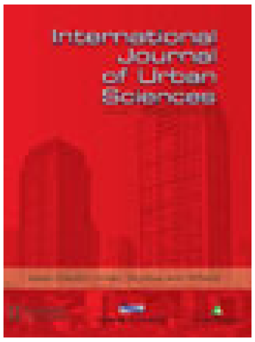

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Appraising the sonic environment of urban parks using the soundscape dimension of visually impaired people

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ABSTRACT

The study aimed to investigate the specific soundscape dimension of visually impaired people and to learn about the possibly unique soundscape dimension elicited by the hearing sense alone. The soundscape dimension of the visually impaired will be used as a reference for improving urban parks to accommodate users inclusively. A semantic-scale questionnaire survey of sighted and visually impaired people in both in-situ and off-site modes was performed. Data were extracted using principal component analysis with polychoric correlations, which produced three soundscape dimensions elicited from the sighted and six from the visually impaired. In sum, evaluation of the park's sonic environment identified the eventfulness soundscape dimension and the pleasantness soundscape dimension as being the most prominent for visually impaired and sighted people, respectively.

Highlights

- An entirely aural soundscape method by visually impaired people is used to appraise urban parks.
- Soundscape dimension of eventfulness is the most prominent for visually impaired people.
- Visually impaired people extract more information from the acoustic environment.
- Visually impaired people sense the danger and direction of a space from sound.

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Public space; urban park; soundscape; sighted people; visually impaired people

1. Introduction

The terminology of parks is easily associated with the natural environment. Unthreatening natural environments can have significant stress-reducing effects for many people (Gramann, 1999), and relaxation has been greater when natural sounds have been perceived dominantly (Zhang, Ba, Kang, & Meng, 2018). Yang and Kang (2005) showed that people like to hear a natural soundscape, as it comforts and calms the heart and mind. Also, there is a greater preference for natural sounds over those that are anthropogenic and mechanical, and together with an evaluation of visual comfort, acoustic comfort evaluation plays a vital role in park visitor acceptability of the urban

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park environment (Tse et al., 2012). People place a high value on naturally quiet, pollution-free settings (Mace, Bell, & Loomis, 2004). When the natural environment has been preserved, parks, particularly in the urban area, are among the essential public features to provide places that may improve the physical and mental health of urban dwellers (Chiesura, 2004). However, the tranquil atmosphere may not easily be achieved in urban parks surrounded by heavy traffic; in fact, the urban park soundscape has been found to be significantly less restorative than the rural soundscape (Payne, 2009).

The study reported here was triggered initially by the fact that Indonesia cities are noisy (Colombijn, 2007). In addition, most of the urban parks in Indonesia are relatively small and surrounded by roads, and traffic noise usually creates a dominant effect in the park. As measured in a previous study, the noise level in city parks was shown to be Leq 61.7 dBA, which was dominated by the presence of nearby traffic (Prasetya, Hermawansyah, & Hidayati, 2017). A good soundscape quality can only be achieved if the traffic noise exposure during the daytime is below 50 dBA (Nilsson & Berglund, 2006). Secondly, this present study was also triggered by observations concerning public facilities in Indonesia, which hardly accommodate people with disabilities, especially the visually impaired. Parks are among the areas where this limited accommodation is mostly spotted. Jawa Timur Province, with Surabaya as its capital, is the second most-populated province with visually impaired people in Indonesia (Kasim, Fransiska, Lusli, & Okta, 2010). Therefore, a study of how the visually impaired feel sonically accommodated, safe and comfortable in urban parks could be quite beneficial for Surabaya.

The study aimed to determine the soundscape dimension of visually impaired people in urban parks, including details of the acoustic environment that develops the soundscape dimensions. The soundscape dimensions of visually impaired people in urban parks are hypothesized to be uniquely different from those elicited by the hearing population (Axelsson, Nilsson, & Berglund, 2010; Kang & Zhang, 2010). The soundscape of visually impaired people may differ not only in its dimensions as compared to those of the sighted, but also in terms of the local context, as soundscape is affected by personal, sociocultural backgrounds and previous experiences (Jeon et al., 2018). Based on local context and sociocultural background, the soundscape of local sighted people was also examined in order to learn whether it weakened or strengthened the studies by Kang and Zhang (2010) and Axelsson et al. (2010). Investigating the soundscape dimension of blind people can also be valuable for further examination as to how these extraordinary people live their lives and respond to their surroundings. Later on, the soundscape appreciated by the visually impaired is to be reported in order to improve the inclusive condition of urban parks.

2. Literature review

2.1. Indonesia's urban parks

Not many references about Indonesia's urban parks could be captured. Among these few, all are in Bahasa Indonesia, which stipulated that urban greenery and nature in Indonesia cities are very scarce compared to its population (Rijal, 2008). In some cities, it is worsened by the conversion of urban parks into other facilities such as food courts, district offices, district head official residences and car parks (Sasongko, 2002). The parks were also designed sporadically, were not well-planned and were made to be merely available (Kustianingrum, Sukarya, Nugraha, & Rachadi, 2013; Sasongko, 2002). Therefore, the

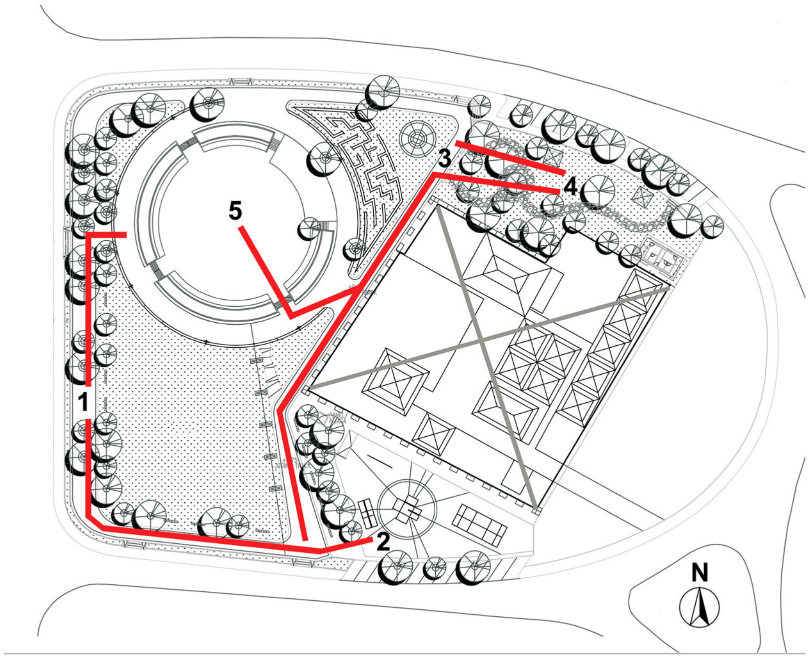

Figure 1. The five spots and routes in Bungkul Park for the soundwalk survey (source Surabaya City Government; the cross-marked area is the tomb of Mr Bungkul).

condition of urban parks in developing countries may differ from that in the developed countries. Two of the most distinctive and most visited parks in Surabaya are Taman Bungkul (Bungkul Park; Figure 1) and Taman Flora (Flora Park; Figure 2). The area of Bungkul Park is only 9,000 m^2, and that of Flora Park, 30,000 m^2, which are considered significant in Surabaya and in Indonesia as a whole. No specific research has been conducted to study the acoustic environment of these two parks, nor even of Indonesia's parks elsewhere. However, several studies about soundscape, particularly in parks, have been conducted in developed countries, such as those by Jeon et al. (2018), Jeon and Hong (2015), Filipan, Boes, Oldoni, De Coensel, and Botteldooren (2014), Nilsson, Botteldooren, and De Coensel (2007), Brambilla, Gallo, Asdrubali, and D'Alessandro (2013), Liu, Kang, Behm, and Luo (2014) and Tse et al. (2012). Nonetheless, only by considering the area of the parks in these previous studies – which are between 110,000 m^2 to 1,200,000 m^2 (Jeon & Hong, 2015); 11,000 m^2 to 14,000 m^2 (Filipan et al., 2014); 80,000 m^2 to 400,000 m^2 (Brambilla et al., 2013); 1,000 m^2 to 23,000 m^2 (Liu et al., 2014); and 85,000 m^2 to 135,000 m^2 (Tse et al., 2012) – we can see that even if there is a soundscape study of parks in Indonesia, it is not comparable to the abovementioned investigations. With considerably small sizes, parks in Indonesia hardly produce natural quietness, which is mostly obtained only in the middle of the park (Filipan et al., 2014).

