The development of emotional indicators for the soundscape in urban open public spaces

Yan Zhang¹ and Jian Kang¹²*

¹School of Architecture, Harbin Institute of Technology; Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, Harbin, Heilongjiang, 150001, China
²UCL Institute for Environmental Design and Engineering, The Bartlett, University College London (UCL), London, WClH 0NN, United Kingdom
*Corresponding author’s e-mail: j.kang@ucl.ac.uk

Abstract. Increasing urbanization has had a profound impact on the acoustic environment. Research on soundscapes in urban open spaces depends on users’ perceptions and feelings. By exploiting the semantic differential method, this study aims to investigate the emotions that constitute the perceptions and feelings of soundscapes in urban open public spaces. This research was carried out through a laboratory audio–visual experiment using photographs and binaural recordings of 16 urban open public locations across Harbin, China. A total of 48 participants were required to assess both the ‘perceived emotion’ and ‘felt emotion’ of the soundscape by questionnaire. A semantic differential analysis of the results shows that although the soundscapes in urban open spaces are rather complicated, it is still possible to identify five major factors of felt emotion and seven major factors of perceived emotion. Distinguishing between “felt emotion” from “perceived emotion” in soundscapes may bring about changes in evaluation and design, which will help planners better understand how to design a place to provide its users with their expected experience.

1. Introduction

Soundscapes, defined by the International Organization for Standardization (ISO), are “[the] acoustic environment as perceived or experienced and/or understood by a person or people, in context” [1]. Thus, ‘soundscape’ refers to not only a perceptual construct but also how people actually experience the acoustic environment [2, 3]. Soundscapes are influenced by cognitive effects, and the feelings of emotions, as human responses or reactions, are linked to psychophysiological restoration, while both are based on research approaches grounded in linguistic and psychological paradigms [4]. Cognitive refers to rational effects, “from the head”, and the affective parameter refers to more emotional responses, “from the heart” [5]. Therefore, emotion is of two kinds: perceived emotion and felt emotion. Responses to the very interesting question, “If you perceive that the music expresses an emotion, do you also feel that emotion?”, showed that the difference between the emotion actually experienced by the listener and the emotion recognized in the music is of fundamental importance [6, 7]. Felt and perceived emotions both have an extensive tradition in the music research area. An emotion is classified as a felt emotion if the instructions state that the participants should focus on their own emotional experiences or on the emotions that the sound induces or arouses in their heart. This is in contrast to perceived emotion directions that emphasize the perception and recognition of emotions represented or expressed by sounds
[8]. These two emotions have not been clearly defined in the present stage of soundscape research.

This study, therefore, aims to investigate the emotions that constitute the perceptions and feelings of soundscapes in urban open public spaces. The present study conducted a laboratory audio–visual experiment involving 48 participants, using photographs and binaural recordings of 16 urban open public locations across Harbin, China. Furthermore, participants were required to assess both the ‘perceived emotion’ and ‘felt emotion’ of the soundscape by questionnaire.

2. Method

2.1. Stimuli

As the experimental samples should be typical and representative, 16 open-space spots in Harbin were selected to carry out binaural recording at typical time points for the local soundscape. This was done to ensure that the collected acoustic samples resemble the urban dwellers’ actual experience. In order to duplicate the complex acoustic environment in the study area, two types of experimental samples were collected. The first are 60 second soundscape excerpts from the binaural recordings, which contain both sound events and ambient sounds. The others are photos edited from the 360° panoramic photos that contain the most information.

The acoustic measures were calculated for all 16 soundscape excerpts, measuring the overall loudness $[L_{Aeq, 60s} (db)]$, and $N_{10}$ (sone), the level of variability over time $[N_{10}-N_{90}$ (sone)], and the relative proportion of low-frequency sound $[L_{Ceq, 60s}-L_{Aeq, 60s} (db)]$.

2.2. Design

The experiment was conducted in an audio–visual laboratory with background sounds lower than 11 dBA. The 16 audio files were stored as HEAD Data files and were binaurally replayed in headphones (BHS I) from the original recording system (SQuadriga II) at an authentic sound-pressure level.

Six of the 16 soundscape excerpts were selected to form a subset. A total of 48 subsets were assigned to 48 subjects randomly. Every subject was asked to evaluate the six excerpts in a subset in an irregular order, and each excerpt received evaluations from 18 subjects, that is, $(48 \times 6)/16 = 18$.

2.3. Soundscape emotion measurement

In order to obtain a soundscape emotion measurement tool, i.e., a semantic differential scale, a series of “semantic” items needs to be achieved first. The following four steps are required.

