Can attitude towards greenery improve road traffic noise perception? A case study of a highly-noise exposed cycling path

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Summary
This study was based on an on-site survey along a highly noise exposed cycling path immersed in the green, in close proximity of Antwerp Ring Road in Belgium. The survey was held at 181 passers-by during a working week in September 2017. The survey included questions about overall cycling/walking experience, perceived loudness of road traffic noise, soundscape appreciation, perceived dominance of sound sources, and overall attitude towards greenery's potential to reduce noise and improve air quality. A *k*-means cluster analysis was performed on the scores of the attitude towards greenery (ATG) questions to create an ATG variable reflecting two profiles of users: "positive" and "sceptical" towards greenery's potential. The effect of ATG on overall cycling/walking experience, perceived loudness of road traffic noise, soundscape appreciation and perceived dominance of sound sources was tested through a set of independent samples t-tests. Results show statistically significant differences between the positive and the sceptical group for the dimensions of annoyance and calmness, perceived loudness of road traffic noise and perceived dominance of road traffic sounds and natural sounds. However, no difference was observed for the two groups in terms of overall cycling/walking experience, suggesting that, for the investigated case, other factors might be playing a role.

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1. Introduction

In the public opinion, green areas in urban agglomerations are typically associated with tranquillity and restorativeness [1]. Even when they are only meant as residual or accessory areas for commuting functions (and not strictly leisure), green areas often offer opportunities for cognitive relief and repair from environmental stressors [2–4].

When highly exposed to unwanted environmental noise, the restorative potential of such areas might be compromised [5,6]. However, looking at this issue from the opposite perspective, greenery features might also be seen as an important moderator of noise perception. Indeed, previous studies have shown that in complex environments, noise perception depends on a number of individual and non-acoustic factors, such as personal beliefs and preconceptions [7] or vision-related elements [8–10]. In particular, noise levels and the presence of greenery features in the field of view have been shown to be strongly related in the construction of tranquillity (or, conversely, noise annoyance) and related perceptual dimensions [11,12].

The City of Antwerp is planning a landscape architecture intervention on a cycling path close to a segment of the Antwerp Ring road, between Stenenbrug and Lippenslaan (Figure 1). At present, a vegetation belt with trees exist between the Ring road and the cycling path, but passers-by are definitely exposed to high noise levels due to the always intense road traffic on the Ring. The City plans to create a new berm, which should shield (both visually and acoustically) the path from the Ring road.

The aim of this study was testing whether a personal factor, like the attitude towards natural features as mitigation means to fight noise and air pollution, could affect people's perception of the acoustic environment on the cycling path.

2. Methods

2.1. Survey procedure

Data collection for the survey on the designated cycling path took place during five working days in September 2017 (from Monday the 4th to Friday the 8th), between 10:00 am and 06:00 pm. Two research students worked simultaneously at the two ends of the path (Figure 1). Depending on which end of the path they were standing, they had been instructed to approach only passers-by who were leaving the path, while disregarding those who were entering the path from their side. This is because the survey was meant to address people who had "just experienced" the path and could recall it in the short term in memory.

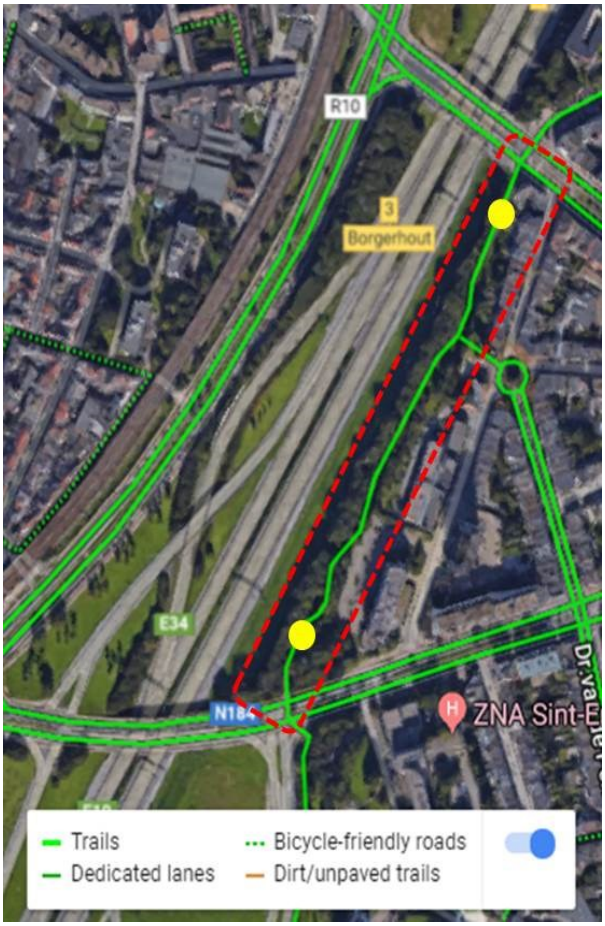

Figure 1. The case study area: the investigated cycling path highlighted inside the red dashed line, with the Ring road on the left. The yellow dots represent the survey positions, at the end of the cycling path.

