauer Str.. Station (4) RAW Area. Image: Antonella Radicchi 2019 ©.

Selection criteria for the identification of the four stations included diversity in the acoustic and light components of the environment (Figure 3). The first station was at the intersection of two streets: Schlesische Str. and Falckensteinstr. in a mixed area composed of medium-high residential buildings with commercial activities at the ground floor, such as bars, restaurants and clubs. The second station was along Stralauer Allee, a multi-lane traffic route, next to the Oberbaum bridge, a double-decker bridge linking the Kreuzberg and Friedrichshain neighbourhoods, which are separated by the River Spree. At this double-decker bridge, cars run on the lower part and trains on the second level. The third station was at Warschauer Str. on the bridge which spans over the S-Bhan trains and the regional railways. The fourth station was in the RAW area, formerly the German national railway repair workshop and today a hot-spot for Berlin nightlife, hosting famous clubs such as the Cassiopeia.

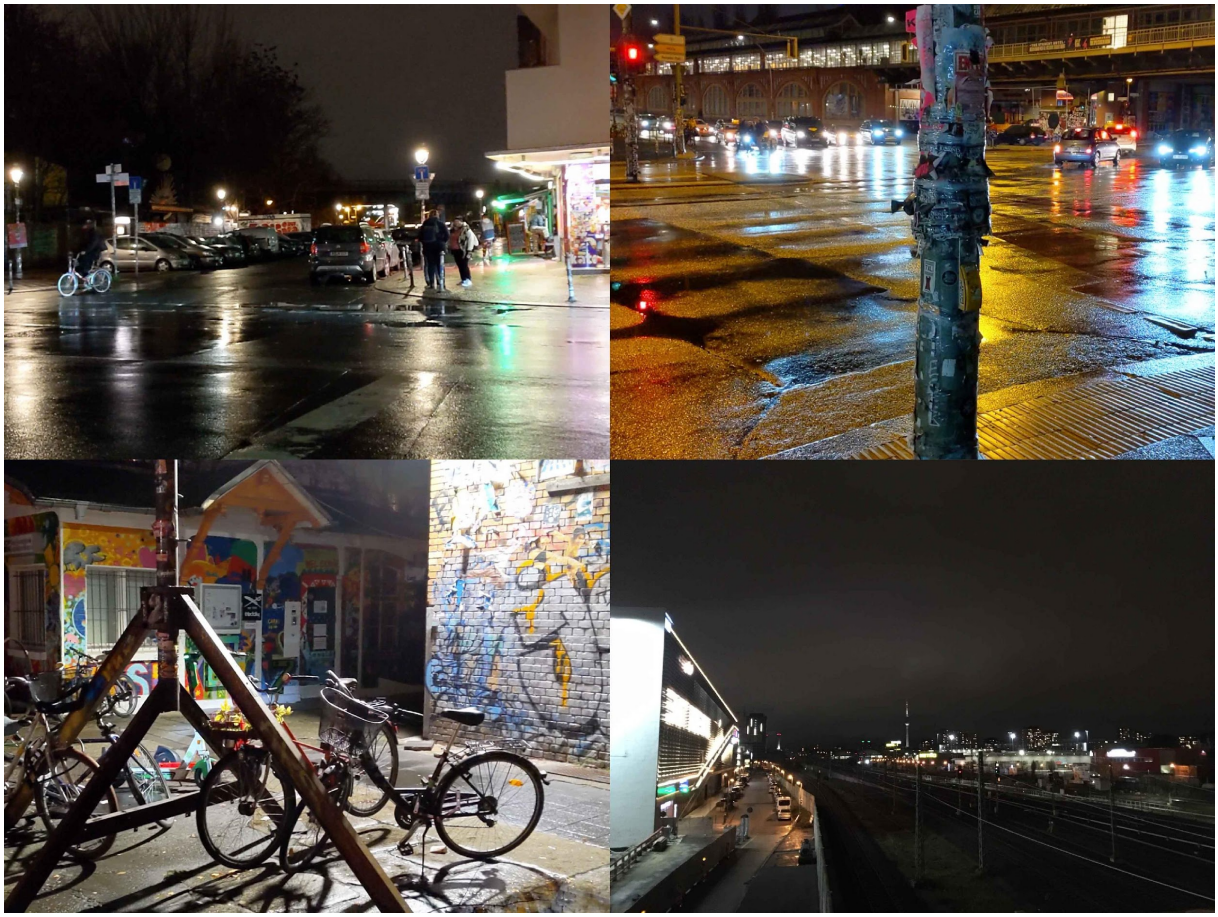

Figure 3: Pictures showing the four stations of the Berlin combined sound- and lightwalk. From left to right, clockwise: Station (1) Schlesische Str./ Falckensteinstr.. Station (2) Am Oberbaum/Stralauer Allee. Station (3) Warschauer Str.. Station (4) RAW Area. Pictures of the stations (1), (2), (4) were extracted from a video recording made during the walk. Picture of the station (3) was taken by the author. Image: Antonella Radicchi 2019 ©.

Before the start of the combined sound- and lightwalk, an introduction was given to the participants to contextualize the research activity, as to explain the procedure and the printed questionnaires handed out to be filled in during the walk. Then, the participants were guided in silence at a slow pace, along the pre-defined route. At each station, the group stopped and the participants were invited to listen and look at the environment for three minutes, in silence. Afterwards they were requested to assess the acoustic and light quality of the environment, by filling in questionnaires. While the participants were observing the environment, the walk leaders made light and sound measurements, and a student assistant made a video recording of the settings and the participants in action. Sound and light measurements were made while the participants were observing the environment in silence. Specifically, sound measurements were taken as dB(A)L_{aeq}, using a *SAUTER SU 130* sound level meter in a timeframe of 3/5 minutes. Light measurements were made using a *testo 540 lux* meter at different spots in the location, according to the diverse light sources. This procedure was repeated at each station. At the end of the walk, a group discussion took

