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A pilot study on the analysis of soundwalk data

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ABSTRACT

Revealing the relationship between human perceived data and acoustic data is important in soundscape studies. The annex of ISO/TS 12913-2 proposes a method in which soundwalk participants are asked to list sound sources. Binaural recording is necessary to obtain acoustic data. In the current study, we proposed two simple methods for expressing the relationship between perceived sound sources and acoustic data: Track Sheet Style Chart and TM Chart. The results revealed that the Track Sheet Style chart was the most useful method for clarifying the time structure of noticeable sounds, whereas the TM Chart was the most useful method for clarifying the time dominance of the sound level of the respective noticeable sounds.
Keywords: soundwalk, perceived sound, sound sources, Track Sheet Style Chart, TM Chart

1. INTRODUCTION

The soundwalk method is an effective approach for understanding human sensations, responses and outcomes, by examining participants' evaluation of soundscapes in a particular area. Many researchers have conducted soundwalks in soundscape studies. However, there has been little research into methods for analyzing the relationship between human perception data and acoustic data, which remains poorly understood. Further exploration of these methods is needed to standardize data analysis methods in soundscape studies.

The annex of ISO/TS 12913-2 (1) recommends that lists of sound sources noticed by soundwalk participants at respective evaluation points should be obtained. These lists constitute some of the simplest data regarding participants' perception. In addition, simultaneous binaural recording at the evaluation points is recommended. The relationship between the lists of sound sources and acoustic data is the simplest relationship regarding human perception and the acoustic data obtained in the soundwalk. Therefore, this pilot study explored two simple methods for expressing the relationship between perceived sound sources and acoustic data obtained in soundwalks.

2. BASIC CONCEPTS OF DATA EXPRESSION

As a starting point, the basic concepts for expressing the relationship between perceived sound sources and acoustic data are discussed.

In the method proposed in the annex of ISO/TS 12913-2, soundwalk participants are required to list the sound sources they notice, in descending order, starting with the most noticeable sound sources, up to eight. In this procedure, only noticeable sound sources were listed. Therefore, we can consider the listed sound sources as significant features (2) of the relevant soundscape. The temporal structures of the significant features of a certain soundscape are thought to constitute one of the important features of the soundscape (3). In addition, domination of soundscapes by significant features is one of the most important aspects of analysis, as pointed out by the World Soundscape Project (WSP) 1973 (2). Therefore, in the current study, two expression methods were examined: first, a method to express the temporal structures of the noticeable sounds, and, second, a method for expressing the domination of a certain soundscape by a specific sound(s).

Regarding acoustic parameters, only the A-weighted sound pressure level was used, to simplify the results in this study. However, notation of A-weighted sound pressure level used in this study

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could be adapted to other acoustic parameters. Thus, sound pressure level can be easily replaced with other acoustic parameters, including loudness, if necessary.

2.1 Track Sheet Style Chart: A Method for Expressing Temporal Structures

The Track Sheet Style Chart method is based on the track sheet in Digital Audio Workstations (DAW) software. In general, DAWs typically display a time structure of a certain work, in a plane in which sound tracks are arranged in a longitudinal direction, while the lateral direction indicates the time. In each sound track in the display, periods of time in which respective sounds are not present are displayed as blanks.

Similarly, in the Track Sheet Style Chart, the temporal structure of noticeable sounds in a certain soundscape is indicated in a plane in which respective noticeable sounds are arranged in a longitudinal direction, and the lateral direction indicates time. At the bottom of the figure, A-weighted sound pressure level(s) are displayed. Figure 1 illustrates the basic concept of the Track Sheet Style Chart.

