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# COMPARISON OF TEXT-BASED AND GRAPHICAL METHODS FOR SOUNDSCAPE ASSESSMENT

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## ABSTRACT

The soundscape approach enables the improvement of acoustic environments and the development of acoustic design strategies in various spaces. Soundscape data are mainly collected through text-based method in soundwalk or laboratory experiments. However, the text-based method could be time- and cost-intensive for constructing soundscape databases. Furthermore, insufficient data can undermine the validity of acoustic improvements and design strategies. Therefore, this study proposes a novel graphical method for collecting soundscape data. Unlike traditional text-based method, this method evaluates the soundscape by positioning each descriptor on a coordinate plot using a mobile app. A laboratory test with 30 participants compared to indoor soundscape assessments using both text and graphical methods. The text method represented eight descriptors in terms of Comfortable and Full of content dimensions using the conversion formula specified in ISO/TS 12913-3. The results were compared to using Pearson's correlation coefficient and RMSE. In the Comfortable dimension, the two methods showed a notably high correlation (r = 0.95) with an RMSE of 33.01, whereas in the Full of content dimension, the correlation was high (r = 0.67) with an RMSE of 18.72. Additionally, the graphical method reduced the average evaluation time by 74.67% compared to the text-based method.

**Keywords:** *soundscape, mobile-based method, database*

## 1. INTRODUCTION

The soundscape approach conceptualizes environmental sound not merely as negative elements to be eliminated, but as resources that can be comprehensively understood and designed. Furthermore, soundscape evaluation does not assess acoustic environments solely through decibel measurements. It also considers perceptual and emotional responses, playing a crucial role in urban planning and interior design strategy development. Previous soundscape studies have primarily focused on outdoor spaces, with recent expansion into indoor environments across various types of places. For examples, outdoor soundscape studies have investigated urban parks, city streets, and such places [1-2]. Indoor soundscape research has investigated residential spaces [3], educational facilities [4], and office environments [5].

Soundscape assessment mostly applies text-based method according to ISO/TS 12913-2 [6], which utilizes eight descriptors individually assessed. This method measures the degree of correspondence between the surrounding acoustic environment and each descriptor. Additionally, the eight descriptors are transformed into the cognitive dimensions of Pleasantness and Eventfulness, by equations presented in ISO/TS 12913-3 [7]. Most studies utilize the text-based method for in-situ assessments or laboratory listening experiments. According to Aletta *et al.*'s study [8], in-situ assessments offer the advantage of reflecting actual contexts and ensuring high ecological validity. Laboratory experiments enable precise measurements by controlling variables beyond the experimental parameters. However, text-based method that requires individual scoring of eight descriptors in field or laboratory experiments may present cost and time-consumption challenges. Moreover, field experiments are characterized by continuously changing sequences of sounds, with participants' auditory experiences varying moment by moment as they navigate through spaces [9]. Most significantly, from an acoustic environment design perspective, soundscape data collected through a text-based

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method remains limited in quantity. The validity of using such insufficient samples to inform acoustic environment characteristics or design strategies may be limited.

To overcome these limitations, this research focuses on the advancement and increasing use of mobile technology, proposing a graphical method for soundscape assessment. The graphical method assesses soundscapes using coordinate axes with descriptors embedded in a mobile application interface. To examine the applicability of this graphical method, this study conducts a comparative analysis between traditional text-based and the graphical approach. This research aims to suggest an evaluation methodology that overcomes the data collection limitations and enhances the efficiency of soundscape database construction.

## 2. METHODOLOGY

### 2.1 Experiment set up

In this study, the listening experiment was conducted to control experimental variables and to compare results between text-based and graphical-based methods. The experiment was performed in a sound-proof room (W: 2.7 m × L: 4.4 m = 11.9 m²) with a background noise level of 15 dBA, and the room is shown in Fig. 1 (a). Indoor soundscape descriptors [3] were used since the experiment was conducted in an indoor environment. As the proposed scenario in the referenced study was a residential living room, this research also considered contextual features by designing the laboratory environment to resemble a residential space. Additionally, participants were instructed to imagine themselves in a state of relaxation within a residential space prior to the experiment. The descriptors for indoor soundscape evaluation were Comfortable, Annoying, Full of content, Empty, Engaging, Detached, Private/controlled, and Intrusive/uncontrolled, all of which were presented to participants in Korean translation [10-11].

