Environmental Impact Assessment Review 70 (2018) 45–56

Contents lists available at ScienceDirect

Environmental Impact Assessment Review

journal homepage: www.elsevier.com/locate/eiar

Effects of soundscape on rural landscape evaluations

Xinxin Ren[a], Jian Kang[b,*], Peisheng Zhu[a,**], Shiyuan Wang[a]

[a] School of Architecture, Dalian University of Technology, Dalian 116024, PR China
[b] School of Architecture, University of Sheffield, Sheffield S10 2TN, United Kingdom

1. Introduction

In recent years, the number of people visiting their local countryside has been increasing. One of the major reasons is that the rural soundscape is considered a more restorative and tranquil environment, providing relief from cognitive overload and reducing the stress of everyday life, as man-made noise is at a low level, while the dominance of natural sounds promotes the rural landscape's sense of tranquility (Lam et al., 2010; Pheasant et al., 2010; Watts and Pheasant, 2013; Watts and Pheasant, 2015a; Watts and Pheasant, 2015b; Filipan et al., 2017). Aside from tranquility, most previous studies on rural areas have focused on visual aspects, without considering non-visual cues (Arriaza et al., 2004). The assessment has been carried out with respect to certain assumptions or design criteria that are relevant to visual landscape quality. Some perception-based studies found that vegetation, water, well-preserved man-made elements, and traditional, rather than more uniform, modern farming landscapes have been found to improve the aesthetic assessments of rural landscapes considerably (Vos and Meekes, 1999; Dramstad et al., 2006; Howley, 2011). Within rural settlements, traditional architecture (Kalivoda et al., 2010) and family houses (Sullivan, 1994) are appreciated. Moreover, certain landscape elements, such as the presence of woodlots, plants, water, and mountains are found to be preferred, while abandoned farmlands and landscapes crossed by rural roads produce negative perceptions (Arriaza et al., 2004; Benjamin et al., 2007; Howley, 2011). Lower preference is also given to the landscapes with wires, automobiles, and other disturbing elements (Stamps, 1994).

The existing studies indicate that the rural soundscape is not statistically related to common acoustical and psychoacoustical metrics, but has higher correlations with the absence or presence of wanted and unwanted sounds (Lam et al., 2010). Along the urban–rural gradient, landscape preference is affected much more by soundscape perception than visual landscape perception (Gan et al., 2013). During the evaluation of rural landscapes, the visual attention areas were significantly influenced by the soundscape from those without sound stimuli (Ren and Kang, 2015a). However, few previous studies have investigated auditory perception in the environmental assessment of rural areas.

In the above studies, the evaluations of rural landscapes can be approached in different ways, using evaluation indexes including the visual aesthetic quality (VAQ), landscape tranquility, or landscape preference. While the importance of the effects of different soundscapes on the evaluation of rural landscapes has been suggested and incorporating the valuable perspectives that have evolved in environmental assessment directly into the project design has been encouraged (Botteldooren et al., 2006; Brown and McDonald, 1995; Wang and Bao, 2007; Lee et al., 2014; Oberman et al., 2016), there is still a lack of systematic studies in this respect.

The aim of this study is, therefore, to examine in greater depth the effects of soundscapes on rural landscape evaluations in terms of landscape VAQ, landscape tranquility, and landscape preference indicators. This study also aims to identify the specific contribution of a soundscape to the rural landscape with different landscape characteristics for effective environmental assessment, soundscape conservation, and landscape design. The research was conducted using both audio-visual experiments and eye-tracking tests based on landscape field images and sounds collected from typical villages in China. A range of rural landscape types are considered, including distant views, farmlands, waterscapes, roads, and family houses.

2. Methodology

2.1. Study area

Traditional villages in China were chosen as the study area for field surveys in terms of visualization and auralization, covering typical villages in Heilongjiang, Jilin, and Liaoning provinces, located in the northeast plain, the largest of China's plains, between the greater and lesser Hinggan ranges and the Changbai ranges. The study was not intended to examine the rural landscapes of specific sites; rather, typical actual rural areas centered by human settlements are used, with natural landscapes as a background (Wang and Liu, 2003). The villages are rather dispersed in this area, and the rural landscapes in the villages contain elements of irregular farmlands, waters, and mountains. The rural family houses are usually distant from the courtyards, and some are surrounded by farmlands (Wang and Liu, 2003; Wang, 2003; Shen, 2010).