2.2. Soundscape

Research on soundscape, a concept introduced by Schafer (1977), has been conducted widely to evaluate people's sonic perception in urban public places, including in a

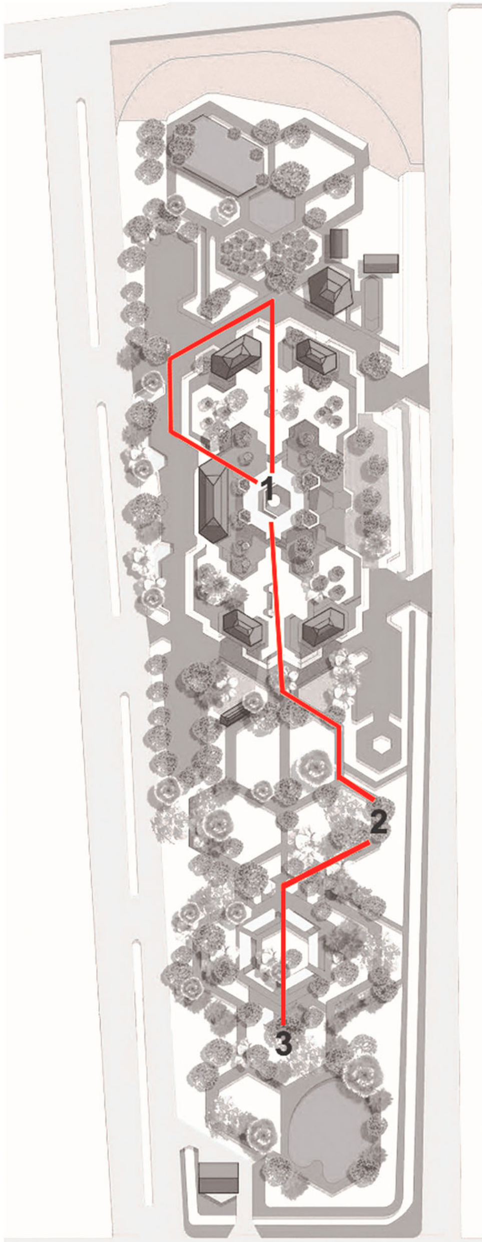

Figure 2. The three spots and routes in Flora Park for the soundwalk survey (source Surabaya City Government).

specific area of urban public spaces such as parks. It was triggered by a growing belief that the appraisal of the acoustic environment should be a complementary relation between the physical measurement using an ordinary noise control methodology and the perceptual construct (i.e. soundscape; Aletta, Kang, Astolfi, & Fuda, 2016). The soundscape definition has been standardised by the International Organization for Standardization (2014) to mean the acoustic environment as contextually perceived or experienced and/or understood by people.

Some prominent studies of the soundscape in public spaces were able to extract soundscape dimensions as perceived by participants using a statistical method, namely principal component analysis (PCA). While Kang and Zhang (2010) elicited four soundscape dimensions of urban public places – relaxation, communication, spatiality and dynamic – Axelsson et al. (2010) identified three – pleasantness, eventfulness, and familiarity. Sudarsono, Lam, and Davies (2016) offered their own three dimensions – calmness/relaxation, dynamic/vibrancy and communication. Even though the terminologies used by the earlier studies are not entirely identical, they nonetheless operate within the similar concept that the soundscape dimension appreciated by sighted people mainly consists of comfort, dynamic and social dimensions.

The soundscape dimensions found in public spaces were all elicited from sighted people, where the participants' visual awareness could bias the perceptual construct on sound. Studies have shown that there is a correlation between the aural and visual aspects of the soundscape assessment, which means that the perception of the soundscape is not purely auditory but also visual (Tse et al., 2012; Carles, Bernáldez, & Lucio, 1992; Viollon et al., 2002). Even the International Organization for Standardization describes how the interpretation of auditory sensation may be influenced by many factors, to include other sensory factors such as visual impression and odour (ISO, 2018). Mostly achieved in a visual manner, spatial impression such as openness and density also influenced soundscape perception (Jeon, Lee, Hong, & Cabrera, 2011). It was thus interesting to study the soundscape appreciated by visually impaired people in urban public spaces, as the judgment thereof would be borne by the hearing sense alone. As they mostly use the auditory sense in their life, blind people are found to be more sensitive to sound than are normal-sighted people (González-Mora, Rodriguez-Hernandez, Rodriguez-Ramos, Díaz-Saco, & Sosa, 1999), and they are also typically able to process acoustic information better (Lessard, Paré, Lepore, & Lassonde, 1998). Blind people localise sounds and assimilate them with the sound from the environment more accurately than do sighted people (Dunai, Lengua, Peris-Fajarnés, & Brusola, 2015). Thus, the soundscape appreciated by the visually impaired is possibly more specific and detailed compared to the soundscape appreciated by sighted people. To date, studies of one particular soundscape of visually impaired people are very scarce. Although Rychtarikova (2015) investigated how blind people perceive sound, she did not mainly discuss the specific soundscape perceived by the blind.

3. Methodology

The study was carried within one and a half year time frame. It comprised of four stages consisting of both off-site and in-situ questionnaire survey of two groups of participants: sighted people and visually impaired people. The stages were ordered as follows: (1) off-site-focused group discussion, (2) off-site questionnaire survey, (3) in-situ soundscape survey of Bungkul Park and Flora Park, and (4) off-site reproduced soundscape survey. Stages (1) and (2) were conducted to collect attributes to further develop the questionnaire to be used in stages (3) and (4). This paper reports stages (3) and (4) in particular.

3.1. The participants

The study involved 35 sighted and 35 visually impaired participants. The sighted participants were Petra Christian University (PCU)'s undergraduate students consisting of 17 females and 18 males between 19 to early 20 years of age. The visually impaired participants were a group of junior and senior high school students of the Foundation of Education for Blind Children, namely YPAB, of Surabaya. The project plan of partnering with YPAB has been presented to a panel of the Independent Research Ethics Committee of the Ministry of Research and Technology and Higher Education of the Republic of Indonesia. Approval was granted by the Body of National Unity, Politics, and Community Protection (Bakesbangpol), a body under the Surabaya City Government with license number 070/6619/436.85/2017 dated 19 July 2017, and an official approval letter from the Headmaster of YPAB dated 1 August 2017, to include publishing images taken during the project.

The visually impaired are 19 females and 16 males between 16 to early 20 years of age. The YPAB students' age is within a similar to that of the PCU student's age as the YPAB students have special needs. They are all categorized as adolescent and early adult, according to the World Health Organization. The age difference at this point was considered to be within an acceptable range since the survey would only collect their instant appraisal of the studied parks, which does not require advance knowledge or experience. It was stipulated by Payne, Mowen, and Orsega-Smith (2002) that different ages have different preferences in visiting parks, but the respondent age was grouped into the broad range of 18–49 years (young to middle adulthood) and those 50 and older (older adulthood). Chiesura (2004) also indicated that the different motives of visiting a park are relative to the different age groups, but the grouping studied was also across a broad range (youngest age categories and adult/elderly categories), spanning from 15 to 65 years. Compared to the previous studies, the age range in this investigation is considered to be as identical groups of participants, which will minimize error during data interpretation. Also, Ma, Wong, and Mak (2018) showed that many studies of soundscape involving extensive age ranges and various backgrounds elicited quite identical responses. The somewhat different educational background of the respondents was also thought to contribute insignificantly to their sonic perception, as Xiao and Du (2011) have concluded that the satisfactory degree of city parks shows insignificant differences for gender and educational background.

