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The Adequate Sound Levels for Acoustic Signs for Visually Impaired in the Sound Environment with Ambient Musics from shops

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Providing acoustic signs for the visually impaired is one of the most effective ways to support their orientation and mobility. Although the use of such sounds by the visually impaired has been revealed qualitatively, the acoustical properties of ideal sound-designs for them have not known sufficiently, even a basic property such as the sound level of these sounds. On the other hand, the advertising sounds from shops such as ambient music are the one of the typical sounds in the Japanese down town. Although these sounds let them know their surrounding and the direction toward the down town, these sounds disturb their sound information and make difficult their mobility. Our previous studies revealed the adequate sound levels of acoustic signs under the road traffic noise environment. This study discusses the effect of the ambient music from shops on the adequate sound levels of acoustic signs through the psychoacoustical experiment. The results showed that the relative difference between the adequate sound level of acoustic signs and the environmental noise levels are larger than that under the road traffic noise environment. This trend is thought to be attributed to the frequency characteristics of the acoustic signs and the environmental noise.

1 Introduction

For visually impaired people, the auditory information is the one of the most important sources for orientation and mobility. Providing auditory information for the visually impaired is one of the most effective ways to support their orientation and mobility. Therefore, many kinds of auditory information for such citizens have been designed and provided. In Japan, especially in urban districts, the acoustic traffic signals and the entrance chimes of public buildings are the most common auditory information for them.

However, inappropriate auditory information sometimes creates dangerous conditions for such citizens. Nagahata[1] has indicated the existence of the inappropriate sounds for the visually impaired and the reasons why these sounds were provided. According to his results, one of the most typical forms of inappropriate auditory information occurs when the sound levels are too low. On the other hand, if the sound levels are too loud, non-impaired citizens may complain about such sounds creating noise problems. Therefore sometimes the sound levels must be lowered, but these lowered sound levels are usually too low to be useful to the visually impaired.

These kinds of problems have been caused because the sound levels of such auditory information have been adjusted according to ad-hoc rules, with no existing standards for the sounds levels of auditory information. For example, the only official guidelines for the sound levels of acoustic traffic signals state that the acoustic traffic signals should be audible in certain areas by people with normal hearing[2]. Regarding the entrance chimes of public buildings, the guidelines[3] propose only that the consultations with neighbours are needed to prevent noise problems.

Although the use of such auditory information by visually impaired has been revealed qualitatively[4-7], the acoustical properties of ideal sound-designs for them have not known sufficiently, even a basic property such as the sound level of these auditory information.

To make barrier-free acoustical environments, it is necessary to determine the acoustical properties of ideal designs of auditory signs to be provided to the visually impaired. We have designed and conducted the psychoacoustical experiments to estimate the adequate sound levels of acoustic signs under the environmental sounds. In particular, our studies focused on subjective evaluations of the sound levels of acoustic signs by visually impaired persons. The evaluations measured not only whether the participants felt safe but also whether they felt at ease in the situation.

Our previous study[8] revealed the adequate sound levels of acoustic signs under the road traffic noise environment. However, the real sound environment in Japanese down-town includes many kind of music. When the pedestrians are on the street, they can hear the ambient music and announcements that are used in the shops. Furthermore, some shops actively present music and announcements toward the street in front of the shops. The adequate properties of the auditory information could be different on such sound environment. This study discusses the effect of the music form shops on the adequate sound levels of the acoustic traffic signals and the entrance chimes through the psychoacoustical experiment.

2 Acoustic traffic signals and the entrance chimes of public buildings

Acoustic traffic signals are mainly provided at pedestrian crossings that are often used by the visually impaired. These may include crossings in front of train stations, hospitals, and shopping areas. Two loudspeakers 2.5m from the ground are set up at both ends of the pedestrian crossing for this kind of signal. The sounds used for these signals were originally comprised of two melodies: a Japanese folk song and a Scottish folk song. Recently, however, two imitative songs of birds have been replacing these folk songs. One is the song of cuckoo bird, while the other is onomatopoeically expressed in Japanese by the sound of “piyo.”

These sounds are presented properly in order to indicate the direction of the pedestrian crossing. These signs only sound when pedestrians can cross the street.

In this study, only the imitative sound of “piyo” is used as a target stimulus. The sound “piyo” is a harmonic complex tone sweeping from high to low, and its fundamental frequency is around 2 kHz. Figure 1(a) shows the average power spectrum of this signal.