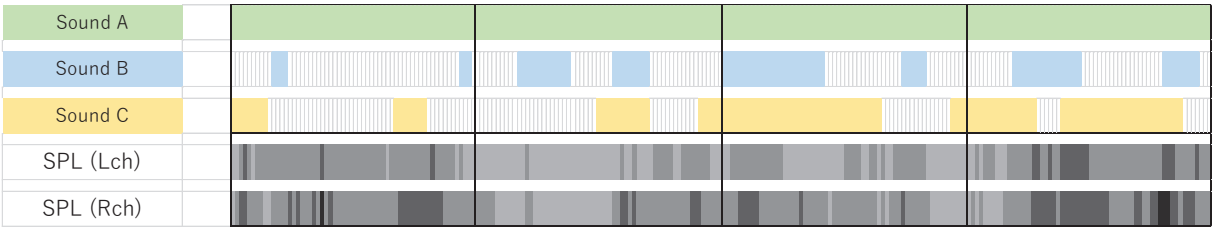

Figure 1 - Conceptual illustration of the Track Sheet Style Chart

Regarding time resolution in this chart, the higher the time resolution, the more effort it takes to draw the chart. However, if the time resolution is insufficiently low, the chart cannot express the time structure of respective sounds precisely. Considering evaluation times at soundwalks are typically 3 to 5 min, 1 unit per 1 sec appears to be an appropriate time resolution for the chart. For example, if 1 unit in Figure 1 is assumed to be 1 sec, the chart can express a 4-minute time structure of respective sound sources.

The arrangement order of the sound sources in the chart may be arbitrary, and may depend on the purpose of drawing the chart. The simplest method for arrangement of the data is to show the sound sources that are listed by more participants as higher on the chart. Another common method of arrangement is to show the sound sources that are preferred by more participants as higher in the chart. In cases where the type of sound (e.g. sounds of technology, nature, or humans) is an important point, sound sources should be divided into appropriate types, and arranged in respective groups.

In Figure 1, the sound pressure levels of respective time units are shown using a five-step gray scale. In cases where the dynamic ranges of the sound pressure levels are broad, using a more finely-stepped gray scale (e.g. a 10-step gray scale) may be appropriate.

2.2 Time Component Matrix Chart: A Method for Expressing Dominant Sounds

The basic concept of the Time Component Matrix Chart (TM Chart) was proposed by Furukawa et al. as a method for visual expression of a soundscape (4,5). In this method, the percentage of time of sound levels and the percentage of time of sound sources are expressed in two dimensions.

In the original method, the percentage of time of respective sound sources is defined as the percentage of time for which the measurer(s) thinks that the sound pressure level of a particular sound source is highest among the sounds they hear (4). According to Hiramatsu et al. (5), the percentage of time of sound sources indicates the rates of respective sounds which are heard predominantly during the observation period. However, in some cases, the influence of a certain sound source can be very high, due to specific source attention processes, even if the acoustic contribution to the overall noise caused by this source is relatively low in a physical sense (6).

From the viewpoint of the soundscape, it is clear that the noticeable sound sources identified by the soundwalk participant(s) are more important than the sound sources the measurer(s) thinks have the highest sound pressure levels. Thus, the authors modified the method of the TM Chart to measure the percentage of time in which a particular noticeable sound source listed by the soundwalk participant(s) can be heard, instead of the percentage of time defined by the original method. Figure 2 illustrates the concept of the TM Chart. In this figure, Sound C in Figure 1 is selected as the noticeable sound, as an example. The left cells in this figure describe the results regarding the sound that was heard and the right cells show the sounds that were not heard. The size of each cell in the

TM chart is proportional to the audible/inaudible percentage of time of the noticeable sound and the percentage of time of the sound pressure levels.

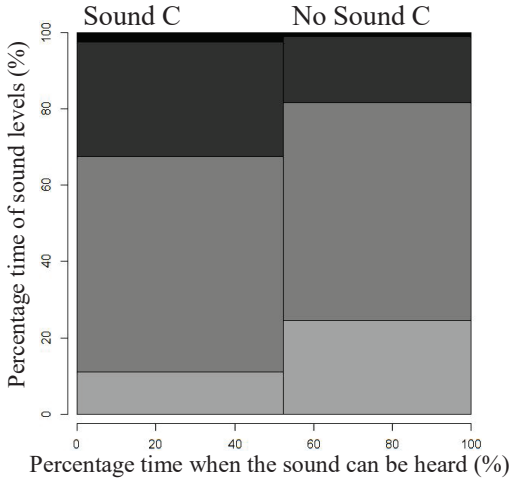

Figure 2 - Conceptual illustration of the Time Component Matrix Chart (TM Chart)

The noticeable sound in this chart could be changed to a group of sounds. For example, to understand preferred sounds, the percentage of time in which the preferred sounds were heard may be more appropriate. If the percentage of time of a group of sounds is used, the cells showing the group of sounds heard can be divided in the lateral direction into sub-cells, indicating that sounds belonging to the group are heard.