The participants have resided in Surabaya for quite some time, either as locals or as students. Thus, all are considered locals. The sighted participants were involved during stages 1, 2 and 3 to study the difference in the sonic perception of the two groups. Stages 4 and 5 were carried out by visually impaired participants only, as the findings of the earlier stages showed the soundscape dimension of the sighted participants to be generally similar to the soundscape dimension found by Kang and Zhang (2010) and Axelsson et al. (2010). Whereas the soundscape of the visually impaired was found to be unique, a deeper evaluation of this result is needed.

3.2. The parks

Two of the largest and the most visited parks in Surabaya, namely Bungkul Park and or Flora Park, were selected for the study. Bungkul Park is known as the most iconic park in Indonesia, which is referred to by other parks in Indonesia cities as they seek to improve their environment. Bungkul Park is located in downtown Surabaya, with commercial and office buildings in the neighbourhood. It was initially a tomb complex of Kyai Bungkul, who was an early figure in the spread of Islam in Surabaya. The park was named after him. The graveyard routinely attracts local and regional Moslems making pilgrimages, and in 2007, the tomb complex was renovated into a city park. The main entrance of the park faces Darmo Street, the most crucial main road of Surabaya, and one that is congested with traffic. The other three sides are edged by Taman Bungkul, Serayu and Progo streets. Thus, the park is practically in the middle of traffic.

Bungkul Park has an area of 16,800 m^2, 80% of which is covered by vegetation of more than 300 species – from ground cover and ornamental plants, to shade plants with heights of up to 25 m and canopy spans of 15 m in diameter. It is a typical design of open spaces in a tropical region, which require large shading to protect the underneath area from direct sunlight. It does not resemble the parks of temperate regions, with their spacious, grassy areas upon which to sit and lie; its milieu is more of benches, paved pathways and amusement objects beneath trees. The park only occupies an area of 9,000 m^2 area. With the preserved tomb and culinary stalls residing at the rear segment toward Serayu Street, the park comprises five primary zones: front sitting area, amphitheatre plaza, skate park, fountains and playground. It is also equipped with toilets, security post and a prayer room. The specific design elements of each segment and the familiar sound sources are listed in Table 1. Figure 3 shows the typical sounds emerging in and around the park. Visitors come to the park from the afternoon to the evening on weekdays and almost for the entire day on weekends. Commonly held activities in the park are light jogging, aerobics, skateboarding, relaxed seating and chatting and enjoying the local cuisine.

Flora Park is also located in downtown Surabaya at the corner of Raya Manyar Street and at the Ngagel Jaya Selatan Street intersection. It is surrounded by heavy traffic as well as commercial and office buildings. It was the most iconic park before the Bungkul Park

Table 1. The design element of each spot or route and the typical sound sources in each spot.

Routes/ Segments	Spots	Parks	Design elements	Typical sound source (from the most to the least dominant)
1	Front area	Bungkul	3.5 m wide concrete footpath, concrete benches, trees along footpath, driving license kiosk at the corner	Traffic, crossing-signs, footsteps, voices
2	Skate park	Bungkul	320 m^2 triangle-shaped concrete skate arena, concrete benches at the boundary shaded by trees	Skate board, traffic, footsteps, voices
3	Fountain	Bungkul	Large ring-shaped fountain within areas of 200 m^2, shaded by trees	Fountain, loud voices, traffic, voices
4	Playground	Bungkul	400 m^2 rectangular-shaped playground, concrete footpath, ground cover, shaded by trees	Loud voices, traffic, fountain, swings, see-saws, slides, voices
5	Amphi-theatre plaza	Bungkul	Ring-shaped concrete plaza with a diameter of 40 m, concrete benches at the edge, small fountains along the edge after benches	Music (from the aerobics activity), fountain, traffic, footsteps, voices
6	Main plaza	Flora	Large fountain, concrete benches, concrete footpath	Fountain, voices, footsteps
7	Sitting zone	Flora	Concrete benches, concrete footpath, ground cover, shaded by trees	Traffic, footsteps, voices
8	Playground	Flora	60 m^2 playground, concrete benches, ground cover, shaded by trees	Loud voices, traffic, swings, voices

Figure 3. The neighbourhood of Bungkul Park and the typical sounds emerging in and around the park.

era and the largest in the city centre of Surabaya. Culinary stalls are located along Ngagel Jaya Selatan Street, heading to the park main gate. Just as in Bungkul, Flora is also typical of tropical parks, with vegetation of more than 600 species covering 90% of the area. Plant varieties range from ground cover and ornamental plants, to shade plants with heights of up to 35 m and canopy spans of 15 m in diameter. The main elements of the park are fish ponds, a giant cage for birds, a deer cage, outbound area, playground, a large fountain, small fountains, a main plaza and small plazas with a seating area, plant nursery, food court, library, offices, prayer room and toilets. The detailed design elements of each segment and the typical sound sources are listed in Table 1. The typical sounds emerging in and around the park are shown in Figure 4.

3.3. Stages 1 and 2: developing the questionnaire

Stages 1 and 2 were carried off-site, with the intention of developing an appropriate questionnaire for the specific participants. The adopted procedure belongs to a method of direct elicitation, namely, individual vocabulary techniques introduced by Bech and Zacharov (2007), which were referred to in constructing the attributes used in the questionnaire. The technique uses the vocabulary developed by the individual subject and a set of principal components representing the common attributes, which is then identified using statistical procedures. A perceptual measurement of sound quality is a multidimensional problem that includes some individual auditory attributes. Therefore, it is possible to elicit and use individual attributes emerging from a mixture of interviews and personal experiences. In stage 1, a focused group discussion (FGD), with two sighted and two

Figure 4. The neighbourhood of Flora Park and the typical sounds emerging in and around the park.

visually impaired persons taken from the 35 sighted and 35 visually impaired participants, was held to generate the attributes. FGD participants were selected based on their experience of visiting Bungkul Park frequently as well as their ability to communicate and maintain involvement in the discussion. The selection criteria of FGD participants is essential to creating a lively discussion that elicits a detail narration before it can be extracted into the questionnaire items for stage 2. The discussion began with a question of what a park is, why they visit it, and what activities are carried inline with the park visit. All answers were listed to construct an open-ended questionnaire used in stage 2, where the questions deepened the terminology arose during the FGD. Seventy respondents (35 of sighted and 35 of visually impaired) participated in stage 2. They were requested to answer questions about their feeling, the ambience, types of sound, the dominant sound, the important sound, the good sound and the bad sound in a park. Stages 1 and 2 reported a consistent response for both FGD

Table 2. The attributes used to develop a semantic scale of the close-ended questionnaire.

Number	Sighted	Visually Impaired
1	Crowded	Crowded
2	Calm	Calm
3	Nice	Nice
4	Disturbing	Disturbing
5	Comfortable	Comfortable
6	Clamorous	Clamorous
7	Noisy	Noisy
8	Fun	Fun
9	Rough	Rough
10	Unhurried	Unhurried
11	Natural	Natural
12	Dense	Safe
13	Good	Good*
14	Fine	Unclear Direction
15	Full	Full
16	Silence	Far
17	Neat	Slow
18	Relax	Variation*
19	Like	Recognize the location
20	Monotonous	Important sound*
21		Scary
22		One direction*
23		Spacious

Annotation: the principle component analysis (PCA) showed that the scores of the asterisk-marked (*) were < 0.5, which must be omitted from the constructed questionnaire, accordingly.

and questionnaire surveys, where the visually impaired participants explained the sonic environment of a park with more terminologies (56 terminologies) than the sighted participants (32 terminologies; Mediastika et al., 2019).

