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Soundwalk of visually impaired people on Surabaya's sidewalks

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ABSTRACT

A series of surveys to obtain data about the sonic perception of sidewalks in Surabaya Indonesia was conducted. The surveys involved visually impaired people considering that the soundscape of these people is specific since they use sound to identify the surrounding. The surveys were conducted in-situ using a soundwalk method consisted of nine segments, i.e., Siola (3 segments), Bambu Runcing (2 segments), and Raya Darmo (4 segments). The data were collected using an online questionnaire consists of semantic scale close-ended questions, where a visually impaired participant was accompanied by a sighted person to fill in the form. With ten visually impaired participants for each segment, 90 data were collected and analysed using varimax rotated principal component analysis. It shows there are four soundscape dimensions, i.e., dimension associated to relaxation (25%), dynamic (11%), communication (10%), and contour (9%). These are consistent with the soundscape dimensions from earlier studies, except the dimension of contour which is considered as the unique dimension perceived by the visually impaired people.

Keywords: Soundwalk, Sidewalk, Visually Impaired People
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1. INTRODUCTION

Sidewalks are important integral parts of streets and urban life, but yet an underestimated element of the urban form, particularly in developing countries, where the existence of public spaces is less appreciated. It is not only functioned as a walking space between roadways and buildings or built environments, but also accommodates vendors and merchants, a place of panhandlers, a quarter for homeless residents, also a place for demonstration by political activists [1].

In 1961, Jane Jacobs [2] even called sidewalks as "the main public places of the city." It is agreeable. Therefore, sidewalks should carefully be planned and designed to provide comfort and safety for city dwellers. Sidewalks differ from one another based on their location in the city, surrounding demographics, and association with particular uses and buildings [1]. Simply by comparing sidewalks around the world, we see that the demographic factor clearly becomes the main factor in differentiating sidewalks one another.

The not carefully designed sidewalk may reduce comfort and safety of users within a short time, such as the onset of fast-growing tree roots to the sidewalks [3], or a large obstruction that significantly reduces the walkability [4]. In Indonesia, city dwellers prefer to use vehicles, even to reach the destination as shorts as 300 m caused by the low quality of sideways [5,6]. The low quality and the less walkability of sidewalks in most Indonesia cities are easily spotted. Hitherto, further evaluation of city dwellers' perception of Indonesia sidewalks was carried out to obtain more detail data about how users perceived the sideways and later to improve the condition.

2. THE SIDEWALKS OF SURABAYA

Surabaya is the second largest city in Indonesia after Jakarta as the capital city. Many urban elements of Surabaya are within better quality compared to those of other cities, including Jakarta. Limited studies are found about sidewalks of Surabaya, and most of them are in Bahasa Indonesia. Among those limited is a study by Randy [7] who indicated that the main sidewalk of Surabaya located on Jalan Urip Sumohardjo and Panglima Sudirman classified B in the pedestrian level of service. B classification is a condition where the pedestrian space 40-60 ft^2/person and flow rate 5-7 person/min/ft. At this level, a sufficient area for pedestrians to select walking speeds freely to bypass other pedestrians is available [8]. Sidewalk segments whose functions are violated due to improper use are easily captured [9]. The city government has made efforts to accommodate the need of people with different ability to have equal access to sidewalks. Even so, there are conditions where the sidewalks hardly accommodate the needs of the difable community [10]. In other cases, Utomo and Wahjudjanto suggested the addition of bus stop bays along selected sideways [11], which without careful planning and design will only reduce the sidewalk width to cause even less passable sidewalks for the difable community.

In accordance with the Government Regulation of Republic of Indonesia number 43 dated 1993 [12], sidewalks are the facilities provided to support traffic activities and road transportation both on the roadside and adjacent to the road, in the context of safety, security, good order, and smooth traffic, and provide convenience for the users. Thus, the keyword of this regulation is a convenience, which includes safety and security. When the conclusions of previous studies and the regulation seem to disagree, further investigation to map the real condition of sidewalks, particularly by using the perception of all users inclusively is of importance.