3. EXAMPLE

This section shows examples of usage of the two data visualization methods for results obtained from soundwalks. The soundwalks in this study were conducted to elucidate the appropriateness of locations in which benches are installed for resting spots for pedestrians around Fukushima Station, the main station of the Fukushima city (7). There were 2–6 participants in each soundwalk. All participants were students at Fukushima University. None of the participants were residents of the soundwalk area, but had visited the soundwalk area at least several times before participating.

Regarding the noticeable sound sources, participants were required at each evaluation site to list up to eight noticeable sounds in descending order, starting with the most noticeable sound sources, as recommended by Annex C of the ISO/TS 12913-2. In addition, participants were required to evaluate each noticeable sound they listed in terms of whether the sound was preferable or not.

Regarding acoustic data, binaural recordings were performed simultaneously using dummy-head microphones (B&K; 4100 or Southern Acoustics; Type 2500R II) and a digital audio recorder (TASCAM; DR-60D) around the benches.

The data obtained at two evaluation sites were analyzed, as described below.

3.1 Benches Installed at a Square Facing a Main Road

The first site for analysis was a square facing a main road. This square had only one tree, planted at the far side from the main road, with benches installed around it. On the days of the soundwalks, building construction was being carried out diagonally across the intersection facing the main road. At the intersection, acoustic traffic signals for visually impaired persons were installed.

Concerning the list of the noticeable sounds at this site, footsteps, sounds of bicycles, road traffic noise, acoustic traffic signals and construction noise were pointed out by at least one participant in every soundwalk. Regarding preferences for those sounds, only footsteps were evaluated as preferable sounds, although these sounds were not pointed out by all participants. In contrast, all participants listed road traffic noise and construction noise as unpreferable sounds. Some participants evaluated the sound of bicycles and acoustic traffic signals as positive, while some evaluated these sounds as negative, and others did not list them as noticeable sounds. Regarding participants' impression of the site, the square was evaluated as monotonous (7).

Figure 3 shows the Track Sheet Style Charts for the square on the day on which the number of the noticeable sounds was lowest. In this figure, a cell in each track shows 1 (sec). As the figure shows, the two noticeable sounds listed by all the participants were continuous sounds. This may be one of

the reasons participants evaluated the soundscape of the square as monotonous.

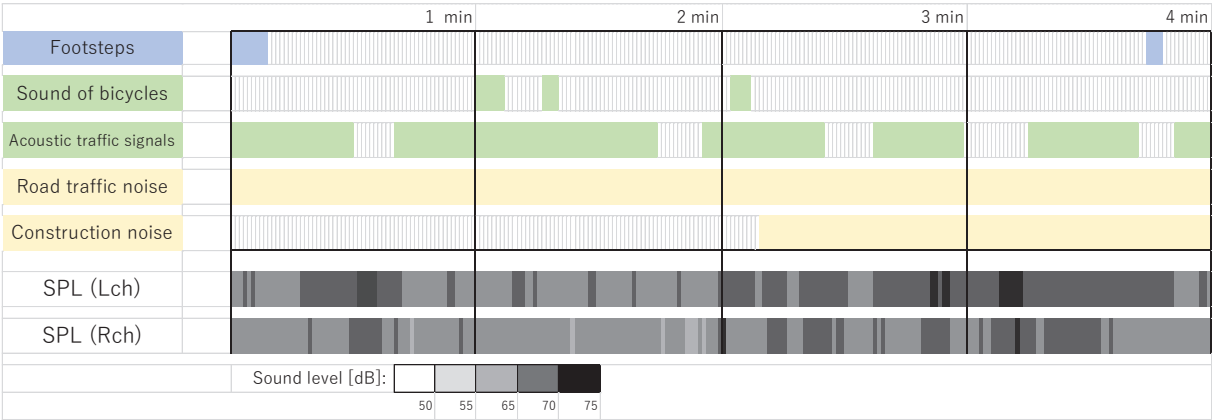

Figure 3 - Track Sheet Style Chart of a square facing a main road

Figure 4 shows the TM chart regarding construction noise at the square, on the same day as the data shown in Figure 3. Because road traffic noise continued throughout all measurement periods, this figure also shows the TM chart regarding unpreferable sounds at the square. From this chart, it is clear that the rate of time of higher sound levels is higher when the construction noise was heard than when it was not heard. In contrast, it is difficult to understand this from Figure 3.