The entrance chimes of public buildings are set up in the eaves of entrance, next to entrance, and sometimes independently in front of buildings to notify the existence of the entrances to the buildings. These chimes play during business hours.

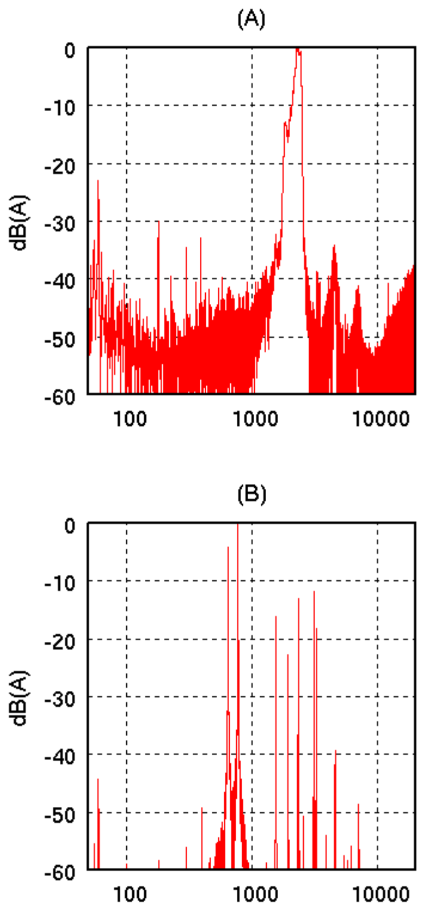


Figure 1: Average power spectrum of (A) the acoustic traffic signal and (B) the entrance chime of public building used in this study.

The sounds used for the entrance chimes are usually combinations of two-pitch tones with a minor third interval, which is usually onomatopoeically expressed in Japanese by the sound "ping-pong." The sounds are harmonic complex tones, and their fundamental frequencies are usually between 500 Hz and 1 kHz. Figure 1(b) shows the average power spectrum of this chime.

3 Methods

3.1 stimuli

Three environmental sounds were recorded in Fukuoka, Japan, to be used as "background" stimuli. The recordings were conducted with a head and torso simulator (HATS; B&K type 4100) to Digital Audio Tape (DAT). The HATS was set up on the sidewalk s paralleling the roads. The A-weighted equivalent sound levels were also measured simultaneously.

The first and second were recorded at a six-lane road with heavy traffic (Env.1) and a two-lane road in a residential district (Env.2), and their A-weighted equivalent sound level throughout the recording time (5 min) was 73.2dB.and 67.8 dB. The third was recorded at a two-lane busy street with ambient music from shops and announcements, sounds of crowd and road traffic noise (Env.3), and its A-weighted equivalent sound level throughout the recording time was 65.9 dB.

The sound levels of Env.1 and Env.3 are steady compared to the Env.2 in where the traffic loads was unsteady, thus, the effect of the ambient music are discussed by the comparison between the Env.1 and Env.3.

The "target" stimuli were the acoustic traffic signal and the entrance chime of public building. The sources for these were those that are actually used in Japan. Each target stimulus was played back in anechoic room, and recorded with the HATS to DAT. The distance from the HATS to the loudspeaker was 1 m horizontally and 2.5 m vertically.

These stimuli were recorded onto recordable compact discs (CD-R) with a standard sound (1k Hz pure tone).

3.2 Procedure

First, one of the background stimuli was presented, and then about 10 seconds later, one of the target stimuli was presented simultaneously via headphone using a sound mixer. The levels of the background stimuli were set to the same levels as the recording points. The stimuli were presented from two compact disc players in random order.

The participants are asked to adjust the playback level of the each target stimulus to an adequate level by using the fader of the sound mixer while comparing the target and background sound levels. They were instructed that the adequate level means not only the sound level at which they could hear the target, but also the sound level with which they felt safe and at ease to cross the pedestrian crossing or to search for the entrance of the building. They were also instructed to imagine that they were on a sidewalk and that they were in front of a pedestrian crossing or a public building that was playing its entrance chime. These are the positions where they can hear each sign at its highest level.