3. SOUNDS PERCEIVED BY VISUALLY IMPAIRED PEOPLE

A specific method to evaluate the level of convenience of sidewalks' users using the sonic perception of visually impaired was entangled. The method is soundscape, a concept introduced by Schafer [13], which then defined in ISO as an acoustic environment as perceived or experienced and or understood by people; in context [14]. On one side, studies have shown that there was a correlation between the aural and the visual aspect of the soundscape assessment, means that the perception of the soundscape is not purely aural but also visual [15,16,17]. Spatial impression such as openness and density also influenced soundscape perception [18]. These all are acceptable since the soundscape surveys were carried out by sighted participants. On the other side, if no bias between the aural and visual factors of a soundscape study is required, it is hypothetically better to carry soundscape research engaged by visually handicapped people. Blind people are more sensitive to sound than the normal-sighted people [19], and they are also typically able to process acoustic information better [20]. Plasticity of the brain helps people with a visual handicap for developing extra abilities in processing auditory cues [20,21,22,23]. These have positioned the blind people to be more attentive to acoustic information and dispose of more brain volume to process the sonic information [24]. The blinds show a greater skill than blindfolded sighted subjects in using auditory cues for guidance [25]. In the outdoor spaces, the sound of nature and the weather (such as wind, rain, and thunder) plays a crucial role for the visually impaired people in perception the surrounding [24]. Blind people localise sounds and assimilate them with the sound from the environment more accurately than sighted people [26]. The visually impaired people are also better echolocators than the sighted ones [27]. However, people with a visual disability has been reported to be delayed in mobility [28].

4. METHODS

4.1 Participants

The series of study involves 10 visually impaired participants. The visually impaired participants were a group of junior and senior high school students from Yayasan Pendidikan Anak Buta (the Foundation of Education for Blind Children) or YPAB of Surabaya in their 16 to 20 years of age. As this is a school with special needs, the students' age was not as the age of junior and senior high school students which commonly at 13 to 18 years old. The 10 participants consisted of 6 male and 4 female. YPAB was selected as the project partner since YPAB is a long-known partner of several inclusive design projects with the first author's institution of Petra Christian University (PCU). Besides, it is not easy ethical permission to get when the visually impaired persons are laypeople without attachment to institutions. The official ethics permission to partnering with YPAB was granted by the Body of National Unity, Politics, and Community Protection (Bakesbangpol), a body under Surabaya City Government licensed number 070/6619/436.85/2017 dated 19 July 2017 and approval letter by the Headmaster of YPAB dated August 1, 2017. The approval includes publishing images taken during the project. There were also another 10 participants who are sighted. The second type of participants was tasked to accompany the visually impaireds during the soundwalk survey. The sighted participants were all PCU undergraduate students of the fifth semester who took the Inclusive Design coursework. Here, we did not collect the soundwalk data of sighted participants to be compared with the visually impaireds as the earlier study has shown that the soundscape dimension of the sighted participants in urban parks of Surabaya [29] was generally similar to the soundscape dimension found by Kang and Zang [30], Axelsson et al. [31], and Sudarsono and Davies [32].

4.2 Location, questionnaire, and process

The study was conducted empirical with the data collected in-situ at 9 sidewalks segments of Surabaya. The sidewalk segments were selected according to the following consideration: (1) location in the area of the Surabaya city centre, (2) the most optimum and improved sidewalk compared to other sidewalk segments in Surabaya, (3) serving major arterial roads with variations of the sidewalk condition, i.e., different width (2.5 m – 5 m), different materials (smooth tiles and slightly coarse tiles), with and without guiding blocks, with or without canopy, and different street crossing types (pelican crossing and pedestrian bridge). The selected sidewalks are Siola (3 segments), Bambu Runcing (2 segments), Raya Darmo (4 segments) (Figure 1). Each segment is approximately 250 m length.

Figure 1. Map of the surveyed sidewalk segments. It consists of 9 segments, each of approximately 250 m length. Each segment represents different sidewalks condition and or different types of street-crossing methods. The area inside the box is the city center of Surabaya (after Google maps).

