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EXPLORING THE EFFECT OF SOUND AUGMENTATION ON SOUNDSCAPE PERCEPTION IN A HOSPITAL OUTPATIENT WAITING AREA

Oya Yildiz[1], Semiha Yilmazer[2], Cem Kaan Sen[3], Zeynep Ugurlu[4], Ceren Sahmaran[4]

[1] *Department of Interior Architecture and Environmental Design, Bilkent University, Türkiye*
[2] *Department of Interior Architecture, Hasan Kalyoncu University, Türkiye*
[3] *Talayman Acoustic Design and Consultancy, Türkiye*
[4] *Independent Researcher, Türkiye*

Abstract

Prior research has shown that human-based sounds dominate healthcare waiting environments and are associated with negative perceptual qualities. Yet acoustic design interventions targeting soundscape quality remain limited. This study explores the effect of sound augmentation on soundscape perception in a hospital outpatient waiting area based on an in situ binaural recording using Odeon's auralization tool. A treated condition incorporated simulated wall and ceiling absorption based on measured impulse responses. Five scenarios were constructed: IR0: original; IR1: with acoustical treatment; IR2: augmented with a bird sound; IR3: augmented with a water sound; and IR4: augmented with a music sound. The augmentation sounds were selected based on findings from a previous healthcare soundscape literature. Five experts evaluated all scenarios using the 79-item Turkish soundscape attribute set. Pleasantness and Eventfulness values were calculated using the loadings of a validated Turkish soundscape circumplex model to compare the perceptual effects of the intervention scenarios. Findings revealed that sound augmentation shifted soundscape perception toward more positive affective dimensions. While bird and water sounds showed the greatest perceptual improvement, music yielded comparatively weaker effects. This study is intended to inform further research involving laypeople and guide acoustic design interventions in outpatient healthcare settings.

Keywords: *hospital soundscape, soundscape intervention, Turkish attributes, perceptual dimensions, auralization*

Corresponding author: *oya.yildiz@bilkent.edu.tr.*

1. Introduction

A well-designed soundscape can positively influence the quality of life and health of individuals [1]. Research has shown that sound plays an important role in shaping people's sense of place [2], while unfamiliar or chaotic sonic environments can increase anxiety and stress in those exposed to them [3]. This relationship is particularly consequential in healthcare settings, where patients are simultaneously more vulnerable to environmental stressors and less able to control or escape them. This is particularly evident in hospital waiting areas. Prior research indicates that such spaces are typically dominated by human-based sounds, including conversation, footsteps, and administrative activity, which are frequently associated with negative perceptual qualities such as annoyance and chaos rather than calm or comfort [4], [5]. Unlike inpatient units, where sound exposure is prolonged and closely tied to clinical care, waiting areas involve shorter, anticipatory periods in which patients are often anxious about an upcoming consultation or procedure, potentially amplifying the impact of a poorly designed acoustic environment on perceived stress. As a complementary strategy to noise mitigation, soundscape augmentation has been proposed in a range of healthcare contexts to improve perceived soundscape quality without necessarily reducing overall sound levels. In intensive care units, Louwers et al. [6] demonstrated that soundscape interventions composed of natural, human, or technological sounds could shift perceived pleasantness and eventfulness toward more positive quadrants of the soundscape circumplex, building on earlier work showing that the removal of sound from single-patient ICU rooms can itself be experienced as isolating rather than restorative [7]. In nursing homes, Talebzadeh et al. [3] similarly showed that carefully selected augmentation sounds could elicit more positive caregiver-reported responses in residents with dementia, framing sound not as pollution to be eliminated but as a resource that can be curated to support well-being [8]. Outside clinical settings, comparable augmentation approaches have improved the perceived pleasantness of noise-polluted urban parks [9], supporting the potential of sound augmentation to improve environmental perception. However, evidence on which sounds are most suitable for augmentation remains mixed, and effectiveness appears to depend on both the specific exemplar used and the context in which it is introduced. Natural sounds, particularly water and birdsong, have repeatedly been associated with improved pleasantness and eventfulness in pediatric intensive care soundscapes [10] and adult ICU rooms [6], consistent with a broader literature linking natural sound exposure to attention restoration and stress recovery [11]. Music, by contrast, has produced considerably less consistent results: Talebzadeh et al. [3] found that sounds recognized as music had a statistically significant negative effect on the likelihood of a positive response among nursing home residents with dementia, and recommended that music be used cautiously in augmented soundscapes. Despite growing interest in soundscape augmentation, research has primarily focused on inpatient and long-stay healthcare settings, such as ICUs and nursing homes, while outpatient waiting areas remain comparatively understudied. Furthermore, intervention studies have typically evaluated perceptual change using the broad dimensions of Pleasantness and Eventfulness. In addition to these dimensions, the present study employs the recently validated 79-item Turkish soundscape attribute set and its loadings [12] to provide a more detailed assessment of perceptual responses. This study investigates how acoustic treatment and augmentation with bird, water, and music sounds influence the perceived soundscape of a hospital outpatient waiting area. The augmentation sounds were selected from a previous participatory expert evaluation conducted in a pediatric healthcare soundscape context, in which the most preferred recording within each sound category was identified [13]. Using binaural recordings, room-acoustic simulation, and controlled listening experiments with soundscape experts, the study evaluates both the overall Pleasantness–Eventfulness circumplex position and attribute-level perceptual responses, extending soundscape augmentation research to outpatient healthcare environments.

