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Effects of the visual landscape factors of an ecological waterscape on acoustic comfort

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ABSTRACT

In an ecological waterscape, acoustic comfort is an important element of the landscape experience; however, there is still a lack of study on the relationships between sounds and landscape factors. In this study, the acoustic comfort influenced by three visual landscape factors was examined based on audiovisual experiments. The results indicate that although landscape factors can influence the acoustic comforts of 11 types of sounds in different ways, the audiovisual matching contexts resulting in higher acoustic comforts are presented regularly. The analysis of the effect of landscape objects suggests that the acoustic comforts of the sounds relating to people's participation are increased by artificial landscape objects compared with those under the effect of natural landscape objects, whereas natural landscape objects closely match natural sounds, as well as the sounds with music-related and melodic characteristics. In terms of the effect of the distance to water edge, the acoustic comfort score (based on a five-point scale) of children frolic is higher with a closer view of a waterscape, by 1.06, compared to that with a distant view, whereas the distant view continuously increases the evaluation scores of road traffic sound by 0.50 per 10 dBA at 30–50 dBA compared to those with the closer view. In terms of the effect of the appearance of animals and humans, the coherence between audio and visual environment is: with the appearance of animals, the evaluations of natural sounds are higher compared to those without, whereas with the appearance of humans, the evaluations of the sounds relating to people's participation are higher compared to those without.

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1. Introduction

In recent years, the number of landscape projects aiming to create a natural and wild environment has been increasing considerably. In particular, an ecological waterscape referring to wetland landscape is designed most commonly. Such ecological waterscapes are regarded as the core ecological patches or the buffer ecological patches of natural or semi-natural landscape characteristics, or a landscape simulation of wetland in city parks [1,2]. Although the landscape consists of natural features, such as vegetation, water and geological features, which contribute to the visual sense of tranquillity, the consideration of audio perception during design is considerably more limited, despite influencing the landscape experience [3–5].

The sounds were found to be in high correlation with people's landscape preferences, particularly the absence or presence of wanted and unwanted sounds, rather than acoustic features, e.g., A-weighted equivalent continuous sound level [6,7]. Previous studies suggested that in a soundscape, natural sounds were often desired, whereas traffic noise and the sound of people's voices were undesired [8–10]. For example, hearing breeze and fountain sounds would significantly increase acoustic comfort, which added to the quality of the soundscape, but the mere presence of traffic sound, even at levels below the background sound level, had a negative effect on acoustic perception; moreover, in quiet areas, people may still be sensitive to road traffic sounds, even though the levels are probably considerably lower than those at roadside sites [11,12].

Except for sounds only, the auditory judgment can also be influenced by the visual setting [13–15]. Previous audiovisual studies indicated that attention to visual form reduced the conscious perception of sound when audio and visual settings were coupled, and the correlations between the appreciation of the landscape and the acoustic environment were different [16–18]. More specifically, Iachini et al. [19] found that visual metro context can decrease the effect of noise on people, causing less annoyance than listening to metro sounds only. On the contrary, Zhang et al. [20] found that in similar acoustic environments, the probability for the individual

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to be annoyed is higher if the noise source could be seen than if it could not. The annoyance of road traffic sound was also found to be decreased and the perception of a positive soundscape increased in the attractive landscape when with a low sound level (43 dB), whereas this effect diminished and the soundscape was instead perceived as more stressing in the attractive than in the unattractive landscape when noise levels increased to 55 dB [21]. Hunter et al. [22], using visual stimulation of beach and freeway images, found that visual context can modulate the connectivity of the auditory cortex with regions implicated in the generation of subjective states. This finding is an explanation for the audiovisual interaction, in which different visual landscape reflecting varying connectivity modulated the audio perception. Further, Jeon et al. [23] performed laboratory experiments with sounds and visual images of a number of water features collected and determined that the soundscape was affected by the acoustical characteristics of the water sounds and the visual images of the water features.

While some useful conclusions have been made regarding audiovisual environment, as mentioned above, there is still a need to consider more types of sounds, as well as visual features. For an ecological waterscape, a key element in landscape, there is still a lack of systematic study on the relationships between acoustic comfort and landscape factors to present audiovisual interactions. Such a study would provide more evidence for the connectivity modulation theory and is also of significance for landscape design and noise management.

The aim of this study is therefore to examine the auditory perceptions of a series of sounds under the effects of landscape factors of ecological waterscape. An experimental study was performed with carefully selected ecological waterscape images, considering the visual factors of the landscape objects, the distance to the water edge, and the appearance of humans and animals. The auditory perceptions include the evaluations of acoustic comfort of human activity sounds, natural sounds and signal sounds.

2. Methodology

2.1. Images

The ecological waterscape images were collected in three natural parks in Harbin, namely, JinHe Bay Ecological Wetland Park, which is a tourist area for ecological wetland landscape and also a demonstration zone for water ecology protection and restoration; Hulan River Wetland Park, which is an ecosystem conservation base of animals and plants; and a wetland park belonging to the Forest Botanical Garden of Heilongjiang Province.

The images were taken from 9:30 to 10:30 on clear days, at the eye height of approximately 1.5 m above ground with typical angles for landscape pictures while also avoiding telephoto shots [24]. To reproduce a more realistic visual environment, all images were taken in 3D format [25,26] using a Fuji DW1 3D camera.

The selection of the images used in the experiment was based on the consideration of the typical landscape factors of ecological waterscapes. According to previous studies, key factors for such landscapes include water, revetment, span structure, distant view, human activities, animal activities, and variable factors (e.g., season, climate, and time of day). As this study focuses on an ecological water body with a natural revetment, and only summer conditions are considered, three categorisations of factors were considered, namely landscape objects, distance to the water edge (i.e. distant or closer to the water edge) and appearance of animals and humans [27–30]. Therefore, the orthogonal sifting method with three factors and three levels was used to select typical landscape images. Table 1 presents the final nine ecological waterscape images selected with their corresponding factor levels; note that Image j is an additional image that has the same environment as Image a but with a closer distance to the water edge.

Further representative images for analysis in the categorisation of landscape factors are presented in Table 2, which take into account reduction of the interaction among landscape elements.

Table 1
Ecological waterscape images used in the experiment based on orthogonal sifting with three key factors (A, B, and C) and three levels (1, 2, and 3).

Waterscape images Image ID/factor levels				
 a/A3, B3, C3	 b/A3, B1, C3	 c/A3, B2, C3	 d/A1, B1, C1	 e/A1, B3, C2
 f/A2, B3, C1	 g/A2, B1, C2	 h/A1, B2, C1	 i/A2, B2, C2	 j/A3, B1, C2

A – landscape objects: A1 = Images d, e, and h, where the artificial landscape objects space occupied is higher than that in other images, defined as level 1, "artificial"; A2 = Images f, g, and i, balanced between man-made facilities and natural objects, defined as level 2; A3 = Images a, b, and c, provided with natural scene with natural landscape objects, which are defined as level 3, "natural".

B – distance to water edge: B1 = Images b, d, and g, with closer distance to water edge, defined as level 1, "closer view of waterscape"; B2 = Images c, h, and i, observed at the medium distance (between the distant and closer view), to water edge or waterside pavilion; B3 = Images a, e, and f, presented the farthest distance to water edge, defined as level 3, "distant view of waterscape".

C – appearance of animals and humans: C1 = Images d, f, and h, with humans but without animals appearance, defined as level 1, "only humans appearance"; C2 = Images e, g, and i, mixed with or without animals and humans factors, defined as level 2; C3 = Images a, b, and c, with animals (birds marked in the circles) but without humans appearance, defined as level 3, "only animals appearance".

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