A total of 30 participants (10 males and 20 females) with a mean age of 24.5 years (range: 20-31 years) took part in the experiment. Participants received a modest compensation for their participation. Fifteen sound sources were used for soundscape evaluation, comprising five bird sounds, five water sounds, and three artificial sounds. Each sound source was selected to represent a wide range of emotional dimensions. The sources were presented to participants through speakers connected to the developed application. The distance between participants and speakers was approximately 1.1 m, resulting in sound pressure levels of approximately 45-50 dBA.


Fig. 1 (a). Laboratory Set up, (b). Interface of graphical method

### 2.2 Test Procedures

The experiment was organized into two sessions to compare between text-based and graphical-based methods, with the experimental protocol illustrated in Fig. 2. In the first session, participants used the text-based method to evaluate each auditory stimulus using a ratio scale ranging from 0 to 100 across eight perceptual descriptors. Following an appropriate rest interval, participants proceeded to the second session where they engaged with a graphical soundscape model displayed on a mobile interface as shown in Fig. 1(b). This interface involved the eight descriptors, enabling participants to indicate their acoustic environment perception by positioning coordinate point within the model. Identical auditory stimuli were used across both sessions, with randomized presentations sequencing to mitigate order effects. To quantify the potential advantages of the graphical method, response durations were measured for each stimulus across both methods. Therefore, the playback duration of each stimulus was not fixed, which allowed participants to respond at their own pace.

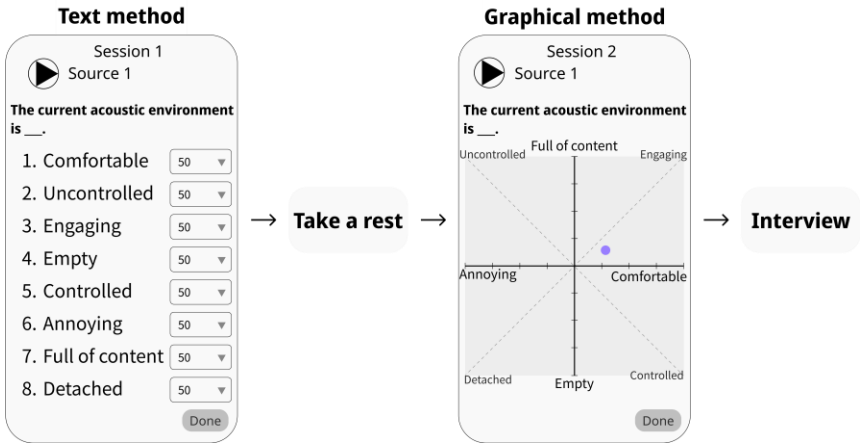



Fig. 2 Experiment procedure

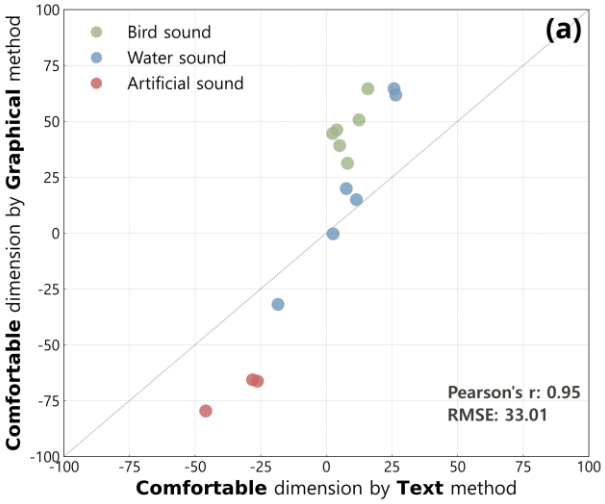
## 3. RESULTS

To examine the accuracy and utility of the graphical method using eight descriptors, its results were compared with those of two different text methods. One used all eight descriptors, while the other used only the four principal ones: Comfortable, Annoying, Full of content, and Empty. For the eight-descriptor text-based method, the eight descriptors were converted to Comfortable and Full of content dimensions according to the axis conversion equations in ISO/TS 12913-3 [7]. For the four-descriptor text-based method, the remaining descriptors (Engaging, Detached, Private/controlled, Intrusive/uncontrolled) were assigned values of zero during the conversion process. To quantify the relationship and difference between the text-based and graphical-based methods, this study analyzed the Pearson correlation coefficients and root mean square error (RMSE).