After the participants adjusted the playback level for each target, the standard sound was recorded at the position of the mixer-fader to which the participants adjusted. The standard sound adjusted to 94 dB was also recorded. The adjusted playback levels were measured by comparing with these sound levels

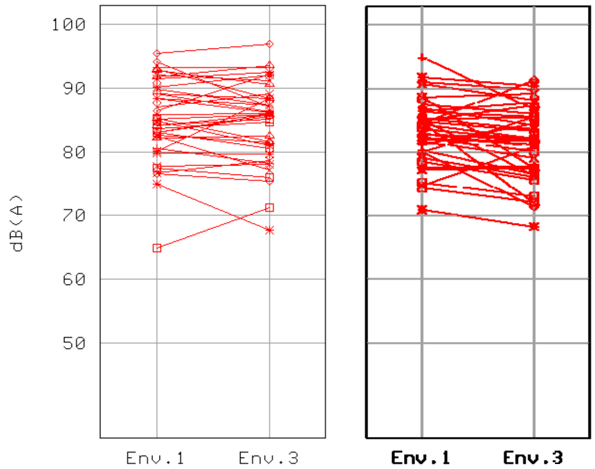
After the experiments, participants were asked about their strategy for adjusting the target sound levels.

The experiments were carried out in Fukuoka, Tokyo, Fukushima and Hokkaido. Thirty-eight visually impaired citizens (28 males and 10 females, aged between 24 to 78 years old) participated to the experiment. Twenty of the participants were totally blinds, and eighteen of them were low visions.

The procedure and participants are same as the previous study[8]. We have examined the effects evoked by the presenting and/or recording conditions of the stimuli previously[9].

4 Results

Figure 2 shows the adjusted sound levels (L_{Amax}) of the acoustic traffic signal and the entrance chime for each background stimulus (Env.1 and Env.3) of all participants.



(a) (b)

Figure 2: Adjusted playback levels (L_{Amax}) of (a) the acoustic traffic signals and (b) the entrance chimes of public building for each background stimulus.

Many participants show the small difference between the adjusted sound levels of the acoustic traffic signal for Env.1 and that for Env.3 (Figure 2(a)). Many participants show the lower adjusted sound levels of the entrance chime for Env.3 than that for Env.1 (Figure 2(b)).

Figure 3 shows the histograms of the adjusted sound levels (L_{Amax}) of each target for Env.3. Though the distribution of the levels seems to be slightly biased, both distributions statistically followed normal distribution patterns.

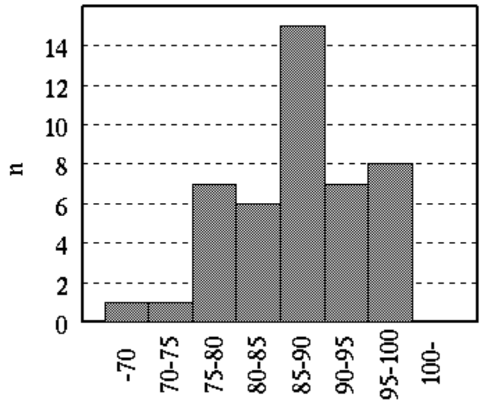
The average of the adjusted sound levels of the acoustic traffic signal was 84.7 dB with a standard deviation of 6.5dB, and the upper limit of a 95% confidence interval was 86.8 dB. The average of the adjusted sound levels of the entrance chime was 81.4 dB with a standard deviation of 5.8 dB, and the upper limit of a 95% confidence interval was 83.4 dB.

According to self-reports of the participants at the end of the experiment, many participants pointed out that the auditory information for the visually impaired must be heard infallibly and be considered by them as being at a sufficient sound level, therefore, the upper limits of a 95% confidence interval should be adopted as adequate sound levels.

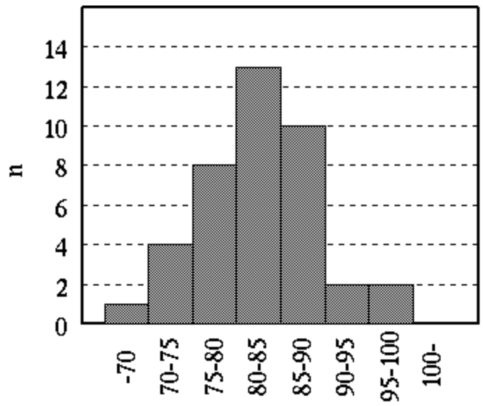
In particular case, the adequate sound level of the acoustic traffic signal is estimated at 87 dB which is about 21 dB higher than the environmental sound level (L_{Aeq}), while the adequate sound level of the entrance chime is estimated at 83 dB which is about 17 dB higher than the environmental sound level.

