Scientific Research Publishing

Open Journal of Social Sciences, 2025, 13(12), 306-311
https://www.scirp.org/journal/jss
ISSN Online: 2327-5960
ISSN Print: 2327-5952

Differences in the Effects of Natural and Environmental Sounds on Cognitive Functions

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How to cite this paper: Matsuo, M., Kadohata, K., & Higuchi, T. (2025). Differences in the Effects of Natural and Environmental Sounds on Cognitive Functions. *Open Journal of Social Sciences, 13,* 306-311.
https://doi.org/10.4236/jss.2025.1312023

Received: November 25, 2025
Accepted: December 22, 2025
Published: December 25, 2025

Abstract

The sounds that people often hear in their daily lives are called "soundscapes." Soundscapes are defined as a collection of biological sounds (e.g., bird calls), geophysical sounds (e.g., wind and rain), artificial sounds (e.g., road and air traffic noise), and sounds perceived in the environment as music. These sounds have a considerable effect on humans. However, little is known about the differences in the effects of natural sounds and environmental sounds on cognitive function. Therefore, this study aimed to examine the effects of natural and environmental sounds on concentration skills. Twenty-two healthy young adults were enrolled in this study. Participants were asked to execute a cancellation test as a concentration task under three conditions: no sound, natural sounds, and environmental sounds. The number of correct answers and completed lines of the task were evaluated, and a one-way analysis of variance was performed to compare concentration performance between conditions. Statistical analysis revealed no significant differences between the conditions in terms of either the number of completed lines or the rate of correct answers. Healthy young adults are less susceptible to the influence of soundscapes on their concentration. Furthermore, it was inferred that concentration performance may change depending on factors such as task sensitivity, duration of exposure, and sound pressure.

Keywords

Soundscape, Environmental Sounds, Natural Sounds, Concentration, Cognitive Function

1. Introduction

Various sounds (e.g., running cars, flowing rivers, and chirping birds) are heard daily. The sounds that people often hear in their daily lives are called "sound-

scapes." Soundscapes are defined as a collection of biological sounds (e.g., bird calls), geophysical sounds (e.g., wind and rain), artificial sounds (e.g., road and air traffic noise), and sounds perceived in the environment as music (Pijanowski et al., 2011). Broadly, biological and geophysical sounds are termed "NS," and artificial sounds are termed "environmental sounds (ES)."

A review article showed that NS can decrease stress and annoyance and improve health. Positive affective outcomes include decreased pain, reduced stress, improved mood, and enhanced cognitive performance (Buxton et al., 2021). Music therapy has also been confirmed to significantly improve the quality of life of patients with dementia compared to non-music therapy (Lin et al., 2023). In contrast, a randomized controlled trial (RCT) investigating the use of music with and without lyrics as background music revealed that music with lyrics had negative effects on attention and concentration (Shih et al., 2012). Health risks from excessive ES exposure can affect the cardiovascular system, metabolism, blood pressure, body weight, cognition, sleep, mental health, quality of life, and overall well-being (Zaman et al., 2022).

Sound has a considerable effect on humans, as suggested by previous studies. However, little is known about the effects of nature and ES on cognitive function. Therefore, this study aimed to examine the effects of nature and ES on concentration skills.

2. Materials and Methods

2.1. Participants

Twenty-two healthy young adults (11 women and 11 men; age: 21.0 ± 0.90 years) were enrolled in this study. All participants received a comprehensive explanation of the study's safety protocols and were assured that their personal information would remain confidential. Subsequently, they provided written informed consent to participate in the study. Additional informed consent was obtained from all the participants whose identifiable information was included in the study. None of the participants had any major physical disorders, including neurological illnesses, brain injuries, or psychiatric disorders. This study was approved by the Ethics Committee of Nishikyushu University (approval no. 24TMV35) and conformed to the principles of the Declaration of Helsinki (World Medical Association, 2024) and its subsequent amendments.

