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TAIPEI MRT CABIN SOUNDSCAPE – ROUTE BETWEEN SHANDAO TEMPLE AND TAIPEI MAIN STATION

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ABSTRACT

Soundscape of a specific transportation event conveys not only messages for communication purpose but also becomes a soundmark for the riders. This Taipei MRT cabin soundscape study documents the series of acoustic events during the rides between two stations: Shandao Temple and Taipei Main Station. Taxonomy of sounds, technical data analysis and soundwalks were used as the soundscape data collection methods. Social, mechanical, and indicators sounds were identified as the three main sound classifications. Spectrogram showed the distinguished frequencies and orders of the acoustic events. On train announcements used four languages due to the country's cultural and social history. This fascinating, unique, and repetitive Taipei MRT cabin soundscape adds to the exuberant soundscape and identity of Taipei.

INTRODUCTION

Studies of transportation soundscape have been done with particular concerns in aural way-finding system's design and upgraded in train station and on train as well. In 2004, Tardieu et al proposes a sound design solution for train stations to improve auditory comfort for its travelers. It is to communicate useful information with proper loudspeakers system to improve the intelligibility of spoken messages in train station.[1] Later in 2008, Tardieu et al studied the perception of soundscape for space typology in train stations. Travelers were able to recognize the type of space in a train station based on sound information listened in the experiments.[2] In 2009, Tardieu et al used non-speech sound signals as the auditory cues to improve wayfinding in a train station.[3] Hansen et al also used non-speech sounds (sonification) to improve the communicating sound environment on the high-speed train for the international passengers. The sonification is independent from culture and language.[4]

Meanwhile, there were also extensive soundscape of traffic and transportation studies from urban design perspective. Yang et al demonstrated the significance of intentional soundscape design in urban squares by investigating people's general perceptions of urban soundscape and sound preferences in Sheffield. The preferences of natural soundscape elements influenced people's choice of using an urban square.[5] It is as Gold proposed that

soundscape is fundamental in establishing a sense of place. Sounds of transportation are an integrated part of the modern urban environment. Sounds must be considered in their proper context and not as isolated units.[6] A perceptual study conducted by Lee et al, evaluated the temporal and spatial aspects of high-speed train noises with different landscape elements where high-speed trains pass by. Result shown that loudness of train noises was dependent on source-receiver distance and that temporal and spatial characteristics of train noises were affected by environments of rural area.[7] Later, Lee et al also assessed the rural soundscape with high-speed train noise using audio recording and visual images for noise annoyance study. Equivalent sound pressure level and natural features were the dominant factors affecting the annoyance from high-speed train noise in the combined audio-visual condition. Zwicker's loudness was highly correlated with the annoyance from high-speed train noise in both audio-only and audio-visual conditions.[8] In Taiwan, soundscape of Taipei MRT systems have also been investigated in the perceptual and noise emission areas. Lee et al, conducted and recorded specific soundscape along the Taipei MRT line in Taipei and Kaohsiung City for the realistic listening perception and reproduction study.[9] Whilst, Lin et al did the subjective impression along the corridor of two Taipei MRT stations with equivalent sound level LAeq (dB) and LAmax (dB).[10] A noise mapping along the railroad was derived and used as future urban planning acoustic control guidance. Later, Lin et al also used LAeq (dB) to evaluate urban comfort along the public transport infrastructures. It is where the NIMBY effect of the noise in the public open space along the traffic facilities.[11] An indoor aural comfort study was done by Sheikh et al, investigating a high-rise naturally ventilated residential housing in Singapore that is subject to train noise. The subjective 'noisiness' and 'disturbances' were significantly correlated with maximum Loudness of 8 Sone, mean Sharpness of 1.25 Acum and maximum Roughness of 33 centi-Asper.[12] Up to this point, it is clearly that the past decade's studies of transportation soundscape were focused on aural way-finding systems design and noise emission perception and controls.

An alternative soundscape of transportation study is done by Backhaus. The appropriateness use of languages in Tokyo's public transportation announcement systems was examined, so that passengers from different cultural backgrounds and languages will find their way through the city.[13] Despite all, as Thompson suggested, soundscape could be used from the cultural aspects to incorporate scientific and aesthetic ways of listening.[14] Kato in 2009 used a particular whistle noise, symbolic to the traditional culture of ama divers in Japan to explain soundscape as a landscape of sonic environment that could be perceived and understood by individuals and social groups.[15] Maffei also noted that soundscape could have in parallel implications as the tangible visualscape on the best conservation and restoration of cultural and natural heritage.[16] ISO 12913-1:2014 also defines a perceived soundscape could be experienced or in memory of a person or people.[17] To this extent, transportation soundscape perceived by passengers could be used as a way-finding cue or correlate to its cultural background as tangible soundmarks or heritage. Per Schafer, "soundmarks, the analogous to landmarks, are unique sound objects, specific to a certain place".[18] Hence, a specific soundscape is capable to represent as a city's identification. Concurrently, it is the aim of this Taipei MRT cabin soundscape study to attempt and establish the alternative Taipei identity by the special soundmarks discovered in a 90-second rides of MRT as well as with its relations to the culture and history.