### 3.1 Comparison for soundscape assessment between 8 text and graphical methods

For both the Comfortable and Full of content dimensions, the average of participants' responses was calculated for each auditory stimulus. Scatter plots, correlation coefficients, and RMSE values comparing the two methods are presented in Fig. 3 for each dimension.

As shown in Fig. 3(a), the Comfortable dimension demonstrated a high correlation coefficient of 0.95 across all stimuli between the two methods ($p<0.01$). This indicates that both methods provide similar results when assessing the Comfortable dimension. Additionally, the RMSE value of 33.01 indicated a moderate difference between the two methods. Notably, for bird sounds, stimuli that were rated highly on the Comfortable dimension in the text-based method tended to receive even higher ratings in the graphical method. Conversely, for artificial sounds, stimuli that received low ratings on the Comfortable dimension in the text-based method tended to receive even lower scores in the graphical method. Furthermore, the Full of content dimension also showed a positive correlation ($r = 0.67$, $p<0.01$) between the two methods (Fig. 3 (b)). The RMSE value was 18.72, which was relatively lower than that of the Comfortable dimension. For water sounds, stimuli that was rated highly on the Full of content dimension in the text method tended to receive higher scores in the graphical method, with artificial sounds showing similar patterns.



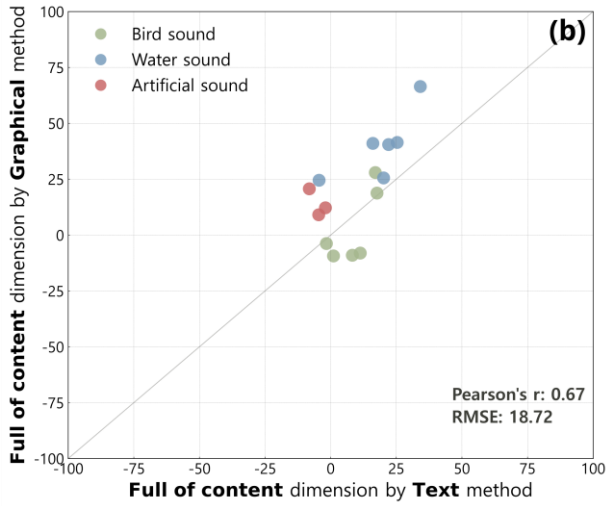



Fig. 3 Average scores of each sound using text and graphical methods across dimensions.
(a): Comfortable, (b): Full of content

### 3.2 Comparison for soundscape assessment between four main text and graphical methods

Correlation and RMSE analyses were conducted to compare the four-descriptor text-based and graph-based methods. Results for each dimension, including scatter plots, correlation coefficients, and RMSE values, are shown in Fig. 4. As shown in Fig. 4 (a), the correlation coefficient between the two methods for the Comfortable dimension across all stimuli was 0.95 ($p<0.01$), as observed in the eight-descriptor text-based comparison. This indicates that the four-descriptor text-based and graphical methods also showed a significant positive correlation. The RMSE value between both methods was 17.65, indicating a substantial reduction in difference in the graphical method results when using four descriptors compared to eight. For the Full of content dimension, the correlation coefficient between the two methods was 0.83 ($p<0.01$) (Fig. 4 (b)). Notable differences were observed when comparing the graphical method with each of the text-based methods using either eight or four descriptors. The four-descriptor text method showed a relatively higher positive correlation with the graphical method compared to the eight-descriptor text method. The RMSE value of 13.69 indicated smaller differences between the four-descriptor text and the graphical methods. Additionally, stimulus-category trends between the two methods appeared similar to those observed with the eight-descriptor text method.