The questionnaire was then constructed in three sections. Section one comprises open-ended questions regarding the impression held about Bungkul and Flora parks. Section two comprises closed-ended questions, as in Table 2, built on a straightforward bipolar semantic scale of −1 0 1. The −1 scale was used as the attributes emerging from stage 3, 0 for the neutral response, and 1 for the antonym of the attributes. It is still debatable whether the use of three-point scales are good enough (Jacoby & Matell, 1971) or misdoubted (Lehmann & Hulbert, 1972). Some may consider three-point scales as incapable of providing sufficient in-depth analyses. However, since an informal interview using five scales caused a miscommunication between the visually impaired participants and the interviewers, the use of three-point scales was confirmed. Simplification of the scale – from the commonly used five or seven points to only three – was intended to allow a quick grasp of the question by the interviewee, who would then be able to answer the item instantly. Using the standard scale would lengthen the question's reading by the interviewer, extend the time an interviewee would have to grasp the issue and lengthen the time to choose an accurate answer. Furthermore, this method is validated by comparing the result of the soundscape dimensions of the sighted participants in this study with the soundscape dimensions of sighted participants from the other studies. The third section comprises open-ended questions that ask about the most favourite and least favourite spots in the parks, including the reason(s) why.

3.4. Stages 3: the soundwalk

Stage 3 was an in-situ survey using a soundwalk method. As its name implies, a soundwalk is a walk in an area focused on listening to the acoustic environment (ISO, 2018). Before engaging in this stage, participants were administered an audiometric test, and all were declared to have normal hearing sensitivity. Stage 3 was conducted in the two aforementioned parks, Bungkul and Flora. The soundwalk in both parks was carried out on Saturday morning (09.00 am to 11.00 am; Figures 5 and 6). Within this period of time, everyday park activities occur, such as groups engaged in aerobics (with mild music; Bungkul and Flora), children riding skateboards (Bungkul), people in queue adjacent to the driving licence kiosk around the corner (Bungkul), visitors sitting and chatting (Bungkul and Flora), children playing on the playground (Bungkul and Flora), children playing around the fountain (Bungkul and Flora) and community gatherings (Flora). Based on

Figure 5. Snapshot of the soundwalk survey at two spots in Bungkul Park: (a) the front entrance area and (b) the amphitheatre plaza (permission to publish the photos is given by YPAB).

Figure 6. Snapshot of the soundwalk survey at two spots in Flora Park: (a) an area adjacent to the main street and (b) a footpath near the playground (permission to publish the photos is given by YPAB).

the taxonomy of the acoustic environment, the acoustic environment during the soundwalk consisted of sound generated by human activity/facility- road traffic, footsteps, voices, laughter, music, alarms and the sound of nature, i.e. water, wind (ISO, 2018). One identified sound that was not in the taxonomy was that of sports, i.e. skateboarding.

Soundwalks were held with the visually impaired participant walking side-by-side the accompanying person; some were also done hand in hand. Here, the accompanying persons were the sighted participants. First, the sighted participants conducted soundwalk of themselves, then they accompanied the visually impaired to do the soundwalk and to fill in the questionnaire. It was held in silence, with communication between the interviewer and interviewee kept into minimum – i.e. only when the visually impaired participants were about to encounter unexpected situations such as contoured routes. The soundwalk passed appointed routes and spots (Figures 1 and 2), and the interview was conducted right after each segment, so that the conversation between the interviewer and the interviewee did not interfere with the soundscape activity (Figures 5 and 6). Five segments plotted in Bungkul Park and three in Flora Park. Bungkul has more spots to be visited than Flora, as the park features in Bungkul have more variety. The soundwalk was conducted in a sequence of 5 groups consisting of 7 participants each. With 35 sighted and 35 visually impaired participants and 8 segments, 560 data elements were collected.

The feature specific to each spot in Bungkul Park are as follows (Figure 7a-7e): (1) spot 1 is the front part of the park with concrete benches, and a pelican crossing with a sound signal and a driving license kiosk were nearby (i.e. just around the corner); (2) spot 2 is the skate park area; (3) spot 3 is the central fountain; (4) spot 4 is the playground; and (5) spot 5 is the amphitheatre plaza. The feature specific to each place in Flora Park is as follows (Figure 7f-7h): (1) spot 1 is the centre fountain; (2) spot 2 is a sitting area close to the main street; and (3) spot 3 is the playground. During the soundwalk, the Sound Pressure Level (SPL) at the eight designated spots was recorded using NTi-SL2 with M2211 microphone Class 1 frequency response by IEC 61672 and ANSI S1.4 that had been calibrated. To describe the general noise levels within the designated spot, the SPL was measured in $LA_{eq(10\text{-min})}$ and LAF_{max} and LAF_{min}.

3.5. Stage 4: the reproduced soundscape survey

This stage was intended to confirm and deepen the finding of the earlier stages. It comprised an off-site survey using a reproduced sound system conducted in a quiet room of YPAB. Prior to this, the sound for the reproduction was recorded using a Zoom H2N Handy recorder in Bungkul Park in spot 1 (the front part of the park), spot 2 (the skate park) and spot 3 (the water fountain area). The three places have a unique soundscape among the eight designated spots. It was then reproduced using a stereo reproduction system, with the aim of promoting recall in the participant's memory of the acoustic environment in Bungkul Park. A laptop connected to two JBL LSR2325P located in two corners of the room was used.

The reproduced soundscape survey was conducted in 5 groups consisting of 7 participants, with a total of 35 visually impaired participants. A sighted person assisted each visually impaired person. The recorded sound of the three spots was played 3

Figure 7. Snapshot of the surveyed spots in Bungkul Park: (a) the front entrance area; (b) the skate park area; (c) the fountain area; (d) the playground and (e) the amphitheatre plaza. Also in Flora Park: (f) an area near the centre water fountain; (g) a sitting corner close to the main street and (h) the playground (permission to publish the photos is given by YPAB).

Figure 8. The reproduced soundscape survey in a quiet room in YPAB Surabaya: (a) the survey of group 1 and (b) the survey of group 2 (permission to publish the photos is given by YPAB).

min each, which was then followed by a questionnaire survey (Figure 8). Each group required about 20 min to listen to the three reproduced sound and to fill in the questionnaire. The questionnaire was designed to be open-ended in order to confirm the answers given in the survey at stage 3, especially those linked to the attributes they selected on the three unique spots of Bungkul and their responses regarding their most and least favourite places. The attributes were taken from the five soundscape dimensions elicited by the visually impaired group at stage 3: eventfulness (crowded/ empty), pleasantness (comfortable/uncomfortable), direction (know/do not know the location), danger (dangerous/safe) and space (spacious/narrow). They were also asked to give the reason why they selected particular attributes during the previous stage. The dimension of nature was not asked since it is known that this perception is evoked mainly by the sound of nature.

4. Findings and discussion

4.1. The sound pressure level (SPL)

The sound pressure levels measured in each route or spot were plotted in Table 3; therein it can be clearly seen that the noise level at both parks exceeded the noise level standard of a public green open area of 50 dBA (Kementerian Negara Lingkungan Hidup, 1996). At both Bungkul and Flora parks, spots that are adjacent to main streets were exposed to high noise levels. Without particular noise-induced activities held along the routes and in the places, the sound at these spots came from the nearby traffic. Moving inward within the confines of the

Table 3. Noise levels of the eight surveyed spots in Bungkul (B) and Flora (F) parks.