TAIPEI MRT

Taipei MRT has a total of 108 stations for the five main routes and two branch lines in Taipei and New Taipei metropolitan area. It began operation in 1996. In December 2017, the official daily average passenger volume is 2.25 million.[19] This soundscape study focused on one of the east-west direction main line, the Blue Line. Blue Line has 23 stations and is 26.5 km in length. It connects two main train stations in Taipei and New Taipei metropolitan area, which are Taipei Main Station and Banqiao Station. Three most vibrant shopping centers, Xinyi District, East District, and Ximen District, are along its route. It is a high capacity line, using island platform with platform screen doors in the stations. The platform has a length of 150 meters and good for all six Siemens Mobility C341 heavy-capacity train cars. The capacity of six C341 cars is 1914 passengers. The length, width, and height of each train car is 23.5m, 3.2m, and 3.6m respectively. The configuration of the train is a permanently coupled, with two 3-car Electric Multiple Unit (EMU) sets and open gangway connections. Each set has three train cars. The order of the six train cars is motor car with cab, trailer car, motor car without cab, motor car without cab, trailer car and motor car with cab. The maximum service speed is 80 km/h. It has Automatic Train Control (ATC) safety system to control all train movements such as braking, acceleration and speed. In the case of an emergency, operator can manually override the ATC. Since it is a heavy-capacity train, steel wheels are equipped. A standard track gauge of 1,435 mm is specified.[20]

Taipei Main Station (BL12) is a mega transportation hub, with connections for the nation's High Speed Rail, Railways, International Airport, and the city's Buses and other MRT lines. Its highest daily passenger volume at about half million.[21] It is between Ximen (BL11) and Shandao Temple (BL13) stations. The distance between BL11 and BL12 is 1431 meter, and between BL12 and BL13 is 671 meter.[22] The ride time between BL12 and BL13 is about 90 seconds. It is the 3rd shortest distanced ride along its line. With a relative short distance and high daily passenger volume, BL12 and BL13 is selected for the soundscape study.

SOUNDSCAPE DOCUMENTATION

To collect the soundscape data on the Taipei MRT cabin, a professional class 1 sound level meter and a high definition video camcorder were used. Larson Davis Model 831 was used to obtain the A-weighted equivalent sound pressure level (LAeq) as well as the maximum sound pressure level (LAmax) during the 90-seconds ride. Reason to use the A-weighting sound level is that it accounts human hearing defect of loudness sensation at low frequency ranges.[232425] The sampling rate of sound level meter was set at 8 kilo samples per second. SONY HDR-CX900 Handycam was used to record the audio and visual events inside the cabin. Taxonomy of sounds and soundwalks were used as another soundscape documentation method. Despite ISO 12913-2016 part 2[26] have described these two methods, since the standard is under revision now, only definitions were adopted from the standard and used in this research.

As Schafer first pointed it out, taxonomy of sounds will assist people to classify the sound events and soundwalks allows people to evaluate sound and the environment simultaneously.[27] The taxonomy of sound enables a clear classification of sounds analysis and soundwalks is a multidimensional human sensation method. Both methods will be cross check to derive the insights of a soundscape.

RESULT AND DISCUSSION

Taxonomy of sounds, technical data analysis, and perceptual insights of participants in social prospect are the three areas to be discussed in this Taipei MRT cabin soundscape study. Taxonomy of sound will be itemized as the acoustic events in types and orders. Technical data analyses include sound pressure levels and spectrograms of the specific acoustic events. Perceptual insights of participants in social prospect will be summarized and correlate to the acoustic events and/or the technical data.

Since soundscape can last from a second to a period of time, to investigate and understand what happened during this specific sound event, create a taxonomy of sounds is necessary. According to Schafer, taxonomy of sounds includes natural, human, society, mechanical, silence, and sounds of indicators.[28] In this 90-second ride between BL12 and BL13 stations, door closing announcements, door closing warning sirens, train startup and acceleration engine sounds, rail track clunking sounds, station arrival and train transfer announcements, train deceleration engine and braking sounds, as well as the door opening sirens, children speech were identified. Table 1 showed the taxonomy of Taipei MRT cabin soundscape. Since all of the sound events occurred in a social activity context, MRT soundscape is basically categorized under sounds of society. Train engine sounds and public announcements are categorized as mechanical and indicators sounds, creating two dominating sound categories of this Taipei MRT soundscape. Since this specific soundscape captured the MRT cabin sound, it is plausible to believe the aural way-finding cue is important and the sounds of train engines and tracks are not avoidable. Thus, silence do not exist in this MRT cabin soundscape. Natural sounds do not exist either. Yet, it is surprising to see the children speech, since one of the riding regulation on Taipei MRT is to keep the voice down and maintain a quiet environment. Hence, the power of policy could alter a sonic environment.