place: every participant shared their feedback on the combined sound- and lightwalk with the group and discussed the best and worse stations.

The questionnaire was designed by the walk leaders, referring to questionnaires previously designed for a combined sound- and lightwalk led in Rome in 2017 (Radicchi and Henckel 2018). The questionnaire adopted in the Berlin walk was composed of six questions, identical for each station (Table 1). A continuous five-point linear scale in combination with open questions were used to collect the participants' responses at each station during the walk. The participants were asked to rate how dark and quiet the environment was, by using a continuous five-point linear scale: *too bright – dark* and *too loud – quiet* (Question no. 1 and 2, respectively). For the third and fourth questions the participants assessed the pleasantness of the light and the acoustic environment of the environment, by using a continuous five-point linear scale: *very unpleasant – very pleasant*. The final two questions were about what struck the participants most about the light and acoustic environment: free responses could be provided by filling in a blank space.

Table 1. Table reporting the questionnaire used during the Berlin sound- and lightwalk.

No.	**Question**	**Reply Options**
1a	How would you judge the lighting situation here?	Continuous Five-point Linear scale (*too bright-dark*)
1b	How do you judge the sonic situation here?	Continuous Five-point Linear scale (*too loud-quiet*)
2a	How pleasant do you find the illumination here?	Continuous Five-point Linear scale (*very unpleasant-very pleasant*)
2b	How pleasant do you find the sonic environment here?	Continuous Five-point Linear scale (*very unpleasant-very pleasant*)
3a	What strikes you most about the lighting situation? Why?	Open Entry
3b	What strikes you most about the sonic situation? Why?	Open Entry

Data collected by the participants at the four stations were analysed applying mixed methods. A qualitative content analysis was used to synthesize: the responses given to the open questions no. 3a and 3b (Table 1) and the comments provided at the end of the walk.