Routes/Spots	Parks	The main park feature	The primary sound sources	LA_{eq} (dBA)	LAF_{max} (dBA)	LAF_{min} (dBA)
1	Bungkul	Concrete bench (B)	Traffic and crossing-signs	72.2	90.3	62.3
2	Bungkul	Skate park (B)	Skateboards	67.1	75.1	54.5
3	Bungkul	Fountain (B)	Water fountain and people voices	73.3	86.7	60.9
4	Bungkul	Playground (B)	Children voices	71.7	84.4	55.0
5	Bungkul	Plaza (B)	Barely any sound sources	63.4	74.6	57.8
6	Flora	Centre fountain (F)	Water fountain and people voices	64.2	77.1	60.1
7	Flora	Concrete bench (F)	Traffic	68.2	83.2	60.0
8	Flora	Playground (F)	Children voices	61.7	76.3	56.8

park, lower noise levels were recorded. Interestingly, the SPL of the amphitheater plaza in Bungkul Park - which is located in the middle of the park, with barely any sound source - was recorded at 63.4 dBA (Table 3). The amphitheater plaza of Bungkul seemed to get noise from spot 1 (traffic) and spot 3 (fountain). So far, the acoustic environment around the fountain at Bungkul was the highest in term of the SPL, whereas the SPL around the fountain in Flora Park was not as high as that in Bungkul Park. In general, spots in Flora Park were less noisy than those in Bungkul Park. The link between the acoustic environment measurement and the soundscape is to be discussed in the next section.

4.2. The semantic scale scores comparison

A comparison between the sighted and visually impaired participants is extracted from the Bungkul data only, based on the various spots within it. The analysis is significant in studying the participants' sonic perception due to the varied elements of the most iconic park in the region. Unlike spots in Flora Park, which possess an ambience that is generally similar to the typical ambience of a park in the region, the five places in Bungkul Park are unique and very different from one another (i.e. a front sitting area facing heavy traffic with a sign of pelican crossing and driving license kiosk, a skate park, large fountain, large playground and amphitheatre; Table 1). Figure 9 shows the median of the semantic scale score between the sighted and visually impaired of five places in Bungkul. The semantic scale score comparison is analysed based on the identical semantic scales of both participating groups. These scales are: crowded, calm, comfortable, disturbing, noisy, natural, fun, nice, rough, slow and clamorous.

The semantic scale score of the sighted differs from that of the visually impaired. Figure 9 shows that spots 1, 2, and 5 were perceived as more comfortable, nicer, and more fun by the visually impaired than by the sighted. This is interesting since the noise levels of these spots were at L_{eq} 63 to 72 dBA (Table 3), which is above the accepted standard for soothing sounds of 50 to 60 dBA (Cowan, 1994). Another interesting finding is spot 3, which elicits almost identical sonic perception between both groups of participants. Both declared spot 3 to be clamorous and rough, but at the same time, calm, comfortable and fun. It indicates that a clamorous sound produced by a natural sound or a replica of a natural sound as noisy as 73.3 dBA was perceived to be calming and comforting. This strengthens the results of earlier studies reported by Jeon, Lee, You, and Kang (2012) about the sound of water and by Yang and Kang (2005) about people liking to hear the natural soundscape as it comforts and calms the heart and mind. In the case of Bungkul and Flora, the water sound is natural, but it was made artificially.

Spot 5, which had a sound level of 63.4 dBA and which was visually 'quiet' (with barely any particular activities), was regarded as more clamorous and crowded by the visually impaired. It shows that the visually impaired use purely aural perception in appraising their surroundings, one that is not mixed with visual perception, as was the case for the sighted. Again, referring to Cowan (1994), the sonic perception of the visually impaired seemed closer to the standard compared to that of the sighted. However, within a noisy acoustic environment, in general, the visually impaired participants perceived Bungkul Park better than did the sighted. The visually impaired rate the acoustic environment as clamorous and noisy, but they also rate the park as calm, nice and fun, which can be regarded as favourable parameters of a park. The visually impaired feel more comfortable at the park than do the sighted.

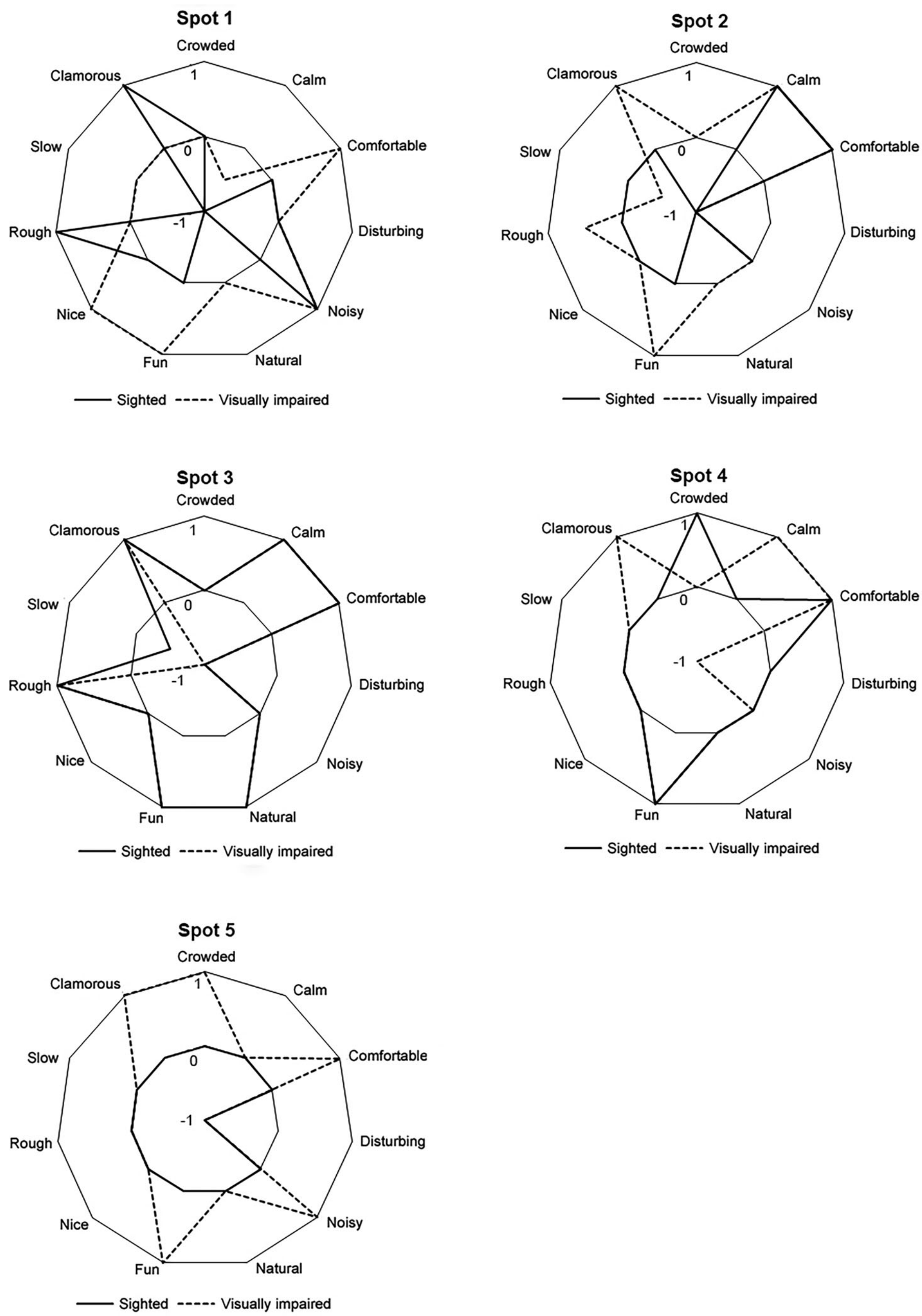

Figure 9. The median of the semantic scale resulted from different routes or spots in Bungkul Park.