The questionnaire of perception rating was constructed in a very simple bipolar semantic scale of -1 0 1 using the Google form. The -1 scale is the attributes emerged from the earlier study [29], 0 is for a neutral response, and 1 is for the antonym of the attributes. The three only scales might not provide a sufficient in-depth analysis but were deliberately used considering the barrier of communication between the participants and the accompanying persons. The simplification of the scale, from commonly 5 or 7 to 3 only, was considered so as the interviewee would shortly grasp the question and be able to answer the question instantly. The scale commonly used would only lengthen the question's reading by the interviewer, lengthen the time of interviewee to grasp the question, and lengthen the time to choose the valid answer, which might lead to a miscommunication to generate non-valid answers.

Table 1. The attributes developed for questionnaire emerged from the earlier study [29].

No.	Attributes	Context
1	crowded	soundscape
2	comfort	soundscape
3	noisy	soundscape
4	fun	soundscape
5	rough	soundscape
6	natural	soundscape
7	safe	soundscape
8	unclear direction	soundscape
9	far	soundscape
10	slow	soundscape
11	know the position	soundscape
12	full	soundscape
13	scary	soundscape
14	spacious	soundscape
15	easy	access
16	slippery	access
17	clear route	access
18	near traffic	access
19	flat	access

The soundwalk was conducted in silence on each segment to allow the participants to listen fully to the soundscape. The participants were using walking sticks to guide them tactically (Figure 2). The accompanying persons took care of the visually impaired participants only when they were about to encounter a dangerous situation, such as toward a quite deep hole, large obstruction ahead, or about to cross the streets. After each segment, both the participant and the accompanying person stop for a break to conduct the questionnaire session. The soundwalk took about 10 minutes, and the questionnaire filling took about 5 minutes. It was conducted in 3 groups consist of 3-3-4 participants. Ten minutes gap was allocated between groups to allow participants to walk the route freely. The surveys were conducted in two Saturdays within a normal traffic flow (no traffic jam, but also not too quiet, the traffic flow has been just fine).

Figure 2. Snapshot of soundwalks at Siola (a), Darmo (b), and pelican crossing at Darmo (c) (Permission to use these images was given by YPAB's head master).

5. FINDINGS AND DISCUSSION

All data obtained from 9 sidewalk segments with 19 attributes were analysed at a time using principal component analysis (PCA) with a change of coordinates known as varimax rotation [33] so that each variable can be associated at most one factor. It will simplify the interpretation of the results of the PCA. Four factors were declared, as shown in Table 2. The dominant soundscape dimension of factor 1 is related to the perception of relaxation which includes "comfort", "fun", "safe", "clear direction", "know the position", "soothing", "easy access", and "clear route". This factor explains 25% of the variance. Factor 2 is associated with the perception of dynamic, which includes "soft", "far", "slow", and "far traffic". This factor explains 11% of the variance. Factor 3 is associated with communication (10%) which includes "crowded", "noisy", and "full". Whereas, the soundscape dimension related to the perception of contour explains 9% of the variance, which is related to the semantic scale of "flat". The soundscape dimension found in this study is inconsistent with the previous study with the same visually impaired respondents at parks, where the dominant soundscape dimension is dynamic [29]. When the visually impaired respondents were tasked to walk on an area with a certain function such as parks [29], they perceived the dynamic soundscape dimension as the most important dimension. The dynamic dimension assists them in location and direction. However, when they were tasked to walk on an area with a clear direction, such as sidewalks, they perceived the dynamic soundscape dimension only as the second important dimension after the dimension of relaxation. With a clear route, the factor of comfort and other factors related to personal perception are more important.