2. Method

2.1. Data Collection

An in situ binaural recording of the outpatient waiting area of the Oncology Outpatient Clinic at Bilkent City Hospital (Approval No. E2-25-9881) was obtained from a broader ongoing research project characterizing the hospital's acoustic environment, using a 3Dio binaural microphone connected to a Zoom H4n digital recorder [14], [15]. The recording was conducted during regular outpatient operating hours, during the busiest periods of the day, to capture a representative acoustic environment. A continuous two-hour recording was collected, from which a 15-minute segment representative of the overall acoustic conditions was selected for acoustic modeling and the listening experiment. The selected recording was taken as the reference soundscape for developing a room acoustic model in Odeon Acoustics Simulation Software (Version 18). Using the software's Auralization Tool, five listening scenarios were generated: the original untreated condition (IR0), an acoustically treated condition (IR1) incorporating simulated wall and ceiling absorption based on measured impulse responses, and three additional scenarios in which the treated condition was augmented with a bird sound (IR2), water sound (IR3), or music (IR4). These categories were selected based on previous findings identifying natural sounds and music as promising soundscape interventions in healthcare environments [6], [16]. The bird, water, and music recordings were selected from a previous participatory study on pediatric healthcare soundscapes, in which candidate sounds were evaluated by users and soundscape experts. The selected recordings comprised a common blackbird song (Turdus merula), rainfall sounds, and Mozart's Sonata for Two Pianos in D Major, K. 448 (2nd movement), representing the most preferred exemplar within each sound category [13].

2.2. Procedure

Five experts in the field participated in the listening test. All participants reported normal hearing or no known hearing impairment. The experiment was conducted in the Acoustic Laboratory of the Department of Interior Architecture and Environmental Design at Bilkent University under controlled acoustic conditions. The binaurally reproduced listening scenarios were presented through Beyerdynamic DT 770 Pro headphones, and all scenarios were presented at the same calibrated playback level. Before the experiment, participants were instructed to imagine that they were waiting for their appointment in a hospital outpatient waiting area and to evaluate only the perceived acoustic environment. Each participant listened to all five scenarios while simultaneously completing the evaluation questionnaire. The questionnaire consisted of five sections corresponding to the five listening scenarios. Following each recording, participants evaluated the sound environment using the validated 79-item Turkish soundscape attribute set proposed by Yılmazer et al. [12]. Each attribute was rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), following ISO/TS 12913-2:2018, Method A [17]. Figure 1 summarizes the overall procedure.

2.3. Data Analysis

Given the limited number of expert evaluators ($n = 5$), all analyses were descriptive. First, an overall affective representation of each listening scenario was obtained by calculating loading-weighted Pleasantness

