Science of the Total Environment 408 (2010) 4368–4375

Contents lists available at ScienceDirect

Science of the Total Environment

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

The influence of preconceptions on perceived sound reduction by environmental noise barriers

Jennifer L.R. Joynt [a,*], Jian Kang [b]

[a] University of the West of England (UWE), Bristol, BS16 9QY, United Kingdom
[b] School of Architecture, Western Bank, University of Sheffield, S10 2TN, United Kingdom

ARTICLE INFO

Article history:
Received 20 January 2010
Received in revised form 1 April 2010
Accepted 13 April 2010
Available online 21 May 2010

Keywords:
Noise barriers
Intersensory
Perception
Materials
Acoustics
Environment

ABSTRACT

The paper presents research that answers three main questions: (1) Do preconceptions held about the constituent materials of an environmental noise barrier affect how people perceive the barrier will perform at attenuating noise? (2) Does aesthetic preference influence the perception of how a barrier will perform? (3) Are barriers, which are deemed more aesthetically pleasing, more likely to be perceived as better noise attenuators? In a virtual reality setting with film to improve the contextual realism of the intersensory interaction test, participants were required to compare the perceived effectiveness of five standard 'in-situ' noise barriers, including concrete, timber, metal, transparent acrylic and a vegetative screen. The audio stimulus was held at a constant sound pressure level (SPL), whilst the visual stimulus changed, as the influential factor. As the noise levels projected during the study were held constant, it was possible to attribute the participants' perception of noise attenuation by the barriers, to preconceptions of how the varying barrier material would attenuate noise. There was also an inverse correlation between aesthetics and perception of how a noise barrier would perform. The transparent and deciduous vegetation barriers, judged most aesthetically pleasing, were judged as the least effective at attenuating noise.

1. Introduction

Changes in legislatively driven programs under the European Directive on the Assessment and Management of Environmental Noise (European Parliament, 2002) are likely to lead to an increase in the use of noise barriers as a means of mitigating road traffic noise.

This paper presents research that answers three main questions: (1) Do preconceptions held about the constituent materials of a noise barrier affect how people perceive the barrier will perform at attenuating noise? (2) Does aesthetic preference influence the perception of how a barrier will perform? (3) Are barriers, which are deemed more aesthetically pleasing, more likely to be perceived as better noise attenuators?

The basis of the research stemmed from an assertion found both in the literature and primary research (Joynt, 2005, Aylor and Marks, 1976, Watts et al., 1999, MD-Taha, 1999), that residents rarely, if ever, are given the 'before' and 'after' installation 'objective' values of noise attenuation levels by noise barriers. Consequently, their opinions are formed largely on a subjective perception.

This subjective perception has been found to be influenced by many factors beyond the actual objective noise reduction, one of which being the engagement in the design of the barriers by those to be affected by it prior to construction. This factor alone has been shown to radically alter the residents' perception of noise reduction (Cohn, 1981; Cohn and Bowlby, 1984; Hall, 1980; Joynt, 2005), and in some cases warrant the removal of the barrier altogether (Orsman, 2003). Equally according to Bailey and Grossardt (2006), 'subject to a minimum sound attenuation capacity, noise walls must present a pleasing visual aspect to their user communities including residents, commuters, and others'.

Additionally, research has found that noise barriers that instil a perception of increased risk of crime, through vandalism or potential concealment of criminals, are also evaluated as less effective (Perfater, 1979).

This is a particularly salient fact when decisions are made over the type of material a noise barrier is constructed from, as it would be logical to choose a material that both incites particular confidence of noise attenuation and reduces the perception of other non-auditory risks, such as perceived increase in crime and vandalism (Perfater, 1979).

The outcome of this research aims to indicate to what extent preconceptions held about varying materials used in noise barrier design impact on perceived noise reduction. The research design extends the number of barriers tested from that used in previous research to five standard noise barrier materials available in the UK.

* Corresponding author. Faculty of Environment and Technology, University of the West of England (UWE), Bristol, United Kingdom, BS16 9QY. Tel.: +44 117 32 83929; fax: +44 117 32 83002.
E-mail addresses: jennifer.joynt@uwe.ac.uk (J.L.R. Joynt), j.kang@sheffield.ac.uk (J. Kang).

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doi:10.1016/j.scitotenv.2010.04.020

The laboratory style test enabled a controlled assessment of the barriers in practice by a sample of randomly selected volunteers. The novel experimental approach, using film and audio projections aims to introduce a new method for illustrating a range of barrier designs and materials in practice, offering a new technique to be used to improve public engagement with communities during the design stage of a noise barrier's development. The research also aimed to determine whether auditory and visual intersensory interaction influenced the respondents' perception of noise attenuation by the noise barriers, which was assessed by keeping the audio stimulus at a constant sound pressure level (SPL), whilst the visual stimulus was changed.

Following the Introduction section, Section 2 reviews the existing literature and experimental approaches adopted by previous researchers. Section 3 sets out the methodology, which draws on previous research and incorporates the use of virtual reality techniques. Section 4 presents the findings, and answers the main research questions. Section 5 compares the findings with previous research. The final section reflects on the findings in the context of previous research and practical implications for barrier choice and use.