Replies given to questions no. 1a, 1b and 2a, 2b were correlated with the measurements made by the authors at the stations. The entries given to the open questions no. 3a and 3b were evaluated by applying a qualitative coding analysis and represented through word-clouds, as illustrated in Figure 4.

Results

The results outlined in this section pertain the sound and light measurements and the subjective responses provided by the participants in the combined sound-and lightwalk conducted in Berlin for the 2019 Conference *Stadt Nach Acht – International Nightlife* (an overview of the results is illustrated in Figure 4 and Appendix A.

At the first station, at the intersection of the streets Schlesische Str. and Falckensteinstr., participants perceived the environment as *too loud* and *fairly loud*, mainly due to traffic noise. The perception of participants was consistent with the sound level measurements which reported high values of 70.4 dB(A). From the final discussion, it emerged that this location was perceived by a participant as the most unpleasant station, due to high levels of traffic noise. At this station, artificial light was perceived as either *pleasant* and *unpleasant*. A participant reported that the combination of variety and intensity of artificial light made the overall impression blinding at times, although the light measurements reported rather low values, i.e. 1-2 Lux. A vision-impaired participant could not reply to the questionnaire, because this location was too dark.

At the second station along Stralauer Allee next to the Oberbaum bridge, participants found the environment *too loud* and *fairly loud*, due to traffic, loud music and many different noises. This perceptual assessment was consistent with the sound measurements, which reported high values of 71 dB(A). Overall the acoustic environment was perceived as *low-fi* (Schafer 1977), characterized by the absence of *acoustic perspective* in the area. This impression was confirmed by a participant, who reported the feeling of being "*lost [due to] too many different noises*". In terms of artificial light, the area was perceived as *too bright*, *fairly bright*, and overall as *unpleasant* by the participants, although the light measurements reported high or low values depending on the light sources, i.e. 8 Lux and 1-1.50 Lux at the Oberbaum bridge. Controversial comments were expressed by the participants, i.e.:

> "*I loved the light from inside of the S-Bahn, warm, cosy*" and "*I don't like these yellow street lights: they are too high and too shiny*".

A participant found the artificially-lit environment "*chaotic, […] not help[ing] to orientate and create a mental image of the area*".
At the third station, at Warschauer Str. on the bridge which spans over the railways, participants rated the acoustic environment fairly loud, just right and even fairly quiet, although the sound measurements reported rather high values of 68.5 dB(A). Comments about quality of the acoustic environment were overall positive:

> "*I heard a group of people approaching and talking, that was nice*", "*cars and trains – they were quieter, than I would think – especially trains – and then comes music – too loud*".

The presence of rhythms was also highlighted by the participants with appreciation:

> "*the pleasantness when cars pass and quick moment of almost silence emerges. And then a sudden music from concert appears*", and "*the acoustic environment is unpleasant due to the traffic along the bridge: when the cars stop, it's beautiful listening to the S-Bahn trains passing by.*"

In terms of artificial light, the environment was perceived as fairly dark, just right and even fairly bright, with light levels measured of 5 Lux. Participants' comments reported to explain how they evaluated the light environment were very precise:

> "*too mixed, in terms of lights and colours, the train track without light is nice*", the "*East Side Mall [is]very big and bright*", "*the patches of visual pollution from advertisements combined with fairly pleasant distant lights of people's homes*", and again "*the new mall is kind of a "spaceship" too bright and white, you can barely see Alexander Tower because of the light*".

Nevertheless, the environment was perceived as too dark by the vision-impaired participant, who needed a lamp to reply to the questionnaire. In terms of pleasantness, participants reported inconsistent assessment of the light and acoustic environment, rating them both fairly unpleasant and neutral.
At the fourth station, in the RAW area, participants found the artificial light mainly, fairly dark and dark, in line with the light measurements that reported values of 2 Lux. Nevertheless, comments made during the final group discussion primarily focused on an

extremely bright LED light on a building nearby (see Figure 2, the fourth image from above left clockwise).