2.2. Experimental Protocol

Participants were seated in a quiet room on a chair with a backrest. Participants were asked to wear earphones and complete the tasks under three conditions: no sound (no-S, 0 dB), NS (50 dB, e.g., birdsong, flowing water), and ES (70 dB, e.g., traffic noise, office chatter), so that they could hear a sound volume similar to actual NS and ES. This study used the cancellation test of the Clinical Assessment for Attention (CAT) by the Japan Society for Higher Brain Dysfunction (**Figure 1**). The participants were instructed to eliminate the target shapes, numbers, or letters from the interfering stimulus as quickly as possible without continuously

overlooking them for 15 min. A rest period of 1 min was provided between conditions, and the condition order was counterbalanced.

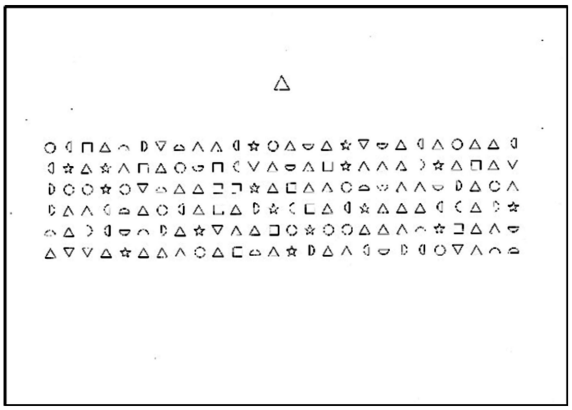

Figure 1. Image of the cancellation test.

2.3. Data Analysis

The numbers of correct answers and completed lines on the task were evaluated. The percentage of correct answers was calculated as follows: Number of correct answers/Number of targets × 100.

2.4. Statistical Analysis

A one-way analysis of variance (ANOVA) was performed to compare the concentration performance between conditions using IBM SPSS Statistics (version 29.0; IBM Corp., NY, USA), with a statistical significance level of $P < 0.05$.

3. Results

Figure 2 and Figure 3 show the average numbers of correct answers and completed lines for each condition (no-N, NS, and ES). Statistical analysis revealed no significant differences between the conditions in terms of either the number of completed lines or the rate of correct answers.

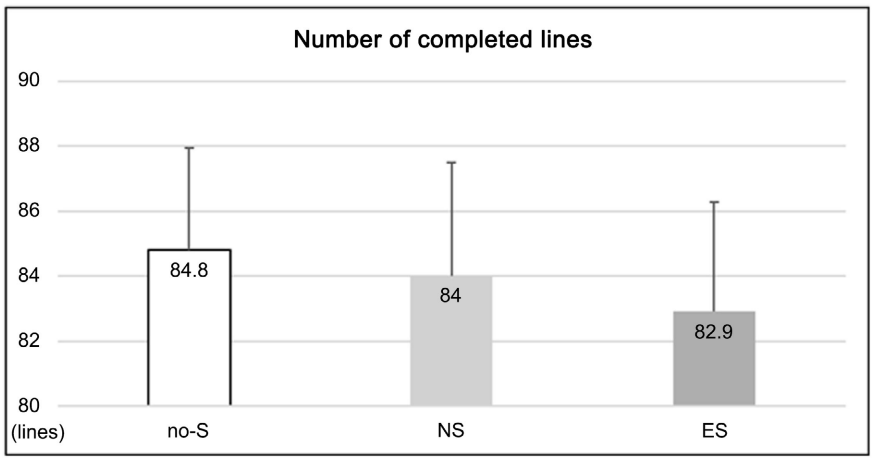

Figure 2. Result of the number of completed lines.