Table 2. Factor analysis of the soundscape evaluation on Surabaya's sidewalks (Kaiser–Meyer–Olkin measure of sampling adequacy=0.739 and Bartlett's Test of Sphericity Sig.=0.000)

Attributes	**Factors**			
	1 (25%)	**2 (11%)**	**3 (10%)**	**4 (9%)**
crowded - uncrowded	0,392	0,127	0,667	
comfort - uncomfort	0,642		-0,205	0,401
noisy - quiet		-0,200	0,832	
fun - boring	0,621	0,130		0,405
rough - soft	-0,217	-0,587	0,303	-0,126
natural - artificial	0,317	0,101	0,111	0,426
safe - dangerous	0,676			
unclear direction - clear direction	-0,777		-0,107	
far - near		0,722		-0,249
slow - fast		0,633		0,123
know - don't know the position	0,753		0,112	
full - empty	-0,189	-0,271	0,713	
scary - soothing	-0,714		0,249	0,137
spacious - cramped	0,145	-0,222	-0,138	0,461
easy - uneasy access	0,733		-0,122	0,143
slippery -coarse	0,462	0,218		0,327
clear - unclear route	0,765			
near - far traffic		-0,706	0,174	
flat - up and down	-0,18	0,131		0,847

The first three dimensions appear in this study, i.e., relaxation, dynamic, and communication was identical to the study conducted in urban areas by Kang et al. [30] and Sudarsono and Davies [32]. This result also consistent to a study conducted by Axelsson et al. [31], which the first dimension found in this study is identical with the dimension of pleasantness and the second and third dimension is identical to the

dimension of eventfulness. The fourth dimension of contour, which is uniquely found in the study, appears because the participants were requested to walk and rate the sidewalks. This dimension might be related to the way visually impaired people characterise the environment.

6. CONCLUSION

The study of sidewalks using soundwalk method of visually impaired people has shown there is four soundscape dimension of sidewalks in Surabaya, i.e., relaxation (25%), dynamic (11%), communication (10%), and contour (9%). The dimension of relaxation is affected by the easiness of the access and how clear is the sidewalk. The dimension of contour is not related to the first three dimensions and become one independent dimension. The fourth dimension of contour uniquely emerges in the study. This result indicates that it is possible to design a contoured sidewalk as long as the sidewalks are clear and easy to access.

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8. REFERENCES

1. Anastasia Loukaitou-Sideris and Renia Ehrenfeucht, "*Sidewalks: conflict and negotiation over public space*", MIT Press, Cambridge (2009)
2. Jane Jacobs, "The use of sidewalks: safety", *The City Readers*, 114-118 (1961)
3. TB Randrup, EG McPherson, and LR Costello, "*A review of tree root conflicts with sidewalks, curbs, and roads*", *Urban Ecosystems* 5 (3): 209-225 (2001)
4. Nicholas Blomley, "*Rights of Passage: sidewalks and the regulation of public flow"*, Routledge, Taylor Francis, London (2010)
5. Bambang Susantono, "*Revolusi Transportasi*", Gramedia Pustaka Utama, Jakarta (2014)
6. Senjaya Setianto and Basuki Joewono, *"*Penilaian walkability untuk wilayah perkotaan di Indonesia", *Proceeding of Symposium XIX FSTPT*, Universitas Islam Indonesia (2016)
7. Gumelar T. Rendy, "Studi Evaluasi Pelayanan Pedestrian Pada Jalan Urip Sumoharjo–Panglima Sudirman Surabaya, *Diss. Faculty of Civil Engineering and Planning*, UPN Jatim (2011)
8. Michael R Bloomberg and A. M. Burden. "*New York City pedestrian level of service study phase I*", NYC DCP, Transportation Division (2006)
9. Dewi Lailatul Qodrilia and Hananto Widodo,"Upaya Penertiban Trotoar Untuk Melindungi Hak Pejalan Kaki Terkait Pelanggaran Fungsi Trotoar di Jalan KH Mas Mansyur Kecamatan Semampir Surabaya", *Jurnal Novum* 1.1 (2016)