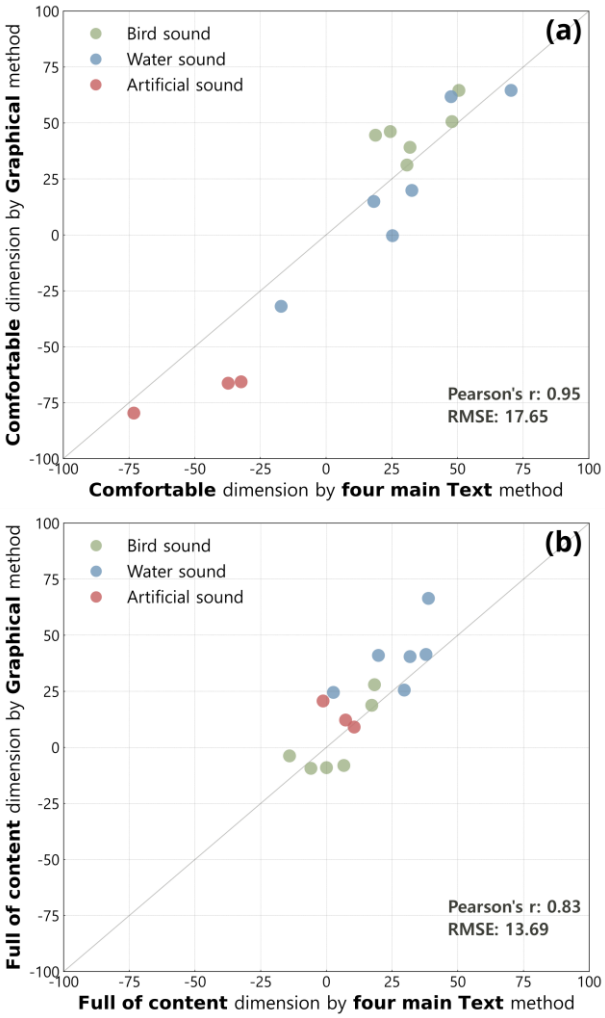



Fig. 4 Average scores of each sound using four text and graphical methods across dimensions.
(a): Comfortable, (b): Full of content

### 3.3 Evaluation time differences between the text and graphic assessment

Conventional text-based method requires respondents to evaluate multiple cognitive attributes individually, leading to longer assessment durations and increased cognitive fatigue. Furthermore, soundwalking and listening experiments demand considerable time and resources, presenting challenges for database construction. Accordingly, the difference in response duration between text-based and graphical methods is significant for constructing soundscape databases.

Therefore, evaluation duration was measured for each stimulus across both methods. The results showed that when using the graphical method, the average duration per stimulus was 16.3 seconds, whereas the text-based method required an average of 64.5 seconds per stimulus. Thus, the graphical method reduced the duration by 75% compared to the text-based method, demonstrating potential for overcoming limitations in soundscape database construction.

## 4. SUMMARY

This study compared text and graphical methods to evaluate the utility of graphical approaches for soundscape assessment. Both methods demonstrated a positive relationship, particularly in the Comfortable dimension with a notably high correlation coefficient of 0.95 ($p<0.01$, RMSE: 33.01). The Full of content dimension showed a comparatively lower level of consistency, with a correlation coefficient of 0.67 ($p<0.01$, RMSE:18.72). When comparing the four principal descriptors (Comfortable, Annoying, Full of content, Empty) text method with the graphical method, the Comfortable dimension maintained a high correlation coefficient of 0.95 ($p<0.01$, RMSE: 17.65). The Full of content dimension showed improvement with an increased correlation coefficient of 0.83 ($p<0.01$, RMSE: 13.69). These findings highlight a limitation of the graphical method in fully capturing the remaining descriptors (Engaging, Detached, Private/controlled, Intrusive/uncontrolled) beyond the four principal descriptors. Future research should aim to refine the graphical method to better incorporate these additional descriptors. Nevertheless, regarding response duration, the graphical method (averaging 16.3 seconds) resulted in a 75% time reduction compared to the text-based method (64.5 seconds). Despite some degree of difference, the substantial decrease in response time suggests that the graphical method could offer significant advantages for soundscape database construction.

## 5. ACKNOWLEDGMENTS

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