5 Discussion

The previous study[8] has indicated that the adequate sound level of the acoustic traffic signal is estimated as the level about 14 dB higher than the environmental sound levels, while the adequate sound level of the entrance chime is estimated as the level about 12 dB higher than the



(a) acoustic traffic signals



(b) entrance chimes of public buildings

Figure 3: Histograms of the adjusted playback levels (L_{Amax}) of (a) the acoustic traffic signals and (b) the entrance chimes of public building for Env. 3.

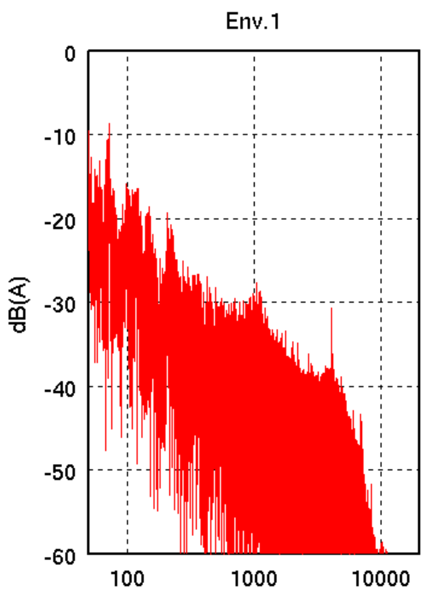
environmental sound levels, when the environmental sound consists essentially of only road traffic noise.

The result of this study showed that the estimated adequate sound level of the acoustic traffic signal was higher than that of the entrance chime. This tendency is similar to the previous study, even when the environmental sound includes advertising music and announcements from shops (Env.3).

The many participants pointed out that the acoustic traffic signals must heard at least during the entire time that they are crossing the street, but that the entrance chimes were only needed near the building entrances as indicated in previous study[8]. This difference of needs is thought to be the main reason why the adjusted levels were higher for the traffic signals than the entrance chimes.

On the other hand, the relative differences between the estimated adequate sound levels and the environmental sound levels are larger when the background is Env.3, even though the environmental sound level of Env.3 is lower than that of Env.1. These increases are thought to be the effect of the music in the environmental sounds, and are attributed to the similarity of the frequency characteristics between the environmental sound and the acoustic signs.

Figure 4 shows the average power spectrum of 10 s interval at the 10 s later from the outset of the background stimuli. Concerning to the Env.3, there are some peaks on the



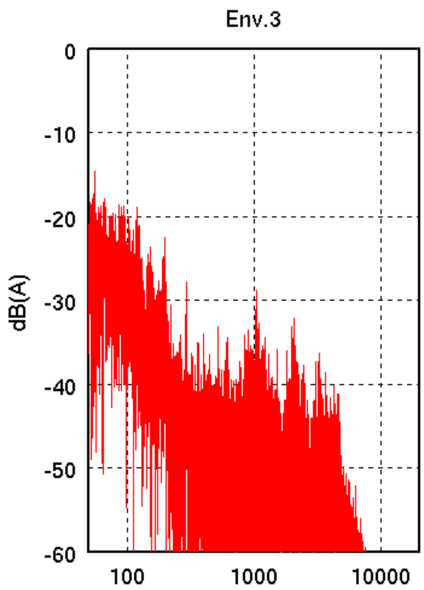


Figure 4: Average power spectrum of 10 s interval at the 10 s later from the outset of Env.1 and Env.3

frequency range higher than around 1 kHz. According to the recording source, these peaks are seems to be attributed mainly to the advertising music and announcements from the electronics retail store.

From the comparison of power spectrum between two acoustic signs (Figure 1) and the environmental sound (Figure 4), the peak frequency of the power spectrum for each acoustic sign is close to that for the background stimulus including music.

This similarity is thought to be the main reason why the relative differences between the estimated adequate sound levels and the environmental sound levels are larger when the background is Env.3. Several participants pointed out that the acoustic signs should be louder in the acoustic environment including music, because the acoustic signs sound similar to the sounds in down town like the music from shops.

The results of this study indicated that the relative difference between the adequate sound level of acoustic signs and the environmental noise levels are larger than that under the road traffic noise environment, and the acoustic sings used in this experiment which are the one of the most common design of such signs for visually impaired in Japan are easily masked by the sounds in down town.

Acknowledgements

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