2. A review of previous intersensory research on noise barriers

The perception of noise and the complexities of intersensory interactions using many different experimental approaches have been widely reported in the literature of Psychology (Viollon et al., 2002; Watts and Nelson, 1992). Despite this, a common potential risk is that controlled experimental designs limit contextual realism and do not truly illustrate the impact of intersensory interactions.

Intersensory interaction occurs when experimental situations are designed to allow only one, or more than one, modality to receive information (such as eyes and/or ears). Warren et al. (1983) indicated that 'intersensory interaction has not occurred, if the addition of a second sensory modality does not change a perception. Often, however, the perception does change when information is available to a second modality, and in such a case it is claimed that intersensory interaction has taken place'.

Several authors have concentrated specifically on the perception of noise through environmental noise barriers, with the aim of determining the most appropriate design. Two of the earliest authors to undertake this were Aylor and Marks (1976), who devised an experiment using human observers to measure perceived loudness of noise as it was transmitted through outdoor barriers. This experiment used a selection of four noise barriers, positioned around the circumference of a circle, with a swivel chair for the respondent to sit in, in the centre. The experiment was under free-field conditions and used a sound source projected from speakers behind each of the barriers as a stimulus. The respondents recorded their perception of the noise reaching them, by allocating a value proportional to the perceived value and in association to the other noise incidences heard.

Aylor and Marks (1976) revealed that visual shielding by a barrier dramatically affected the perception of sound transmitted through the barrier, but the direction of this effect was not simply related to shielding. 'As long as the source of sound can be seen, reduced visibility of the source is accompanied by a reduction in apparent loudness' (Aylor and Marks, 1976, p.400). However, when the sight of the source was completely obscured by the barrier, this effect completely reversed, i.e. the apparent loudness increased.

Aylor and Marks (1976) discovered strong audio–visual interactions; however, visual information did not necessarily affect auditory judgement in a linear way. Aylor and Marks (1976) related this to a phenomenon uncovered by Kryter (1968, p. 293–297), where it was indicated that 'noises heard indoors are judged slightly more acceptable than noises heard outdoors, but not nearly as much as would be expected from the sound attenuation produced by a building'. Aylor and Marks believed that the effect of a solid barrier on perceived loudness might hinge on peoples' expectations of the barrier's effectiveness. They presented the phenomenon as an analogy between their findings and the 'size-weight illusion', whereby a pound of lead feels heavier than a pound of feathers' (Stevens and Rubin, 1970 cited in Aylor and Marks 1976). Thus, if this reasoning is comparable, then 'when a sound source is occluded visually, one expects its loudness to be diminished. Therefore, sounds coming from behind barriers appear surprisingly loud and hence is overestimated relative to sounds coming from open space' (Aylor and Marks, 1976, p.400).

Viollon (2003, p.1) offered the following conclusion in the context of an experiment to determine audio–visual interactions in an urban context: 'visual information were not neutral but indeed influenced the auditory impression: the more urban the visual setting, the more contaminated the auditory judgements and the more pleasant the noise barrier, the more beneficial the effect in auditory judgement of stress'. Viollon (2003) also revealed similar results when road traffic noises were used as an auditory stimulus projected from behind a wooded visual setting. The wooded visual setting did not exercise a positive influence on auditory judgement, and the explanation for this was that the auditory expectations were not fulfilled, and the sound of road traffic noise was a disappointment (Viollon, 2003, p.1). These assertions were highlighted in Joynt (2005, p.183) who reviewed a community's perception of a noise barrier's effectiveness following its installation adjacent to their properties. The review found that the community reportedly perceived little or no benefit from the noise barrier installation. Representatives of the Highways Agency, who were responsible for the barriers installation, attributed these perceptions to the high and unrealistic expectations of noise reduction held by the residents. Consequently, two factors emerged with regard to perceived noise reduction. The first one is that preconceptions and skewed perceptions of how different materials will attenuate noise, influence actual perceived noise attenuation. The second one is the importance of realistic expectations being instilled in those people the noise barrier is built to protect (Joynt, 2005, p.153).

Neither Viollon (2003) nor Aylor and Marks (1976) reported which noise barrier material impacted most upon the perceived noise attenuation. There has been some research in the field of auditory perception of barrier effectiveness by Watts et al. (1999), who tested the perception of noise reduction through a variety of screens both in-situ and under laboratory conditions. The screens used were a willow noise barrier, a metal noise barrier, a row of conifer trees and an open space. Different noise levels were played from behind the barriers throughout the course of the test. In the in-situ experiments, it was the density of vegetation that was varied, by taking the respondents to a range of roadside locations displaying varying traffic flows, and altering degrees of concealment of the road by vegetation. A limitation to this method is that the respondents may have lost some clarity of thought on which barrier performed better during the change of location, consequently resulting in a perception based on memory recall rather than real spontaneous reactions.

Watts et al. (1999) concluded that any difference in the sensitivity of people to noise depended on the degree of visual screening obscuring the noise source. This phenomenon was found to be largely independent of the noise exposure levels; thus listeners were more sensitive to noise where the screening was highest. These findings concurred with those of Aylor and Marks (1976), Viollon (2003), and Nilson (2007).

The experiment by Watts et al. (1999) confirmed that it was the visual screening of the source of sound, not the other factors connected to the presence of vegetation, which had the greatest influence. Similar findings were also previously affirmed by Mulligan et al. (1987) and Kragh (1981).

In addition, Watts et al. (1999) asked the respondents which of the four barriers under consideration was the most aesthetically