4.3. The soundscape dimensions

The data were analysed one at a time using PCA with a change of coordinates known as varimax rotation (Field, 2000) so that each variable can be associated with, at most, one factor. PCA also been used by Kang and Zhang (2010) and Axelsson et al. (2010) to extract their data into soundscape dimensions. Polychoric correlations are used here instead of Pearson's correlation given that the ordinal data gathered is a three-scale bipolar data, which tends to have strong skewness or kurtosis (Muthén & Kaplan, 1985; Gilley & Uhlig, 1993 in Basto & Pereira, 2012). The analysis was run for the sighted and the visually impaired. The soundscape dimensions are selected based on the eigenvalue of the PCA (eigenvalue > 1). By PCA, the terminologies used were grouped into dimensions that were named relative to the word that could explain or represent the dimension in general, based on the terminology that appeared in the group. It is a subjective judgement, as was that of Kang and Zhang (2010) and Axelsson et al. (2010). Some studies named the first urban soundscape dimension, which is related to general judgement, as (1) relaxation, (2) calmness or (3) pleasantness. The second dimension, which is related to the sensation of temporal and spectral aspect from the sounds, has been named as (1) dynamic, (2) eventfulness or (3) vibrancy. The naming here refers to the previous study, with a little modification to adjust to the local context.

Three soundscape dimensions declared from the data of sighted participants were named as pleasantness, eventfulness and dynamic, as is shown in Table 4. The dominant soundscape dimension of component 1 is related to the perception of pleasantness, which includes 'comfortable', 'disturbing', 'natural', 'fun', 'good', 'rough', 'fine', 'nice', 'relax', and 'like'. This dimension explains 25% of the variance. Component 2 is associated with the perception of eventfulness, which includes 'crowded', 'calm', 'disturbing', 'noisy', 'dense', 'unhurried', 'clamorous', 'silence', and 'full'. This dimension explains 22% of the variance. Component 3 is associated with the perception of dynamic, which includes 'monotonous', 'neat', and 'relax'. This dimension explains 9% of the variance.

These are consistent with the results of Kang and Zhang (2010), who identified four dimensions of the soundscape – relaxation, communication, spatiality and dynamic. They are also consistent with the results of Axelsson et al. (2010), who identified three

Table 4. The PCA result of responses from the sighted participants (Kaiser-Meyer-Olkin test = 0.907).

	Components		
Attributes	25% (1: pleasantness)	22% (2: eventfulness)	9% (3: dynamic)
Crowded	0.184	0.751	−0.057
Calm	0.346	−0.774	0.056
Nice	0.829	−0.160	0.190
Disturbing	−0.545	0.515	0.220
Comfortable	0.695	−0.444	0.039
Clamorous	−0.467	0.654	−0.133
Noisy	−0.331	0.780	−0.112
Fun	0.804	0.002	0.155
Rough	−0.562	0.493	−0.020
Unhurried	0.413	−0.580	0.210
Natural	0.581	−0.400	0.118
Dense	−0.117	0.791	−0.058
Good	0.817	−0.147	0.062
Fine	0.794	−0.160	0.015
Full	0.037	0.711	−0.388
Silence	0.171	−0.695	0.492
Neat	0.279	−0.068	0.775
Relax	0.500	−0.380	0.577
Like	0.854	−0.077	0.063
Monotonous	−0.264	−0.237	0.622

soundscape dimensions – pleasantness, eventfulness and familiarity – as well as those of Sudarsono et al. (2016), with their prominent soundscape dimensions of calmness/relaxation, dynamic/vibrancy and communication. We did notice a difference in the terminologies used with regards to comfort or relaxation or pleasantness or calm, but the concept is similar. A comparative analysis between the study and the work of Kang and Zhang (2010), Axelsson et al. (2010) and Sudarsono et al. (2016) reveals that the first soundscape dimension of sighted people is related to enjoyment, which is a feeling that is related to subjective preference. While the data here were analysed using Polychoric correlation, two of the earlier analyses used Pearson's correlation. Nonetheless, all show a similar result, which means that the three-scale bipolar questionnaire can be reliably employed in a specific circumstance, such as when communication between the interviewer and the interviewee is designed to be modest, as was the case in this study. The similar soundscape dimensions indicate that the scales developed in this study are valid for the soundscape experiment. With the identical result of soundscape dimensions of sighted participants in this study and in previous studies, the next stage of the study focused on the sonic perception of the visually impaired. The sighted were not involved in stage 4.

Table 5 shows the data analysed from the visually impaired. Here, six soundscape dimensions emerged. The dominant soundscape dimension of component 1 is related to the perception of eventfulness. This dimension explains 17% of the variance, which includes 'crowded', 'calm', 'clamorous', 'noisy', 'rough', 'slow', and 'full'. Component 2 is related to the perception of pleasantness. This dimension explains 14% of the variance, which includes 'nice', 'disturbing', 'comfortable', and 'fun'. Component 3 is related to the perception of danger. This dimension explains 8% of the variance, which includes 'safe' and 'scary'. Element 4 is associated with the perception of direction. This dimension explains 8% of the variance, which includes 'unclear direction' and 'can recognise the position'. Component 5 is related to the perception of space. This dimension explains 7% of

Table 5. The PCA result of responses from the visually impaired participants (Kaiser-Meyer-Olkin test = 0.846).

	Components					
Attributes	17% (1: eventfulness)	14% (2: pleasantness)	8% (3: danger)	8% (4: direction)	7% (5: space)	6% (6: nature)
Crowded	0.708	0.032	0.107	0.090	0.067	0.220
Calm	−0.626	0.432	0.075	−0.002	0.119	0.130
Nice	−0.036	0.740	−0.097	−0.003	−0.052	0.054
Disturbing	0.346	−0.621	0.229	−0.048	0.085	−0.088
Comfortable	−0.283	0.754	−0.155	−0.033	0.181	0.016
Clamorous	0.753	−0.232	0.062	0.081	0.050	−0.069
Noisy	0.803	−0.194	0.021	−0.012	0.014	−0.152
Fun	−0.107	0.729	−0.153	0.107	0.137	0.045
Rough	0.597	−0.115	0.182	−0.144	−0.154	−0.370
Unhurried	−0.137	0.127	−0.092	0.026	0.203	0.578
Natural	−0.218	0.053	−0.096	−0.110	0.107	0.616
Safe	−0.151	0.233	−0.711	0.144	0.065	0.117
Unclear direction	0.088	−0.115	0.145	−0.791	0.023	−0.044
Full	0.508	0.177	0.160	−0.083	−0.369	0.331
Far	−0.076	0.080	0.055	−0.050	0.757	0.253
Slow	−0.670	0.142	−0.181	0.103	0.217	0.173
Recognize the location	0.084	−0.058	0.055	0.810	−0.035	−0.066
Scary	0.066	−0.143	0.843	0.016	0.025	0.006
Spacious	0.059	0.360	−0.146	−0.085	0.530	−0.329

the variation, which includes 'far' and 'spacious'. Factor 6 is associated with the perception of nature. This dimension explains 6% of the variance, which includes 'nature' and 'unhurried'. The first soundscape dimension of the visually impaired is eventfulness, which is related to the acoustic environment. It differs from the first soundscape dimension of the sighted, which is connected to subjective preference. Unique soundscape dimension of the visually impaired were elicited in this study – i.e. the dimension of direction, the dimension of danger and the dimension of space, which is not declared by the sighted. It seems that the visually impaired people use their ears to not only perceive what is commonly held by sighted people but also to navigate, detect danger and feel the environment, whereas the normally sighted rely mostly on their sight sense to perceive the dimensions of direction, danger and space.

Bi-plot charts are used to help us quickly learn the attributes that develop specific soundscape dimensions (correlation value above 0.5). As the plot of the attributes is generally scattered, we also learn that there is no strong correlation between attributes to develop each dimension. By the aspect of eventfulness and pleasantness, the attributes that establish these two – such as crowds, fullness and noise – are not disturbing (the 'disturbing' attribute has a correlation value above 0.5 but in a negative fashion, which means the opposite of the plotted attribute). Moreover, they built comfortable and nice ambience (Figure 10a). By the aspect of eventfulness and direction, the ambience of the parks provides clear direction (the 'unclear direction' attribute has a correlation value above 0.5 but in a negative fashion, which means the opposite). The clear direction helps them to recognize the location in the parks (Figure 10b). However, the visually impaired perceive the parks as unsafe and scary (Figure 10c). When linked to data of the acoustic environment (part 4.4), it seems that the sound of vehicles, which is significantly heard in the parks, causes these feelings. For the sighted, the attributes that establish the dimension of pleasantness and eventfulness are even more scattered. We quickly learn that they perceived the parks in less favour than the visually impaired – i.e. noisy, clamorous, not silence (the opposite of silence), not calm (the opposite of calm) and other attributes that can be clearly seen in Figure 10d.