> "*That light on the corner – it wasn't very pleasant anyway*", and "*the overall area is quite dark, and then, we have this big lamp which helps me write but it is annoying*".

Light measurements taken at the LED light reported very high light values of 320 Lux. Despite the LED light not being appreciated by the participants, it helped the vision-impaired subject, who used this LED light to reply to the questionnaire. The acoustic environment was perceived as fairly quiet, just right and by one participant as fairly loud, with sound levels reporting values of 60dB(A). Participants' comments were somehow contradictory:

> "*quieter place, [with] commercial activities*", "*club – it was disturbing me*", "*sounds from the clubs with traffic, [but] I can hear the sound of wind on leaves and it is pleasant*", "*I like listening to people talking and laughing, it reminds me that there is life out there!*".

In this area, inconsistent feedback was given on the pleasantness of sound and artificial light: comments spanned from fairly unpleasant to fairly pleasant. During the final discussion a participant appreciated this location as the safest and the most pleasant place, with no commercial activities, no traffic, and even some vegetation.

A qualitative coding analysis was applied to the open entries given by the participants to questions no. 3a and 3b (Table 1). The results are displayed in Figure 4 by means of word-clouds: the size of the words displayed is equivalent to the frequency at which the words occurred in the replies. For example, in regard to artificial light (Figure 4, word-cloud on the left), what struck most of the participants was the light emitted by restaurants, advertisements, the East Side Mall and street lights. Participants highlighted several qualities of the environment that impressed them, such as: the brightness, the variety and the warm colour of the lights. Regarding the acoustic environment (Figure 4, word-cloud on the right), distinctive patterns emerged. For example, participants particularly appreciated the sounds of traffic, clubs, trains, music and people talking. Overall the environment was perceived very loud but also pleasant, a contradiction which reflects the results that emerged from the analysis of the entries to question 2b (Table 1 and Appendix A).

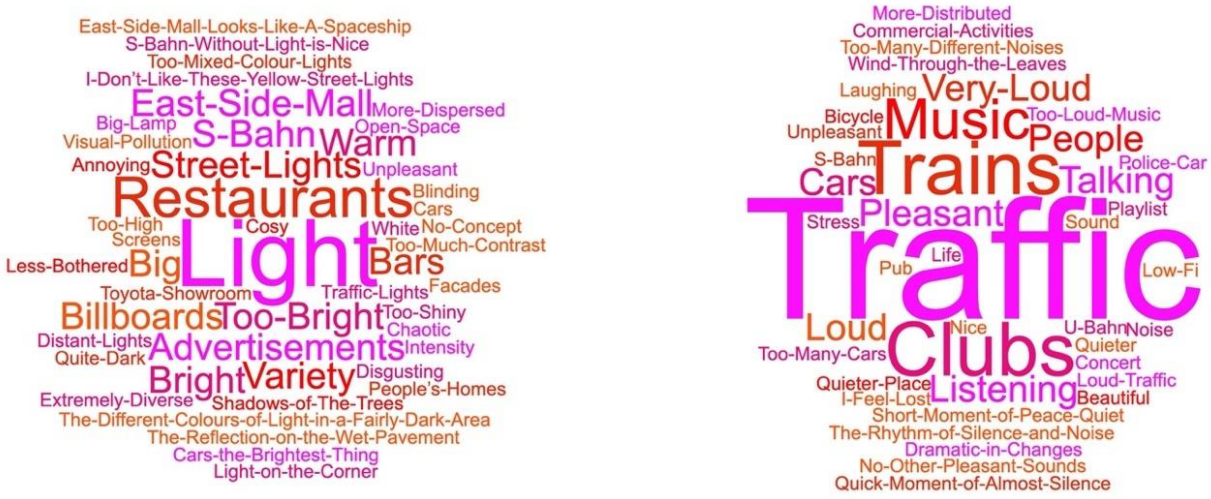

Figure 4: From left to right, word-clouds of what struck the participants most about sound and artificial light of the urban environment at the four station along the walk's route. Image: Antonella Radicchi 2019 ©.

