



The effect of sound level on perception of reproduced soundscapes



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ABSTRACT

The aim of this work was to investigate the perception of soundscape reproduced by an ambisonic reproduction system on a horizontal plane, how the experience of space affected the perception of soundscape reproduction, and how the sound level adjustment on soundscape reproduction affected the perception of soundscape compared with actual conditions. There were three experiments conducted: a soundwalk in situ in Manchester (United Kingdom) city centre, listening tests in Salford (United Kingdom), and listening tests in Bandung (Indonesia). The listening tests used material recorded from four locations on the soundwalk route in Manchester. The Salford listening tests were performed at the in-situ measured sound level, and the participants were asked to adjust the sound level to the level that represents actual locations. The listening test in Bandung was conducted to understand the effect of participants who never come to the actual location to the perception of soundscape and the sound level adjustment. The listening tests in Bandung were conducted at the in situ sound level, at 9.5 dB below the in situ sound level (based on the preference sound level from the experiment in Salford), and the participants were also requested to adjust the sound level to the level that represents the actual space (to examine the consistency with the experiment in Salford). In each case, soundscape perception was measured on 19 semantic differential scales. Analysis of the semantic differential results showed that the ambisonic reproduction produced a similar subjective experience to the in situ soundwalk when the reproduction sound level was 9.5 dB lower than the actual sound level in situ. Reproduction at the actual sound level in situ produced a different dimensional space. The study shows that the sound level adjustment of soundscape reproduction in laboratory experiment produces more ecologically valid results compared to the reproduction at the actual sound level in situ.

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1. Introduction

Audio reproduction systems are often used to recreate an outdoor soundscape in the laboratory for subjective testing. Several methods have analysed the validity of various reproductions to reproduce soundscape. For instance, Guastavino and Katz tried to compare stereo, ambisonic system on the horizontal plane, and ambisonic system with height (three-dimensional ambisonic system) to reproduce soundscape in an anechoic condition [5]. Five scales were applied for the experiment: Readability, Presence, Distance, Localization, Coloration, and Stability. Furthermore, this experiment confirms that ambisonic system on the horizontal plane could reproduce proper spatial aspect of soundscape on the sweet spot, and suitable for outdoor soundscape reproduction.

The different method also conducted to validate the ambisonic reproduction system in reproducing outdoor soundscape in laboratory. Semantic categorization from verbal response has been adapted to compare soundscape reproduction between the stereo system, ambisonic system, and actual condition [6]. Three categories regarding the response were used here: Source, Object-Centered, and Subject-Centered. The experiment shows that ambisonic reproduction in anechoic condition with the speakers conceals from the view enabled the participants to feel that they were in real locations. Although the ambisonic reproduction system appears to offer better reproduction, many other experiments of soundscape reproduction were conducted using binaural system [2,3,8].

Davies et al. conducted one of the studies regarding soundscape reproduction in the laboratory that used ambisonic system and the system confirmed the similar result of Semantic Differential Analysis with the in situ condition [4]. In their study, three-dimensional ambisonic reproduction system was implemented to reproduce soundscape in the semi-anechoic chamber [4]. Four perceptual

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dimensions were established from this experiment: Relaxation/Calmness, Dynamic/Vibrancy, Communication, and Spatiality. The perceptual similarity of this reproduction was confirmed by comparing with the result of field experiment in Sheffield [9]. The dimensions gathered in the laboratory showed similar dimensions compared to the in situ experiment: Relaxation, Communication, Spatiality, and Dynamic. In another word, the three-dimensional ambisonic playback systems in the semi-anechoic chamber could give a similar impression with the actual condition although the information regarding the sound level of reproduction was not well defined.

Interestingly, in the previous work [4], it was found that the participants tended to lower the sound level of event sound objects (not the overall sound level) in the soundscape simulator by -12.3 dB in average from the recording level. The soundscape simulator allowed the participants to compose a soundscape by adjusting the sound level of each sound object in a soundscape. Although the sound level adjustment might indicate that the participant might prefer lower sound level reproduction, this study has not analysed the overall reproduction sound level of simulated soundscape and the effect of the sound level adjustment on the perception of soundscape reproduced in the laboratory.

