Perceived preference of soundscape in a Bamboo Park based on the laws of psychophysics

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Abstract. The purpose of this study was to explore the relationship between the physical and the psychological quantity of soundscape preference in the bamboo park. Through semantic difference method, the preference of different soundscape elements in the bamboo park was evaluated, and the physical index in the observation sites was measured at the same time. Finally, after the subjective and objective data fitted by the law of psychophysics, a model for evaluating the soundscape preference in the bamboo park was established. The results show that the trend of subjective and objective data fitting for each soundscape element conforms to the law of psychophysics. Among them, geophony and biophony tend to Fechner's Law and anthorphony to Stevens' Power Law.

1. Introduction

As a semi-open space with a good ecological environment, the bamboo park is often allocated in forest parks or other urban parks to provide places where citizens can relieve pressure with various functions such as recreation, recuperation and so on. As an important component of the bamboo park, soundscape affects the user's auditory experience. In the study of soundscape, Aylor [1] studies the sound of pine leaves, which proves that the sound of leaves can improve the signal in animal communication. Blesser et al. [2] studies the psychological factors and temporal and spatial factors of the related soundscape evaluation, and considers that space can make the citizens have the corresponding behavioral consciousness corresponding to the emotion of soundscape. Southworth [3] studies the correlation of soundscape evaluation factors, and concludes that the basic elements of sound scene evaluation consist of semantic and physical properties of soundscape. Through exploration, scholars have enriched the study of soundscape, but few reports have been made on how to construct the soundscape preference evaluation model based on the psychophysics.

In this study, the soundscape in a bamboo park was taken as the main research object, the preference of three soundscape elements (geophony, biophony and anthrophony) was evaluated subjectively, the objective physical indexes of the measuring points were measured at the same time, and the evaluation data were fitted according to the law of psychophysics. Finally, the evaluation model of soundscape preference of bamboo parks was established.

2. Method

2.1. Law of psychophysics

By using a logarithmic function, the psychological physicist Fechner connected the physical stimulus *I* with the psychosensory *s*, and establishes the conversion relationship between the psychological sensation scale and the physical stimulus intensity scale based on Weber's law. That is, Fechner's Law [4]:

$$s(I) = \int ds = k' \int \frac{dI}{I + I_0} = a + b\log(I + I_0), \tag{1}$$

Where *a* and *b* are constants.

Stevens studies the relationship between the intensity of different physical stimuli and psychological perception by means of amplitude estimation, and proposed a functional expression of psychological perception based on power function, which is different from Fechner's law. Stevens' Power Law [5]:

$$s(I) = aI^{p} + b, \tag{2}$$

Where *a* and *b* are constants, *p* is an index determined by the type of sensation and the amount of stimulus.

2.2. Study area

Bamboo garden is a special type garden in Fuzhou National Forest Park with an area of 1.5 hectares. There are about 215 species of bamboo in Fuzhou National Forest Park, mainly including *Bambusachungii*, *Bambusa vulgaris*, *Bambusaalbo-lineata*, *Phyllostachysbambusoides*, *Phyllostachysnigra*, *Bambusaventricosa* etc.

2.3. Experimental process

In this study, the ‘like to dislike’ pair of adjectives were chosen as the questionnaire contents to measure the degree of preference to a certain soundscape. On this basis, it is determined that the subjective evaluation grade is five, and it is used to distinguish between strongly like, lightly like, general, lightly dislike, strongly dislike and from left to right to assign a value of 2, 1, 0, -1, -2, respectively.

Thirty measuring points with representative and relatively uniform distribution were selected in the study area of bamboo garden. 18 trained evaluators were asked to carry out subjective evaluation of 5 min independent soundscape preference at each test point, and 5 min L_{Aeq} test was performed by using sound level meter.

3. Results

The maximum value of the total score of the sound scene preference evaluation obtained from the experiment is normalized. The Fechner's Law formula (1) and Stevens' Power Law formula (2) are used to fit the normalized value of the total score of soundscape preference evaluation and the L_{Aeq}.

The data from the preference evaluation of geophony was fitted. The results show that the coefficient of fitness R^2 of formula (1) is 0.903, and that of formula (2) is 0.882. The result of preference evaluation of geophony conforms to the above laws of psychophysics, and is more inclined to Fechner's Law. The relationship between the degree of preference of geophony in the bamboo park and L_{Aeq} can be expressed as follows:

$$s_{geo}(I) = 0.64\log(I - 25.12) - 0.04, \tag{3}$$

Based on the data from the preference evaluation of biophony , the results show that the coefficient of fitness R^2 of formula (1) is 0.911, and that of formula (2) is 0.854. The result of preference evaluation of biophony conforms to the above laws of psychophysics, and is more inclined to Fechner's Law. The relationship between the degree of preference of biophony in the bamboo park and L_{Aeq} can be expressed as follows:

$$s_{bio}(I) = -1.04\log(I - 25.74) + 1.54, \tag{4}$$

The data from the preference evaluation of anthrophony was fitted. The results show that the coefficient of fitness R^2 of formula (1) is 0.952, and that of formula (2) is 0.981. The result of preference evaluation of anthrophony conforms to the above laws of psychophysics, and is more inclined to Stevens' Power Law. The relationship between the degree of preference of anthrophony in the bamboo park and L_{Aeq} can be expressed as follows:

$$s_{ant}(I) = -1.92 \times 10^{-6} I^{3.24} + 0.02, \tag{5}$$

In the practical application, L_{Aeq} in the bamboo forest space can be transformed into the corresponding subjective evaluation score of the soundscape preference degree by the evaluation model, and then the psychological feeling state of the tourists can be simulated at this time. These models provide a reference for the construction and optimization of the spatial environment of bamboo parks.

4. Conclusion

As an important forest type, the soundscape in bamboo parks plays an important role in relaxing people's body and mind, pleasant mood and relieving stress. The model of bamboo forest soundscape preference was established, and the geophony which affected the soundscape preference evaluation was analyzed. The preference relationship between biophony and anthrophony. The main conclusions are as follows: the tendency of fitting the preference of geophony, biophony and anthrophony conforms to the laws of psychophysics, in which the geophony and biophony are relatively inclined to Fechner's Law. In addition, the anthorphony tends to Stevens' Power Law.

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