First, we collected 92 candidate emotional-descriptive terms related to soundscapes from five studies [9-13];

Second, after 34 university students (23 male and 11 female students aged 18–27 years, with an average age of 21.7) finished an urban soundwalk in another experiment, they were required to assess the suitability of the 92 terms that were presented in random order. Participants were asked to rate each term according to the following criterion: “According to you, does this adjective describe an affective state with a specific affective ‘color’ from hearing a soundscape, so that, to describe this feeling, you would choose to use this adjective over another one?” There was a binary yes–no answer format. Terms that received “Yes” as the answer from >50% of the participants were retained.

Third, we scrutinized and eliminated synonyms and antonyms, after which only 63 terms were retained for further analysis.

Fourth, a new questionnaire was created for the present experiment. Under the topic “How does this sound environment make you feel?”, the terms were changed into expressions like “I feel...”, and the 63 terms were reduced to 42 grammatically-correct items. Under the topic “For each scale, to what extent do you agree or disagree that the present surrounding sound environment is…”, “xx” (an adjective) was used directly as an item, thereby reducing the terms to 51.

In this way, we established two semantic differential scales to measure the felt and perceived emotions of soundscapes. That is, each of the adjectives was supplied with a 5-point Likert scale. (1 =
“Strongly disagree”, 2 = “Disagree”, 3 = “Neither agree, nor disagree”, 4 = “Agree” and 5 = “Strongly agree”). All items in each scale were clustered using the factor analysis of SPSS Version 24.0.

2.4. Subjects
Based on the selection criteria of previous studies [14], people with normal hearing and regular or corrected to normal vision were selected as the study subjects. The valid subjects were 21 female and 25 male university students (19 undergraduates and 27 postgraduates) from Harbin Institute of Technology, aged 17–34 years (M age = 22.6 years, SD = 3.9). Ultimately, 264 valid questionnaires were obtained from 46 subjects. Participants received a small monetary compensation for volunteering in the experiment.

3. Results
The factor analyses of felt and perceived emotions were made using the data from all 264 questionnaires for the 16 soundscape excerpts. Promax rotated principal component analysis has been widely employed to extract the oblique factor. As there is no reason to assume that emotions have to be organized orthogonally, the same oblique rotation analyses (Kappa = 4) were run on ratings of felt and ratings of perceived emotion terms [13]. Consequently, a correlation still existed between the factors for subsequent analysis.

3.1. Felt emotion factors of soundscape
With a criterion factor of eigenvalue >1, five major factors of felt emotion in urban open spaces were determined. It can be seen that Factor 1 is labeled Enjoyment, including Peacefulness, Inspired, Soothed, Enjoyment, and Comforted. Factor 2 is labeled Excitement, including Happy, Enthusiastic, Thrilled, and Excited. Factor 3 is labeled Desolation, including Sad, Empty, and Lonely. Factor 4 is labeled Tension, and Factor 5 is Feeling of familiarity. Before oblique rotation, these factors together cover 64% of the total variance, which is acceptable considering the complexity of soundscape evaluation. Factor scores were calculated by the regression method.

The internal consistency of the scale items was analyzed using Cronbach’s alpha. The reliability of the scales for felt emotion was α = 0.86. Meanwhile, the Kaiser–Meyer–Olkin measure of sampling adequacy was 0.957, which showed that the result could be considered reasonable and stable. According to previous studies [9, 15], a sample size that is more than five times the number of indices is generally acceptable for evaluating soundscapes in urban open public spaces.

3.2. Perceived emotion factors of soundscape
With a criterion factor of eigenvalue >1, seven major factors of perceived emotion in urban open spaces were determined. Factor 1 is labeled Comfortable, including Tranquil, Smooth, Comfortable, and Agreeable. Factor 2 is labeled Festive, including Festive, Fiery, and Exciting. Factor 3 is labeled Desolate, including Empty, Solitude, and Inhospitalable. Factor 4 is labeled Familiar, including Familiar, Real, and Common. Factor 5 is labeled Various; Factor 6 is Attractive, and Factor 7 is Nostalgic. Before oblique rotation, these factors together cover 66% of the total variance, which is acceptable considering the complexity of soundscape evaluation. Factor scores were calculated by the regression method.

The internal consistency of the scale items was analyzed using Cronbach’s alpha. The reliability of the scales for perceived emotion was α = 0.87. Meanwhile, the Kaiser–Meyer–Olkin measure of sampling adequacy was 0.940, which showed that the result could be considered reasonable and stable. According to previous studies [9, 15], a sample size that is more than five times the number of indices is generally acceptable for evaluating soundscapes in urban open public spaces.

4. Conclusions
The felt and perceived emotions of soundscapes in urban open spaces have been investigated using a laboratory study. Although soundscape emotions in urban open spaces are complicated, it is still possible to identify five factors of felt emotion and seven factors of perceived emotion. Therefore, this study
developed appropriate scales for felt emotion and perceived emotion of the soundscape, thus making it possible for designers or researchers to select proper emotions to be measured according to their objectives. We anticipate that this knowledge will be helpful in evaluating the existing soundscape and designing a future soundscape.

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