4.4. The sound sources that develop the soundscape dimensions

The open-ended questions at the very end of the questionnaire were plotted to explore in greater depth and in a more profound way the response of both participants regarding the acoustic environment of the visited parks. The finding of the open-ended questions is discussed together with the finding of the reproduced sound survey as these two seem to have a link, although the last survey was conducted by the visually impaired only. A comparison of the response between the sighted and the visually impaired is provided in Figure 11. Both groups of participants agree that the acoustic environment of a park is to indicate comfort or discomfort, at the most. It also represents whether the park has an ideal park's ambience or not. Interestingly, according to the visually impaired, the sound sources in a park are also useful for them to indicate a location and to provide information. These two responses were not elicited by the sighted participants and are directly correlated with the unique soundscape dimension of the visually impaired respondents found using PCA analysis – i.e. dimensions of direction and danger. By the sighted, the acoustic environment of a park also to indicate interaction. The interaction here means

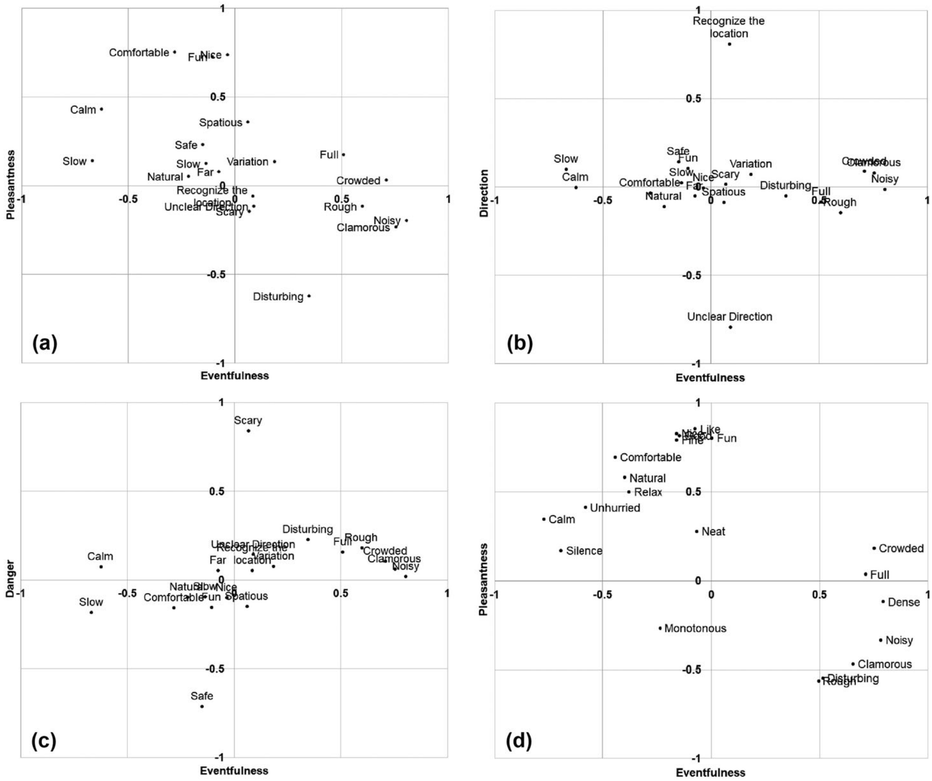

Figure 10. The attribute mapping of soundscape dimension by visually impaired and sighted persons; (a) Attributes that develop soundscape dimensions of eventfulness and pleasantness of visually impaired people; (b) eventfulness and direction of visually impaired people; (c) eventfulness and danger of visually impaired people; and (d) eventfulness and pleasantness of sighted people.

interaction between visitors, between visitors and the park features and between visitors and nature, which is not elicited by the visually impaired. This response is correlated with the soundscape dimension of eventfulness since the soundscape of sighted people is not purely auditory but also visual (Carles et al., 1992; Tse et al., 2012; Viollon, Lavandier, & Drake, 2002). The attributes of 'crowded', 'dense', 'full', 'disturbing', 'noisy' and 'clamorous', which developed the soundscape dimension of eventfulness, are heard and seen at the same time by this type of participants.

The reproduced sound survey, which aimed to explore particular sound types that deliver a specific soundscape of the visually impaired, show sound sources that generate the soundscape dimension of eventfulness and pleasantness (Figures 12 and 13). These two soundscape dimensions were deepened the most and are described in the figures, as these are significant for both the sighted and the visually impaired. The dimension of eventfulness is dominated by the sound of water (fountain), people and vehicles. Meanwhile, the perception of pleasantness is affected by the water (fountain), vehicles and birds. Water and vehicles of any kind are the two most mentioned. Some participants could name in detail the type of vehicles heard, but some just mentioned it in general as the sound of vehicles. Also, some could name the type of people's voices, such as children's voices, but some just mentioned it in general as the voices of people. The rest of the

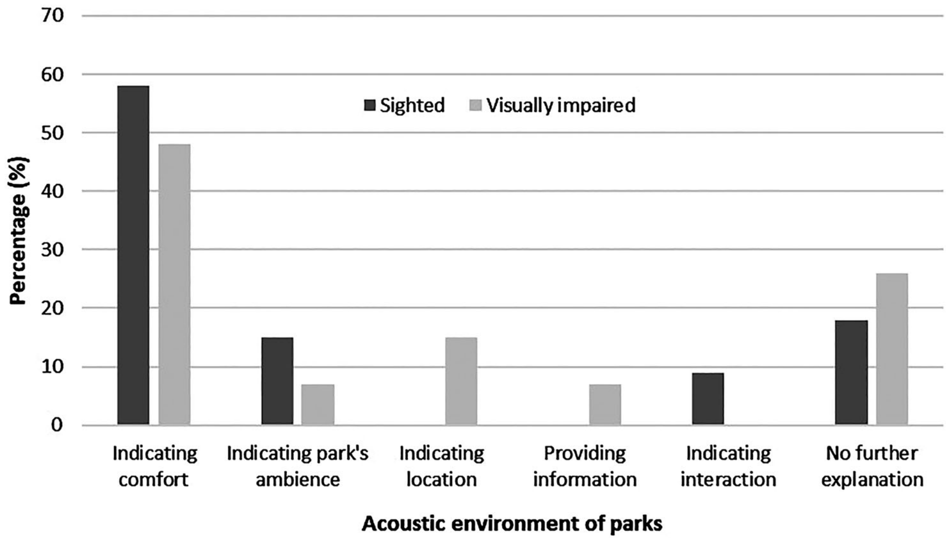

Figure 11. The function of the sound sources in the park according to both groups of participants.

data extracted at this stage show that the dimension of direction is affected by the previous experience of the space and sound mark in the location. There are some sound marks in Taman Bungkul identified in this experiment: the sound of vehicles, the sound of the water fountain and the sound of skateboards. While all these indicate how sound marks are essential to visually impaired people as they navigate a park, the dimension of danger is affected by two particular sounds: the sound of people and the sound of vehicles. The