As this example shows, this chart is suitable for discussing time domination of higher sound levels of respective sound sources.

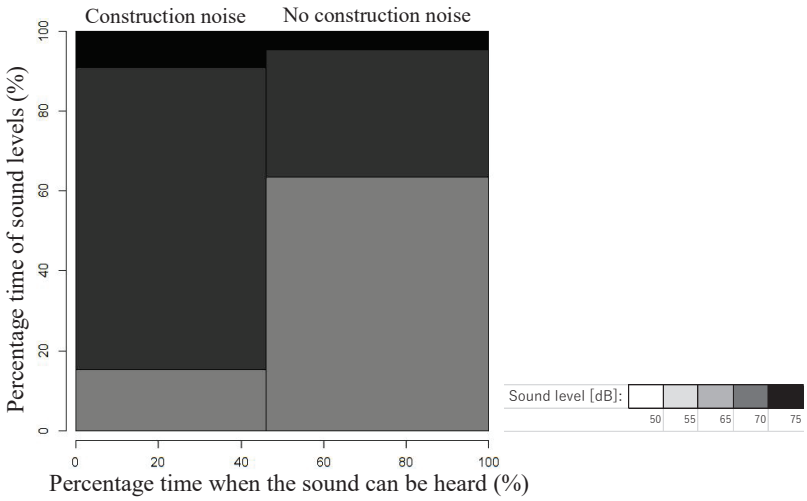

Figure 4 - TM Chart regarding the construction noise at the square facing a main road

3.2 Benches Installed at a Pedestrian Walkway in front of a Pastry Bakery

The next site was a pedestrian walkway in front of a counter-style pastry bakery. This pedestrian walkway was slightly broader than standard Japanese walkways on urban streets. Several benches are installed at this pedestrian walkway. The evaluation site was located near the edge of the street connected to the road to the prefectural office. The street behind the bench has one-way traffic, and a small number of cars drive on the street, at a relatively slow speed. In contrast, the traffic at the road to the prefectural office is always busy. The pastry bakery at this street is popular, especially among high school girls and young women. This site is located approximately 200 m from the square analyzed in the last section. Therefore, the construction noise could also be heard on this site, at lower levels.

Regarding the list of noticeable sounds at this site, only road traffic noise was reported on every soundwalk. In addition, conversations, footsteps, and the sound of bicycles were reported on more than one soundwalk. In contrast, construction noise, twittering birds and music from a pastry bakery were reported in only one soundwalk each. Regarding preferences for respective sounds, conversations (conversations of pedestrians and conversations between the shop clerk at the pastry bakery and their customers) and footsteps were evaluated as preferable sounds. In particular, some

participants mentioned that conversation between the shop clerk and customers contributed to a positive atmosphere around this site. The sound of bicycles was evaluated as neutral. Road traffic noise was evaluated as unpreferable overall, but some participants mentioned that the sound of cars behind the bench was less noisy than at the other evaluated site, because the car speed was slower. Regarding the impression of the site, this square was evaluated as relatively comfortable (7).

Figure 5 shows the Track Sheet Style Charts of the pedestrian walkway on a day when all of the noticeable sounds were listed. In this figure, a cell in each track shows 1 (sec), the same as in Figure 3. As the figure shows, road traffic noise was heard continuously through the whole evaluation period. However, the noise mainly came from the road to the prefectural office. Compared with the square (Figure 3), the time at which preferable sounds were heard was clearly longer here, and this kind of sound was heard in any given 1-minute period. This may be one of the reasons why the site was evaluated as relatively comfortable even though the sound level of the site was relatively similar to that of the square mentioned in the previous subsection.