Table 1. The taxonomy of specific Taipei MRT cabin soundscape from BL12-BL13

Taxonomy of Sound	Natural	Human	Society	Mechanical	Silence	Indicators
Door closing announcements			√			√
Door closing warning sirens			√			√
Train startup engine sounds			√	√		
Train acceleration engine sounds			√	√		
Rail track clunking sounds			√	√		
Station arrival & train transfer announcements			√			√
Train deceleration engine sounds			√	√		
Train braking sounds			√	√		
Door opening sirens			√			√
Children speech		√	√			

The overall and maximum 1/3 octave band frequency sound pressure levels for trips between BL12 and BL13 stations were illustrated in Figure 1. These can be viewed as the background noise levels inside the MRT cabin. It is clearly to see the low frequency between 31.5 and 80 Hz as well as speech frequency of 200 to 2000 Hz has average background noise level above 60 dB and below 70 dB. Likewise, the maximum background noise level is in between 70 and 85 dB. The equivalent A-weighted sound pressure levels for both trips are 74 and 75.4 dB. The peak sound pressure levels for both trips are 105 and 106.9 dB. Both suggested that background noise level inside the MRT cabin is high.

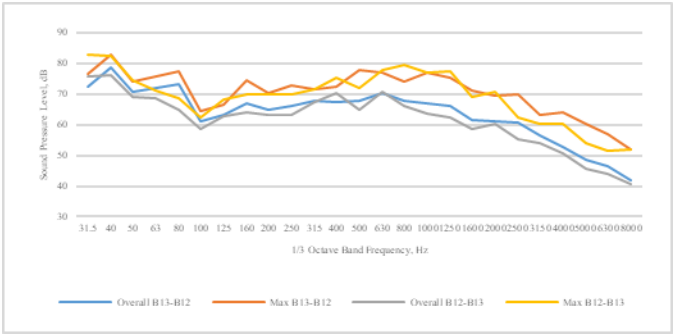

Figure 1. Taipei MRT Cabin sound pressure level - trips between BL12 and BL13

All specific acoustic events with their own dominating and distinguished frequency can be identified in spectrogram. Figure 2 showed the acoustic events and spectrogram of the ride from BL13 to BL12. It is clear to see the train accelerating, constant speed, and decelerating in time and frequency patterns.

The constant speed of train sound is at about 2500 Hz. The announcements in Mandarin, Taiwanese and Hakka are 9 seconds long. For English, it is a 12 seconds long announcements. With spectrogram, the acoustic events occurrences are shown as in an order. For this trip, it is interesting to know that the dominated MRT cabin soundscape of train and announcements will be remained and repeated for as long as it could. Both are the controllable mechanical and indicators sounds.

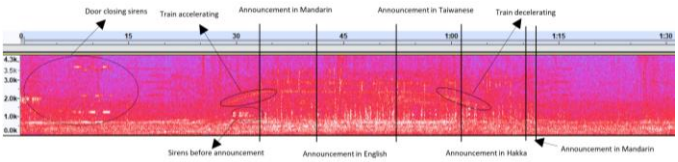

Figure 2. Taipei MRT Cabin spectrogram with acoustic events - trips between BL12 and BL13

Since Taipei MRT uses four different languages for the announcements, it is very different from other major cities with subway systems such as London, New York, Berlin, Vienna, Beijing, Tokyo, Seattle and South Korea. For non-English countries, only one local language and English are used. Thus, the use of four languages in Taipei MRT could be a friendliness aural way-finding cue design and is unique than any of the above major cities. In fact, it was stated in Taiwan's "Public Transportation Broadcasting Language Equality Protection Act" that other than Mandarin, Taiwanese and Hakka should also be included in the public transportation announcement. As the official language in Taiwan is Mandarin, Taiwanese and Hakka are commonly used as well. In Taiwan, about 70 percent of the population speaks Taiwanese and 15 percent of the population speaks Hakka.[29] Thus, the announcement in the cabin comes in English and three varieties of Chinese dialects. The three dialects could represent the country's population formation and culture, hence could be viewed as a soundmark for Taiwan.

An initial study with soundwalks method was carried out and attempted to understand and define the sonic environment under considerations of acoustical, visual, aesthetic, geographic, social and cultural perspectives. Six participants performed soundwalks task in-situ and 8 participants performed soundwalks via Line Group with video stream. Eight out of 14 participants are foreigners. Through discussion in-situ and via Line group, the perceptual insights of observers were well exchanged and documented. For indicator sounds, the uses of four different languages was investigated. The initial results shown that, all of native Mandarin speaker agreed it is not necessary to have Taiwanese and Hakka language announcements as the aural way-finding cue. Four of the respondents stated that they rely on visual way-finding cue more than aural one. For mechanical sounds, train engines and track sounds were found to be loud and noisy for 6 out of 14 participants. Four of the participants felt comfortable on train with the mechanical sounds. A further study with more samples will be carried out to extent this perceptual analysis.

CONCLUSION

Despite of many previous research on soundscape of train and MRT in train station and aural way-finding cue design, as well as urban planning strategies along the railway, it is the initial study of Taipei MRT cabin soundscape in attempting to understand the acoustic events in both technical and perceptual ways as well as to establish train cabin sound as a soundmark based on its cultural and heritage values. A soundscape could reveal a local cultural. A soundmark could be viewed as a city's identification due to its uniqueness.

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