Discussion and conclusion

In line with the 2030 Agenda for Sustainable Development, cities in Europe have implemented policies for addressing economic, social and environmental sustainability. Noise and light pollution can be regarded as challenges to sustainability, due to the detrimental effects they can have on human health, wellbeing and the environment. Increasing levels of noise and light pollution in cities can lead to the loss of quietness and darkness, two qualities of the urban environment that European policies attempt to protect (e.g. EC 2002). Scrutiny of most of the approaches to reduce noise and light pollution showed a tendency to apply quantitative indicators and methods and overlook human perception as a criterion for assessing sound and light phenomena and their interplay. To address these limits, in recent years, scientific interest for research on an integrated approach to sound and artificial light arose, which led to the development of a novel mixed-method for assessing the sonic and artificial light components of the urban environment at night: the combined sound- and lightwalks.

This contribution outlined the theoretical framework which sustains this method and presented the case study of a combined sound- and lightwalk conducted in Fall 2019 in the Friederichshain neighbourhood in East Berlin. Participants in the walk were guided in silence at a slow pace at four stations along the walk route. At each station, they observed the environment in silence and assessed its acoustic and light components, by filling in a

questionnaire. While the participants were observing the environment, sound and light measurements were made by the walk leaders.

The results of this case study showed the potential of combined sound- and lightwalks to reach more articulated and inclusive assessments of sound and artificial light at night, using human perception as an evaluation criterion. However, limitations related to the relatively small number of participants in this study recommend caution in interpreting the results, which are descriptive in nature and not representative of the Berlin population.

Further research is needed to fully assess the potential of this method. For instance, it is recommendable to involve a higher number of participants and collect participants' demographic data, e.g. gender, age, race, cultural background, that would allow for in-depth analysis of the results and casualisation.The participation in this walk of a vision-impaired person highlighted the importance of conducting combined sound- and lightwalks with both vision- and hearing-impaired people, who have different needs and resources to orientate themselves in space. Furthermore, future experimentations should test different rating scales for the perceptual assessment of both sound ad artificial light of the environment at night. An option to consider could be using only open-ended questions, which would allow for a more comprehensive collection of subjective and perceptual responses. Time and space should also be accounted as important variables in designing the combined sound- and lightwalks. Accordingly, different scenarios could be tested including: (a) a sequel of combined sound- and lightwalks with the same group along the same route at a different time of the night; and (b) combined sound- and lightwalks with the same group along the same route at the same time but with a reversal in the order of the stations.

In conclusion, by implementing this method, a quantitative approach to measure the tangible aspects of the acoustic and light on the urban environment at night can be integrated with a social science perspective, considering qualities people value about nocturnal quietness and darkness (Wartmann et al. 2019). In so doing, citizen-generated data can be produced and then used by planners and policy-makers for progressing towards the creation of more inclusive and sustainable approaches for the protection of urban quiet and dark areas at night.

Acknowledgments

The author would like to acknowledge the contribution of her colleague Dietrich Henckel, an artificial light scholar, in the design and execution of the combined sound- and lightwalk presented in this chapter. Together, they first tested combined sound- and lightwalks, as a research method, within the framework of the project studio course "Light- and Soundscapes of the Urban Night – Berlin/Florence", which they co-taught at the Technical University in Berlin in 2016-2017. Then, they further experimented with this method in the occasion of the XXXII Italian Congress of Geographers, where they guided a combined sound- and lightwalk, with a group of congress participants in the Celio neighbourhood in Rome. The author would like to thank: Lisa Henckel for the transcription of the questionnaires' results; TU Berlin student Till Aumüller for his assistance with the video recording; and the participants in this combined walk for their enthusiasm and insights.

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