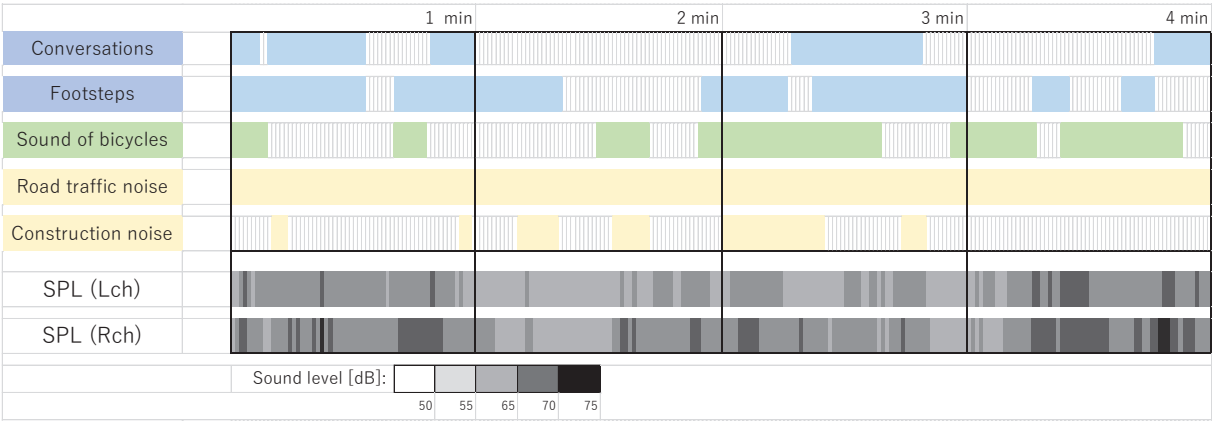

Figure 5 - Track Sheet Style Chart of the pedestrian walkway in front of a pastry bakery

Figure 6 shows the TM Chart regarding the preferable sounds at the pedestrian walkway, on the same day as the data shown in Figure 5. From this chart, it can be seen that the preferable sounds were heard approximately 70% of the time. In addition, the figure shows that the highest sound levels were observed only at the time when conversations were heard, indicating that no unpreferable sounds were louder than preferable sounds.

This example demonstrates the suitability of this chart for understanding the time of dominance of sound levels of respective sound sources.

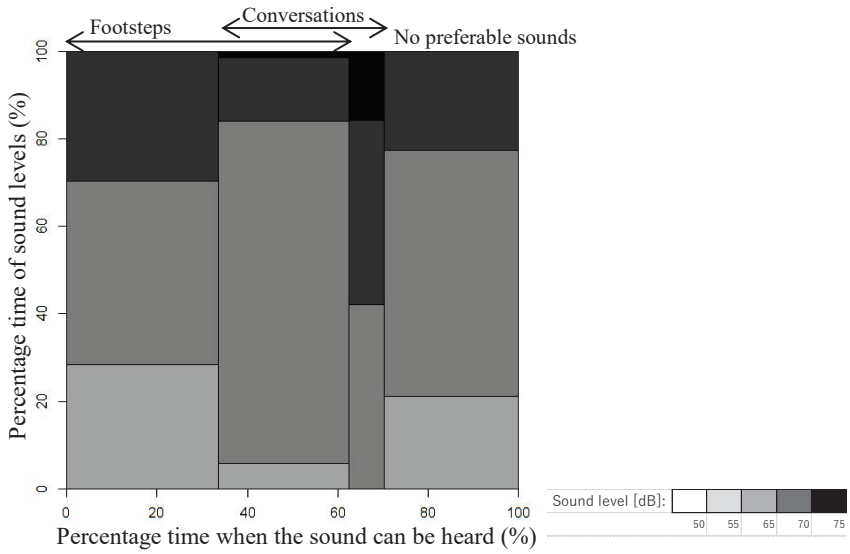

Figure 6 - TM Chart of preferable sounds at the pedestrian walkway

4. FINAL REMARKS

Both the Track Sheet Style Chart and TM Chart methods proposed in this study are effective tools for expressing the relationship between perceived sound sources and acoustic data. These two methods should be chosen to suit the particular context: the Track Sheet Style chart is the most useful method for clarifying the time structure of noticeable sounds, whereas the TM Chart is the useful method for clarifying the time dominance of the sound level of the respective noticeable sounds.

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