* Corresponding author.
** Corresponding author at: School of Architecture & Fine Art, Dalian University of Technology, Dalian 116024, PR China.
E-mail addresses: Renxinxin@dlut.edu.cn (X. Ren), j.kang@sheffield.ac.uk (J. Kang), jz-acoustics@dlut.edu.cn (P. Zhu).

https://doi.org/10.1016/j.eiar.2018.03.003
Received 29 May 2017; Received in revised form 22 February 2018; Accepted 17 March 2018

In this study, rural landscapes including natural and man-made elements were considered. The selection is based on three aspects: typical types of rural landscape (Xie et al., 2003; Xie, 2004), landscape visual attributes, such as openness (Strumse, 1994), naturalness (Ode et al., 2009), and possession of traditional architecture (Kalivoda et al., 2010) and rural characteristics. Consequently, five landscape types were considered: distant views, farmlands, waterscapes, roads, and family houses.

2.2. Images

Perception-based evaluation studies, to a large extent, have used landscape photographs as valid landscape surrogates for actual landscape judgments (Shuttleworth, 1980; Kaltenborn and Bjerke, 2002), although it could be argued that photographs, as a mechanism to ascertain visual preferences, limit generalizability into real-world settings. Nevertheless, a variety of studies have pointed out that carefully selecting landscape scenes for evaluation by the general public yields valid and reliable results, which are also widely used for rural landscape evaluation (Arriaza et al., 2004; Benjamin et al., 2007; Ramírez et al., 2011; Howley, 2011; Yao et al., 2012; Watts and Pheasant, 2013; Cloquell-Ballester et al., 2012; Jiang et al., 2015). To reproduce a more realistic visual landscape, in this study, the photographs were taken in a 3D format (Lindquist et al., 2016) using a Fuji 3D W3 camera. These stereoscopic images were taken at eye-level, at a height of approximately 1.5 m above the ground, with typical angles and panoramic color for landscape photographs (Rogge et al., 2007; Pheasant et al., 2010). To reduce seasonality bias, all of the images were taken in approximately the same season, in the late spring and summer, and on clear days to control for lighting conditions and avoid telephoto shots (Buhyoff and Wellman, 1979; Natori and Chenoweth, 2008).

There are many indicators of landscape visual character (Ode et al., 2009), in which the percentage of natural or contextual features in the scene was found to be of significance for the evaluations of the landscape VAQ, tranquility, and preference (Arriaza et al., 2004; Watts and Pheasant, 2013; Rogge et al., 2007; Ramírez et al., 2011; Yao et al., 2012). For this reason, five images of each landscape type were selected and ordered according to the coverage of contextual features, including natural or artificial elements in the landscape, as shown in Table 1. This was done to eliminate the effects of the proximity of attributes on the evaluation, and to ensure the diversity of scenes in each landscape type.

2.3. Sound signals

During field surveys in villages, a series of typical sounds heard frequently were recorded, with two types of sound for each landscape type, one natural or musical, and the other artificial. According to previous studies (Murphy et al., 2009; Lam et al., 2010; Ren et al., 2015), these were possibly wanted and unwanted sounds, respectively. The recorded sounds included birdsong (A) and highway traffic sounds (B) for the distant view, crickets chirping (C) and tractor sounds (D) for farmlands, water flowing (E) and hawker selling sounds (F) for waterscapes, music (G) and road traffic sounds (H) for roads, and rooster crowing (I) and house repair sounds (J) for family houses.