10. Bianca Andriani Vianto and Muhammad Farid Maruf, "Upaya Pemerintah Kota Surabaya Dalam Penyediaan Pedestrian Yang Layak Bagi Penyandang Disabilitas Di Kota Surabaya", *Publika* 6.5 (2018)
11. Nugroho Utomo and Iwan Wahjudjanto "Analisa Tingkat Pelayanan Jalur Pejalan Kaki Yang Sinergis Dengan Fasilitas Transportasi Publik di Kota Surabaya", *Jurnal Rekayasa Perencanaan*, 4.3 (2008)
12. Law Bureau of Republic of Indonesia, "*Peraturan Pemerintah Republik Indonesia Government Regulation of Republic of Indonesia) Number 43/1993"*, Tentang Prasarana Dan Lalu Lintas Jalan (2003)
13. Murray Raymond Schafer, "*The soundscape: Our sonic environment and the tuning of the world*", Destiny Books, Vancouver (1977).
14. ISO 12913-1: 2014. "*Acoustics–soundscape–part 1: definition and conceptual framework*" (2014)
15. José Carles, Fernando Bernáldez, and José de Lucio, "Audio-visual interactions and soundscape preferences", *Landscape Research* 17.2: 52-56 (1992)
16. Stéphanie Viollon, Catherine Lavandier, and Carolyn Drake, "Influence of visual setting on sound ratings in an urban environment", *Applied acoustics* 63.5: 493-511 (2002)
17. Man Sze Tse, et al., "Perception of urban park soundscape", *The Journal of the Acoustical Society of America* 131.4: 2762-2771 (2012)
18. Jin Yong Jeon, et al., "Non-auditory factors affecting urban soundscape evaluation", *The Journal of the Acoustical Society of America* 130.6: 3761-3770 (2011)
19. José L., González-Mora, et al., "Development of a new space perception system for blind people, based on the creation of a virtual acoustic space", *International Work-Conference on Artificial Neural Networks*. Springer, Berlin, Heidelberg (1999)
20. Nadia, Lessard, et al., "Early-blind human subjects localize sound sources better than sighted subjects", *Nature* 395.6699: 278 (1998)
21. Daniel H. Ashmead, et al., "Spatial hearing in children with visual disabilities", *Perception* 27.1: 105-122 (1998)
22. Patrice Voss, et al., "Differential occipital responses in early-and late-blind individuals during a sound-source discrimination task", *Neuroimage* 40.2: 746-758. (2008)
23. Teija Kujala, et al., "Faster reaction times in the blind than sighted during bimodal divided attention", *Acta Psychologica* 96.1-2: 75-82 (1997)
24. Monika Rychtarikova, "How do blind people perceive sound and soundscape?" *Akustika* 23.1: 6-9 (2015)
25. Edward R Strelow and John A. Brabyn, "Locomotion of the blind controlled by natural sound cues", *Perception* 11.6: 635-640 (1982)
26. Larisa Dunai, et al., "Virtual Sound Localization by Blind People", *Archives of Acoustics* 40.4: 561-567 (2015)
27. Andrew J. Kolarik, et al., "A summary of research investigating echolocation abilities of blind and sighted humans", *Hearing Research* 310: 60-68 (2014)
28. Luigi F. Cuturi, et al., "From science to technology: Orientation and mobility in blind children and adults", *Neuroscience & Biobehavioral Reviews* 71: 240-251(2016)
29. Christina E. Mediastika et al., "The Sonic Perception of Visually Impaired People in Urban Parks", *First International Conference on Future of Urban Public Space Proceedings* (2018)
30. Jian Kang and Mei Zhang, "Semantic differential analysis of the soundscape in urban open public spaces", *Building and Environment* 45.1: 150-157 (2010)

31. Östen Axelsson, Mats E. Nilsson, and Birgitta Berglund, "A principal components model of soundscape perception", *The Journal of the Acoustical Society of America* 128.5: 2836-2846 (2010)
32. Anugrah Sabdono Sudarsono and William Davies, "Soundscape perception analysis using soundscape simulator", *INTER-NOISE and NOISE-CON Congress and Conference Proceedings*, Vol. 253. No. 8. Institute of Noise Control Engineering (2016)
33. Andy P. Field, "*Discovering statistics using SPSS for windows*", SAGE, London (2000)