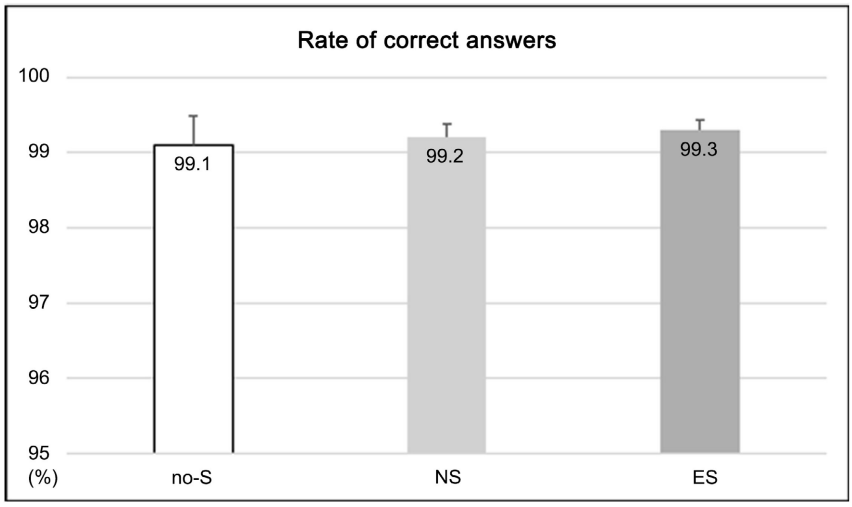

Figure 3. Result of the rate of correct answers.

4. Discussion

Three sound sources were used to examine each sound effect on cognitive function. An experiment was conducted based on the hypothesis that NS has a positive effect on concentration performance, whereas ES has a negative effect. However, this study's results did not confirm any significant differences in concentration performance between the conditions. Previous studies have reported that NS improves attentional function (Van Hedger et al., 2019), whereas others have reported that short-term exposure to NS or ES does not affect cognitive function (Emfield & Neider, 2014). These studies have shown that the psychological recovery (reduced stress and increased favorability) caused by NS is relatively consistent; however, it has been pointed out that the improvement in cognitive performance is likely to depend on the type of task, timing of measurement, exposure time, physical properties (e.g., sound pressure), and subject attributes.

First, all participants in this study were young, healthy adults; therefore, it could be thought that even if there were some differences in concentration due to the sound, the effects were unlikely to manifest as a large difference in performance. Previous meta-analyses of sustained attention tasks have also indicated that the accuracy of younger people is less likely to differ across studies (Vallesi et al., 2021). Therefore, the cancellation task used in this study required sustained attention, which may explain why no differences were observed in the effects of sound in the young healthy group.

Second, previous studies reported that NS significantly reduces stress and improves mood; however, its effect on cognitive task performance is small and inconsistent (Buxton et al., 2021). Furthermore, ES negative effects are generally medium to small, depending on the type of task and volume of noise (Thompson et al., 2022). Therefore, it can also be interpreted that NS and ES have little effect on concentration.

Third, the cancellation task performance had accuracy rates above 99% for all conditions. Therefore, the task may have been too simple for the participant

group, and the task's ease potentially masked the subtle performance differences between the soundscapes.

This study has some limitations. First, the study focused solely on healthy young adults. Therefore, it is unclear whether the results can be generalized to older patients. Second, the concentration task was limited to the CAT cancellation test; therefore, it remains unclear whether other task results are comparable to those observed in this study. Third, the earphones used in the experiment did not exhibit noise-canceling features. Therefore, it is possible that noise from the air conditioner operating in the room or the exhaust vent was mixed with the noise. Fourth, the music preferred by participants may have influenced their ability to concentrate. To address these limitations, future studies should conduct various concentration tasks at different difficulty levels and under different conditions to control the experimental environment.

In conclusion, this study compared the concentration performance during short periods of no-S and NS conditions, but found no significant differences. Healthy young adults are less susceptible to the influence of soundscapes on concentration. Furthermore, it was inferred that concentration performance may change depending on factors such as task sensitivity, duration of exposure, and sound pressure. Although further research is needed for a deeper discussion, sound effects may be different with participants' age or sound preferences; this may affect work or study performance; therefore, clarifying the effects of sounds on cognitive functions is important.

Acknowledgements

We extend our gratitude to all study participants.

Author Contributions

MM and KK: Conceptualization, methodology, investigation, resources, data curation, visualization, supervision, project administration (original draft preparation), and writing (review and editing). TH: Validation, formal analysis, editing, and review. All the authors have read and agreed to the published version of the manuscript.

Ethical Approval

This study was approved by the Ethics Committee of Nishikyushu University (approval No. 24TMV35).

Data Availability Statement

The datasets generated and analyzed in the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

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