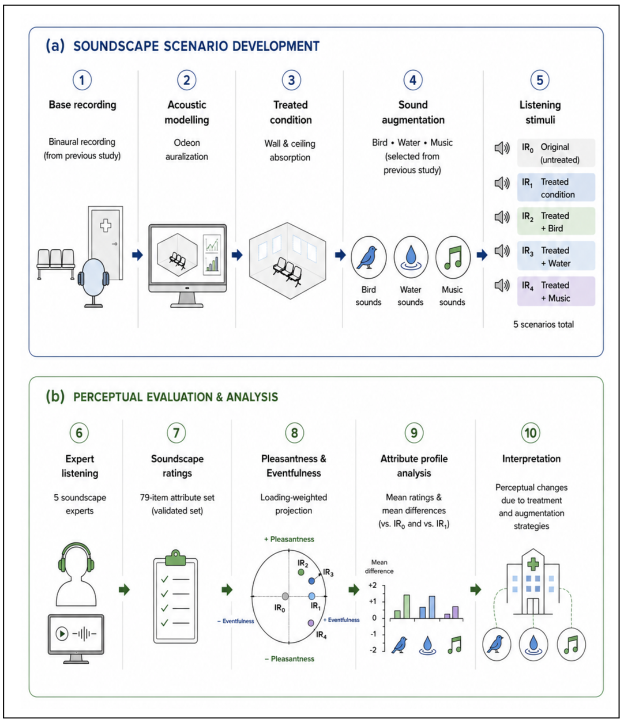

Figure 1: Procedure of the study.

and Eventfulness dimensions using the published component loadings of the validated Turkish soundscape circumplex model [12]. Ratings assigned to each of the 79 attributes were multiplied by their corresponding Pleasantness and Eventfulness loadings, and weighted values were calculated for each scenario. Mean scores across the five experts were then used to visualize the relative positions of the five scenarios within the validated Turkish Pleasantness–Eventfulness axis. Second, to examine which perceptual qualities were primarily responsible for the observed shifts, descriptive statistics (mean and standard deviation) were calculated for a subset of attributes selected a priori according to the highest absolute loading values reported in the validated Turkish circumplex model. Both positively and negatively loading attributes representing the Pleasantness and Eventfulness dimensions were included to characterize the perceptual changes associated with each intervention.

3. Results

Loading-weighted Pleasantness and Eventfulness values for the five listening scenarios are presented in Table 1 and Figure 2. The original recording (IR0) showed the lowest Pleasantness value ($M = -1.37$) and a moderately high Eventfulness value ($M = 0.60$). Acoustic treatment alone (IR1) increased Pleasantness ($M = -0.94$) while slightly reducing Eventfulness ($M = 0.46$). The largest improvement in Pleasantness was observed for the two natural sound conditions. Bird sounds (IR2) and water sounds (IR3) both shifted the soundscape close to the neutral point of the Pleasantness axis ($M = -0.10$ and $M = -0.09$, respectively), although neither reached positive Pleasantness values. Music (IR4) also improved Pleasantness ($M = -0.56$), but less than the two natural sounds. In contrast, music produced the highest Eventfulness value ($M = 0.91$), whereas water resulted in the lowest Eventfulness value ($M = 0.34$). Experts showed the greatest consistency in their evaluations of the original recording, which had the lowest standard deviation ($SD = 0.14$). Greater variability was observed for the treated and augmented conditions ($SD = 0.59$–0.98). A similar pattern was observed for the individual soundscape attributes. The five attributes with the highest Pleasantness loading, peaceful (huzurlu), comfortable (rahatlatıcı), relaxing (dinlendirici), good (iyi), and comfortable (rahat), received their lowest ratings for IR0 and their highest ratings for the bird and water conditions. Music also increased these ratings, but to a lesser extent. The attributes associated with Eventfulness responded differently. Energetic (enerjik), vivid (canlı), dynamic (dinamik), and enthusiastic (coşkulu) reached their highest ratings under the music condition, consistent with its high Eventfulness value. However, eventful (hareketli) gradually decreased from the original recording to the augmented conditions and reached its lowest value under water augmentation.

Table 1: Loading-weighted Pleasantness and Eventfulness values (M, SD) for five listening scenarios.

Scenario	Pleasantness	Eventfulness
IR0 (Original)	-1.37 (0.14)	0.60 (0.59)
IR1 (Treated)	-0.94 (0.59)	0.46 (0.45)
IR2 (Bird)	-0.10 (0.77)	0.76 (0.40)
IR3 (Water)	-0.09 (0.98)	0.34 (0.64)
IR4 (Music)	-0.56 (0.74)	0.91 (0.42)