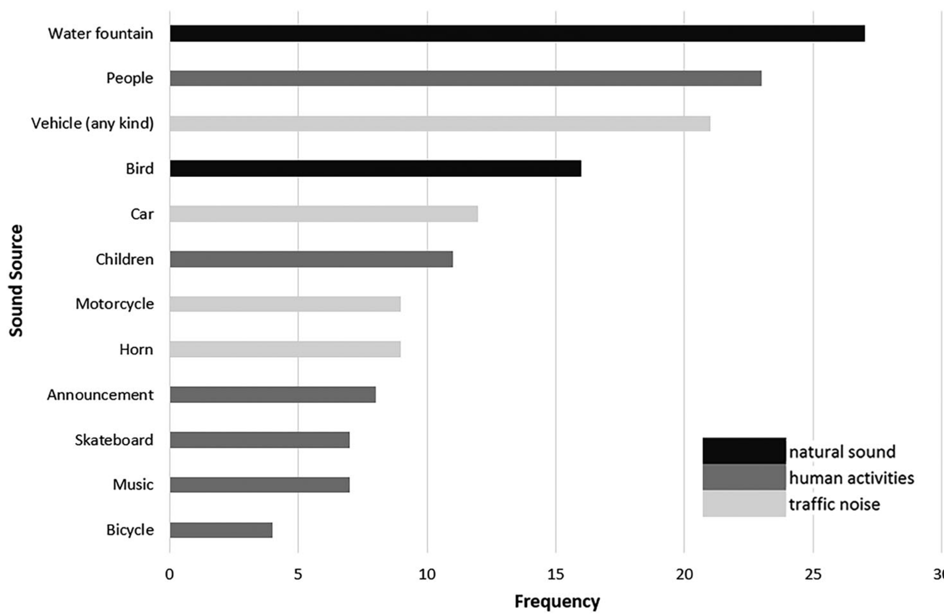

Figure 12. The type of sound sources in the park that triggers a soundscape dimension related to eventfulness.

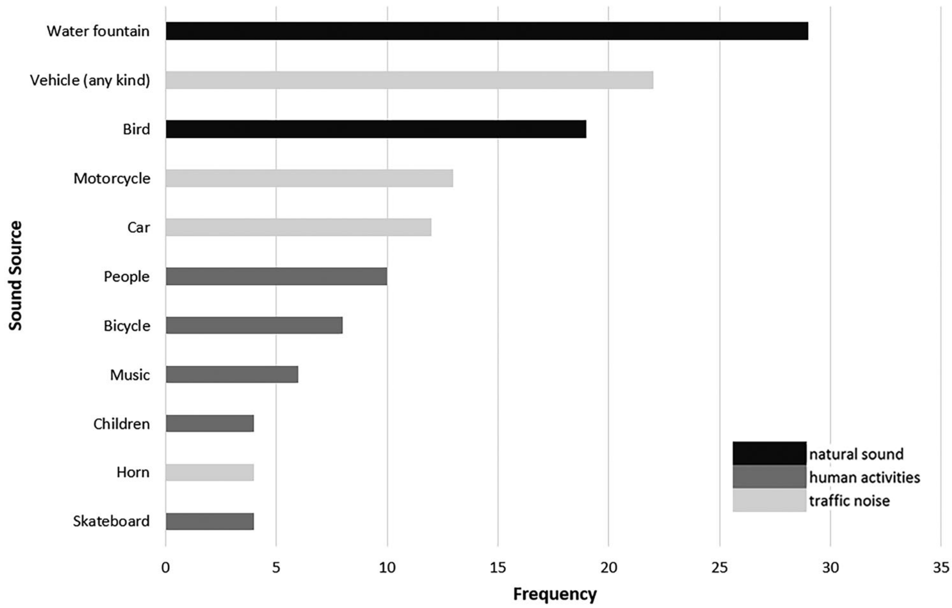

Figure 13. The type of sound sources in the park that triggers a soundscape dimension related to pleasantness.

sound of cars makes the visually impaired participants feel that they are in danger, and the sound of people makes the participants feel safe.

Further data shows that the participants were afraid to be hit by the cars moving nearby, as there are no clear boundaries between the park's area and the sidewalk. The dimension of space is affected by human activities in the park – the more human activities there are in the park, the larger the space that is perceived by the visually impaired. Interestingly, the sound of vehicles is related to the perception of width, with more cars meaning a more extensive area. It seems in this case that the participants were rating the space of the street and not the park. Finally, this stage shows that the sound of vehicles appears to be the most conscious mark of the surveyed parks, which is not the ideally embedded sound of a park. The soundscape related to vehicles appears to have both negative and positive meanings. For instance, the visually impaired feel comfortable when the sound of the cars is low or far, and they feel disturbed when the sound of vehicles is loud or near.

5. Conclusion

The early study of this project has indicated that visually impaired people perceived their sonic environment in more detail than did the sighted subjects (Mediastika et al., 2019). It strengthens the findings of Gonzales-Mora et al. (1999), Lessard et al. (1998) and Dunai et al. (2015) that blind people perceive sound in more detail than sighted people. As reported here, this study pointed out a number of significant findings:

- The visually impaired perceived the noisy parks to be more favourable than did the sighted. It indicates that, so far, the acoustic environment of the surveyed parks comfortably represents the expected environment.

- The visually impaired participants explained the soundscape of parks in six dimensions - eventfulness, pleasantness, danger, direction, space and nature - which is more than the three elicited by the sighted - pleasantness, eventfulness and dynamic. These three soundscape dimensions of the sighted are of the same concept as the four dimensions by Kang and Zhang (2010), and the three dimensions by Axelsson et al. (2010) and Sudarsono et al. (2016). Again, it strengthens earlier findings that blind people perceive sound in more detail than do the sighted.
- The visually impaired add four unique dimensions compared to the sighted - i.e. danger, direction, space and nature. This implies that these sound dimensions ought to be pronounced in the park to assist the mobility of the visually impaired and to serve them with the sounds of nature, as they enjoy parks mostly using their auditory senses.
- According to the visually impaired, the most prominent soundscape dimension is that of eventfulness, whereas to the sighted, it is pleasantness. This implies that the sound environment is more important for the visually impaired than the subjective preference. The sound of the environment becomes a significant element to navigate the visually impaired. The dimension of eventfulness is usually related to how people interact with the sound character of the environment, especially the sensation of temporal and spectral aspects of acoustic information (Ma et al., 2018). Visually impaired people process more information from sound and give more attention to the information carried in it compared to sighted people. When sighted people listen to the environment, the most critical aspect is how the environment makes them feel comfortable. They do not give more attention to the information in the sound, such as the direction of the sound and the type of sound in the environment.
- Visually impaired people can extract more information from the acoustic environment and relate the information with their perception. It is the reason why there are more perceptions or terminologies that appeared in the experiment with the visually impaired than with the sighted.

In general, the study concluded that people with visual impairment sense the danger and direction of a space from sound. Urban planners and designers can adopt this aspect when designing a space that is inclusive for both the sighted and the visually impaired. The design ought to provide a safe environment from the sounds emerging in and around the designed spaces. A safe environment means that the visually impaired people can easily differentiate the dangerous areas (e.g. busy streets) from the safe areas (e.g. pedestrian related). The sound environment also needs to be designed to provide information clearly so that they can carry out potentially dangerous activities, such as crossing the road, independently.

As the dimension of direction shows that visually impaired people use sound to navigate the surrounding area, spaces must be designed so that these individuals can locate their position using the sound emerging in the environment. For example, the presence of a fountain or a playground in the park can help them to identify their location. It is suggested that urban planners and designers include such sounds that can serve as sound marks in urban spaces. In this regard, the sound must be consistently heard in a particular place and possess a unique sound character (e.g. fountain).

The eventfulness and pleasantness soundscape dimensions (vehicle and water) that navigate the visually impaired ought to be maintained in the parks but should be kept within acceptable noise levels. The sound of birds is also recommended to be dominant within parks in order to create a more positive soundscape dimension of comfort. It is also thought to mask the sound of vehicles that dominates the current acoustic environment of parks, and using the sound of nature may represent the sonic environment of parks better. However, this is not to negate all vehicle sound, as it plays a role in navigating the visually impaired.

Nonetheless, the conclusions drawn in this study may not be instantly transferrable to other regions with different park characteristics, particularly in relation to park size and design elements as well as different social backgrounds.

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