In this work, the validity of soundscape reproduction using the two-dimensional ambisonic systems was analysed. Two-dimensional ambisonic reproduction obviously offers much simpler set up than the three-dimensional ambisonic reproduction while at the same time could still reproduce better outdoor soundscape [5]. Also, the study about the overall sound level adjustment of soundscape reproduction, and how the sound level adjustment on soundscape reproduction affected the perception of soundscape compared with actual conditions will be analysed further.

2. Method

2.1. Soundscape recording

The soundscape was recorded using a soundfield microphone in the Manchester city centre area. The Soundfield ST-250 microphone was used with Roland R-44 digital recorder that recorded all four outputs (W, X, Y, and Z signal) from the microphone

simultaneously. The windshield was applied to the microphone to reduce wind noise. The recordings were taken for ten minutes at each location in a stationary condition.

The Manchester city centre soundscapes were recorded at several outdoor locations: National Football Museum, Exchange Square, New Cathedral Street, St Ann Square, Market Street, and Piccadilly Garden. All of the recordings were made in February 2014 during the lunchtime. Four recordings were selected for the experiment: Market Street as a representation of busy shopping spot, St Ann Square due to the tranquillity, Piccadilly Garden as the icon of Manchester city centre, and food market at Piccadilly Garden due to the different function of space. A snapshot of the locations is shown in Fig. 1. The snapshot is also indicating the typical sound in each place: People walking and talking on Market Street, the water fountain at St Ann Square, a combination of people and urban traffic at Piccadilly Garden, and the sound of food stalls at food market at Piccadilly Garden. The audio samples, two minutes long, were selected from each of recordings. The samples were chosen to represent each soundscape based on completeness of the sound components, and the occurrence of wind noise in the recording.

Four soundscape recordings were used in these experiments, and the Sound Pressure Level (SPL) measurement of the locations are shown in Table 1. The SPL data were calculated from the W channel from the soundfield microphone that had been calibrated. The data of L_{10} (the SPL surpassed 10% of recording time), L_{50} (the SPL surpassed 50% of recording time), and L_{90} (the SPL surpassed 90% of recording time) was also calculated from each of recordings. The noisiest location was Market Street (73 dBA), and the quietest location was St Ann Square (62 dBA). Both the recordings made in Piccadilly Garden have a similar condition with the noise level at 70 dBA.

2.2. Experiment

There were three experiments to verify the validity of soundscape reproduction in a room. The first experiment was conducted in a Listening Room at the University of Salford, United Kingdom. The second experiment was performed in a recording room at *Institut Teknologi Bandung*, Indonesia. The third experiment was carried

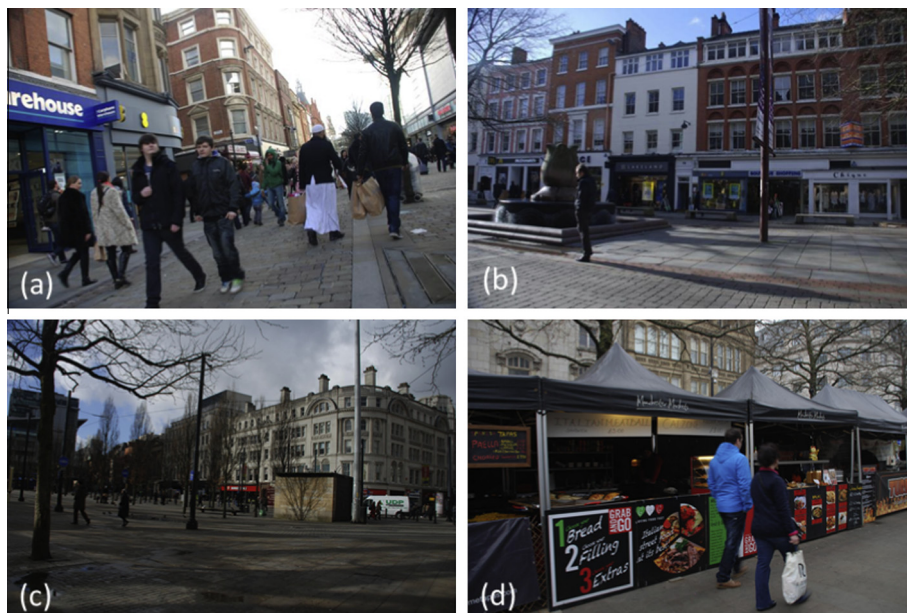


Fig. 1. Snapshot of the locations; (a) Market Street; (b) St Ann Square; (c) Piccadilly Garden; and (d) Food Market at Piccadilly Garden.

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