The sound recordings were made using a FOSTEX FR-2LE high-fidelity audio recorder. The highway traffic and country road traffic sounds were recorded 1 m away from the road edge, 1.5 m away from the ground, and > 3.5 m away from any other reflectors with wind speeds was < 5 m/s (GB 3096-2008, 2008). The other sounds were made at positions close to the sound sources, with no other sounds interfering. The ten recorded sounds (A–J) were edited as ten sound signals, respectively, and were all adjusted to 50 dBA. The sound level was selected for the audio data for two reasons: (1) with a lower noise level, the mean SPL of the field measurements in relatively quiet rural environments was approximately at this level, with the sound identifiable, and (2) this study was focused on the types of sound, rather than the sound level (Hong and Jeon, 2013; Hao et al., 2016), and an acceptable and identical level can make the sound sources comparable.

2.4. Subjects and experimental settings

Previous studies (Weinstein, 1978; Taylor, 1984; Ma, 2004; Yang and Kang, 2005; Lavia et al., 2016) suggested that there are no significant differences in the subjective evaluation of sound levels among different age groups, while the audio sensitivity of adults could decrease gradually with the increase of age. Therefore, young people with high auditory sensitivity were selected as the subjects for the evaluation experiments. The subjects (urban dwellers) were randomly sampled students from Harbin, including ten males and ten females. A sample size of 20 was used according to acoustic experiments (Kang, 2004; Hong and Jeon, 2013), visual landscape evaluation (Daniel, 2001; Cloquell-Ballester et al., 2012), and eye tracking tests (Dupont et al., 2014; Hessels et al., 2016; Ren and Kang, 2015b).

The experiments were conducted in a virtual reality laboratory. For the visual-only evaluation, polarized 3D glasses and 3D display were used. The effects of the 3D images were adjusted using Stereo Photo Maker software. For the audiovisual experience, Sennheiser RS 170 headphones and Tobii T60XL were used. The sound signals were calibrated using a dummy head and 01 dB software, and were edited using Cooledit software.

2.5. Evaluation indicators

For the landscape VAQ evaluation, “ugly” and “beautiful” were thought to be the primary and prototypical descriptive dimensions used to address the aesthetics, and were expected to be influenced by the subjects. In this study, two terms, leading to a judgment within the basic categories of artistic aesthetics, were chosen to represent the two ends of a VAQ evaluation, and they were thus expressed on a seven-point Likert scale (Stich, 2005; Jacobsen et al., 2004; Val et al., 2006; Kalivoda et al., 2010), valued from −3 to +3, encompassing extreme values of “very ugly” and “very beautiful”, namely: −3, very ugly; −2, ugly; −1, somewhat ugly; 0, neither ugly nor beautiful; +1, somewhat beautiful; +2, beautiful; and + 3, very beautiful. Correspondingly, landscape tranquility evaluation was also carried out with a seven-point scale from −3 to +3 (Mace et al., 2012; Watts and Pheasant, 2015a; Watts and Pheasant, 2015b). In terms of landscape preference, corresponding to previous studies (Rogge et al., 2007; Natori and Chenoweth, 2008; Soini et al., 2012; Meng et al., 2017), a five-point Likert scale was used to clarify judgments, with descriptions of “like” and “dislike”: 1, really dislike; 2, dislike; 3, neither like nor dislike; 4, like; and 5, really like. The evaluation indicators in the questionnaire and the instruction were all administered in the subjects' familiar language, Chinese, to speed up the processing of audiovisual perception (Navarra et al., 2010).

2.6. Experimental procedure

In the experiment, the landscape evaluations were recorded according to the audiovisual clips. In previous studies, 30–32-s durations were used for audio only, video only, and combined audiovisual data, and 16 s were used for the remaining stationary clips (Pheasant et al., 2010; Watts and Pheasant, 2015a; Watts and Pheasant, 2015b); the short 8-s duration for sounds tended to repeat, and a 6-s duration for single sounds was also used (Bradley and Lang, 2000; Hall et al., 2013). In this study, the visual images were stationary scenes, and the audio signals were all dominantly single sounds, which were easy to identify. Hence, each clip was relatively short, edited to a duration of 10 s.

The experiments consisted of two parts, as given in Table 2. The first was the visual-only condition. The subjects were instructed to imagine being present in the landscapes shown by the 3D screen and were asked to observe the 25 3D images (as shown in Table 1) in a random order, at