4. Discussion

The results show that sound augmentation changed the perceptual profile of the hospital outpatient waiting area. All intervention scenarios improved Pleasantness compared with the original recording. However, the greatest improvement was achieved by the two natural sound conditions. These findings are in line with previous healthcare soundscape studies [6], [10]. Although bird and water sounds produced similar Pleasantness values, they differed in Eventfulness. Water created the calmest perceptual profile, whereas bird sounds maintained a higher level of Eventfulness while still improving Pleasantness. Music followed a different pattern. It produced the highest Eventfulness value but a smaller improvement in Pleasantness than the natural sounds. This suggests that different augmentation strategies change the soundscape in different ways. The relatively limited improvement observed for music may also be related to the characteristics of the selected musical excerpt, which contained greater dynamic variation than the natural sounds. This may have increased the perceived complexity of an already busy acoustic environment. This is consistent with findings from other healthcare augmentation studies, where music has produced comparatively inconsistent or even negative effects compared to natural sounds. Talebzadeh et al. [3], for instance, found that music elicited a significantly lower chance of a positive response among nursing home residents with dementia, attributing this partly to the residents' unfamiliarity with the specific musical excerpt used. Expert feedback offered further insight into the augmentation sounds' perceptual role. These sounds were intended to mask the dominant human-based sounds in the original recording, but experts reported that human voice remained highly prominent. Moreover, despite calibrating all augmentation conditions to the same overall sound level, they were not perceived as equally prominent, suggesting that masking effectiveness depends on spectral overlap with voice frequencies rather than overall level alone. A spectrogram analysis identifying the frequency bands occupied by human voice would have allowed each augmentation sound to be calibrated accordingly, and should be incorporated in future applications of this method. An important finding is that none of the intervention scenarios reached positive Pleasantness values. Even the most successful augmentations shifted the soundscape only to the neutral region of the circumplex. This indicates that sound augmentation can improve the perceived quality of a busy hospital waiting area, but may not be sufficient on its own to create a genuinely pleasant acoustic environment. It may instead need to be combined with broader architectural or environmental design interventions. The study also highlights the value of the validated Turkish 79-item soundscape attribute set. Previous intervention studies have mainly interpreted results using the eight ISO affective attributes or the two circumplex dimensions; the broader Turkish attribute framework allows more detailed changes in perception to be identified and compared across different intervention strategies.

5. Conclusion

This study investigated the effect of acoustic treatment and three sound augmentation strategies on the perceived soundscape of a hospital outpatient waiting area using the validated Turkish soundscape framework. All intervention scenarios improved Pleasantness compared with the original condition, with bird and water sounds producing the greatest improvement. However, none of the interventions shifted the soundscape into the positive Pleasantness region, suggesting that sound augmentation alone may not be sufficient to create a genuinely pleasant hospital soundscape.

The present study provides an initial expert-based evaluation of sound augmentation strategies for hospital outpatient waiting areas. While the findings should be interpreted as exploratory due to the small number of expert participants (n = 5), they demonstrate the applicability of the validated Turkish soundscape framework for assessing healthcare soundscape interventions. Future studies should include larger and more diverse participant groups, enabling more comprehensive statistical analyses, such as principal component analysis, and investigate alternative augmentation parameters, including different sound samples, relative sound levels, and signal-to-background ratios. This will help inform the design and evaluation of soundscape interventions for hospital waiting areas.

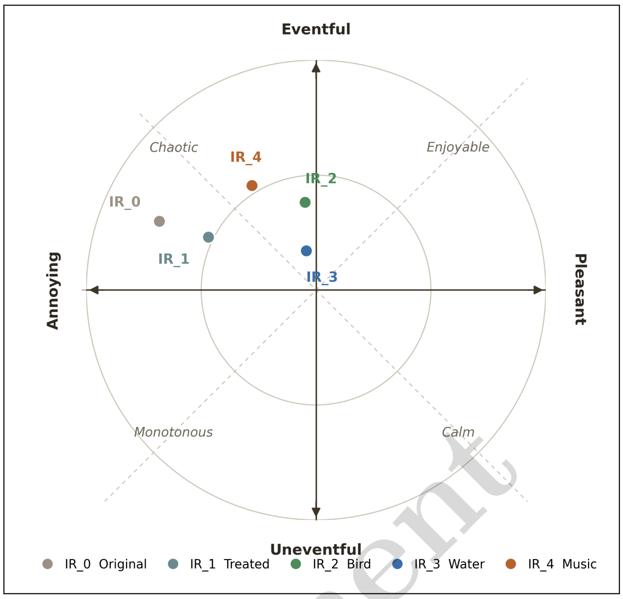

Figure 2: Loading-weighted Pleasantness–Eventfulness positions of the five listening scenarios.

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