



## Research paper

## Effect of traffic noise on perceived visual impact of motorway traffic

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## HIGHLIGHTS

- Visual impact increases by traffic volume in both sound conditions.
- Visual impact is higher in natural landscape in both sound conditions.
- Decrease of visual impact by distance is less rapid and less clear with sound.
- Traffic noise raises visual impact by largely constant levels in various scenarios.

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## ABSTRACT

Visual impact is one of the major environmental impacts of motorways and requires adequate assessment. This study investigated the effect of traffic noise on the perceived visual impact of motorway traffic by comparing impact with sound to impact without sound. Computer visualisation and edited audio recordings were used to simulate different traffic and landscape scenarios, varying in four traffic conditions, two types of landscape, and three viewing distances. Subjective visual judgments on the simulated scenes with and without sound were obtained in a laboratory experiment. The results show that motorway traffic induced significant visual impact. In both sound conditions, increases in traffic volume led to higher visual impact and changes in traffic composition changed the impact significantly when traffic flow was low. Visual impact was significantly higher in the natural landscape and the increment was largely constant and independent from the effect of traffic condition in both sound conditions. The effect of viewing distance was also significant and there was a rapid-to-gentle decrease of visual impact by distance both with and without sound, but the decrease with sound was less rapid and the decrease pattern less clear. Overall, introduction of traffic noise increased the visual impact by a largely constant level which did not show clear dependence with noise level, traffic condition, landscape type, or viewing distance, although there was a possible effect of viewing distance on the increase. It suggests that the additional impact caused by traffic noise should be considered in visual impact assessment of motorway projects.

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## 1. Introduction

Visual impacts are changes in visual landscape quality brought about by developments in association with human experience of the changes, and are required to be assessed as an essential component of the Environmental Impact Assessment by EU reg-

ulations (The Landscape Institute and Institute of Environmental Management and Assessment, 2013).

A considerable amount of research has been done to develop methods for visual impact assessment (VIA) of various developments. Many of the studies attempted to quantify visual impact by developing objective indices (e.g., Torres-Sibille, Cloquell-Ballester, loquell-Ballester, & Darton, 2009; Rodrigues, Montañés, & Fueyo, 2010; Chamberlain & Meitner, 2009; Domingo-Santos, de Villarán, Rapp-Arrarás, & de Provens, 2011), while some others investigate human response to the visual effect of developments (e.g., Bishop & Miller, 2007; Cloquell-Ballester, Torres-Sibille, Cloquell-Ballester, & Santamarina-Siurana, 2012; Tempesta, Vecchiato, & Girardi, 2014). Objective indices can be helpful in reflecting changes in the physical properties of the visual landscape, however, how viewers respond to the changes is also very important in measuring visual impact,

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**Fig. 1.** The base site for computer visualisation.

as visual landscape quality is determined by the interaction of the physical properties of the landscape and the perception of human viewers (Daniel, 2001).

While great effort has been made to understand the relationship between human perception of the visual landscape and the visual landscape settings (e.g., Shafer, 1969; Anderson & Schroeder, 1983; Palmer, 2004; Dramstad, Tveit, Fjellstad, & Fry, 2006; Ode, Fry, Tveit, Messenger, & Miller, 2009), which is helpful and essential in achieving more reliable VIAs where human response is associated, findings in studies involving multisensory environmental perception have shown that sound also plays an important role in visual landscape perception. Carles, Barrio, and de Lucio (1999) studied the interaction of image and sound in the perception of general landscape quality, and found that natural sounds increased the perceived pleasantness of both urban and natural images, while man-made sounds degraded the appreciation of natural landscapes. Anderson, Mulligan, Goodman, and Regen (1983) found similar results for natural sites where natural sounds were shown to have enhancing effect on the aesthetic evaluation whereas mechanical sounds had detracting effects, however, in the downtown areas the effect of sounds were relatively neutral. In regards to the specific effect of traffic noise, Mace, Bell, and Loomis (1999) found that helicopter noise had negative influences on visitor experience in national parks including decreasing the perceived scenic beauty of the landscape. In a later expended study, Benfield, Bell, Troup, and Soderstrom (2010) showed that aircraft and road traffic noise decreased ratings in scenic evaluation of natural landscape especially for scenes of high scenic beauty. Using similar landscape

evaluation procedure and aesthetic indicators, Weinzimmer et al. (2014) investigated the effect of noises of propeller planes, motorcycles, and snowmobiles in national parks. The results indicated that all the three motorised noises detracted from the evaluation of landscape quality and the motorcycle noise had the most detrimental impact. Contrasting to these cases, however, Anderson et al. (1983) observed that road traffic noise turned to have an enhancing effect on the aesthetic evaluation of urban streets.

The effect of traffic noise on visual landscape perception is of particular importance for VIA of motorway projects, as the visually intrusive motorway traffic induces high level noise as well. However, while there are a lot of studies on the effect of visual settings on traffic noise perception (e.g., Joynt & Kang, 2010; Maffei, Masullo, Aletta, & Gabriele, 2013; Watts, Chinn, & Godfrey, 1999), much fewer effect has been made to investigate the effect of noise on traffic visual impact perception. In an evaluation of visual impact of rural road and traffic in Lake District, Huddart (1978) used composite cine films both with and without sound to show controlled combinations of road projects and background sites for subjective assessment, and concluded that traffic noise had no significant effect on the assessment. However, it should be noted that traffic volume on the rural roads in that study were much lower than that of motorways today, and scenes with generally far distances to traffic were used due to the restriction in video simulation using composite cine films. In a study that specifically focused on the visual impact of moving traffic, Gigg (1980) also compared the subjective ratings given to filmed video scenes of moving traffic with and without sound, and found that traffic noise had a dominant

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