The questionnaire was administered using a Google form document showed to invited participants through a smartphone. Informed consent to take part in the study was sought from the interviewees. Participants who successfully completed the questionnaire were rewarded with a small gadget provided by the City of Antwerp, as a token of appreciation for volunteering in the social survey.

Table I. Questionnaire used for the survey. The information about the questions' category was not available to participants.

Question category	*Question*	*Scale (extremes)*
Overall experience	*How would you generally describe your experience today when using the path between Stenenbrug and Lippenslaan*?	Very bad – Very good (0 – 10)
Perceived Loudness	*When cycling/walking along the path, I rate the loudness of the environmental noise from the Ring road as…*	Very quiet – Extremely loud (0 – 10)
Soundscape dimensions [*Overall, the acoustic environment you just experienced was…*]	Eventful	Not at all – Completely (0 – 10)
	Vibrant	
	Pleasant	
	Calm	
	Uneventful	
	Monotonous	
	Annoying	
	Chaotic	
Perceived dominance of Sound source's types [*To what extent did you hear on this path the following sound sources?*]	sounds of other people	Did not hear at all – Dominated completely (1 – 5)
	road traffic from the Ring	
	road traffic from local roads	
	aircraft noise	
	railway noise	
	sounds of nature	
Attitude towards greenery [*Please, state to what extent you agree to each of the following statements*]	*The vegetation located towards the ring road is able to reduce the road traffic noise at the cycling path*	Do not agree at all – Totally agree (1 – 5)
	The vegetation located towards the ring road is able to improve the air quality at the cycling path	
	Being present in a green environment is important for your health	

3. Results

From two semi-permanent microphones installed on site within a broader collaboration between Ghent University and the City of Antwerp it was measured that during the survey period the levels directly bordering the Ring road were near 85 dBA on a 15-minute base; whilst along the cycling path, the 15-minute averaged levels exceeded 70 dBA during the daytime. This confirmed the assumed condition of site "highly exposed to road traffic noise".

During the week of observation 181 valid responses to the survey were gathered. In order to define an "Attitude Towards Greenery" (ATG) variable, a *k*-means cluster analysis was performed on the scores of the three corresponding items of the questionnaire (last Question category, in Table I), forcing the algorithm into a two-cluster solution, since a convergence was achieved due to no or small change in cluster centres after only four iterations of the clustering algorithm (SPSS IBM v.22).

Subsequently, the mean scores of the three ATG items were analysed as a function of cluster membership. Considering the positive direction of the three items, a high level of agreement can be seen as a positive attitude towards greenery in reducing the noise coming from the Ring road and improving the air quality. From Figure 2 it can be observed that the three items are always higher (even if to a different extent) for cluster 1 than for cluster 2; thus the two clusters were interpreted as: "Positive" (1) and "Sceptical" (2) attitude towards greenery. These were then considered as categorical levels of the "Attitude Towards Greenery" (ATG) variable.

A set of independent-samples t-tests was then run to determine if the scores of the survey items were different between the Positive (n = 114) and Sceptical (n = 67) groups. This included all the 16 variables (questions), corresponding to the four variables' types (question categories), as reported in Table I (i.e., Overall experience, Perceived loudness, Soundscape dimensions, and Perceived dominance of Sound source's types).

For the Perceived loudness item (i.e., *"When cycling/walking along the path, I rate the loudness of the environmental noise from the Ring road as…* [*very quiet – extremely loud*]*"*) the Positive (M = 7.90, SD = 1.68) group had statistically significantly lower scores than the Sceptical group (M = 8.79, SD = 1.19), $t(179) = -3.805$, $p < .001$ (Figure 3).

Regarding the Soundscape dimensions, statistically significant differences emerged for the items Annoying and Calm. For Annoying, the scores of the Positive group (M = 6.29, SD = 2.81) were lower than the Sceptical group (M = 7.43, SD

= 2.59), $t(179) = -2.723$, $p = .007$. Conversely, for the Calm item, the scores of the Positive group ($M = 2.09$, $SD = 2.47$) were higher than the Sceptical group ($M = 0.88$, $SD = 1.46$), $t(179) = 3.637$, $p < .001$ (Figure 3).

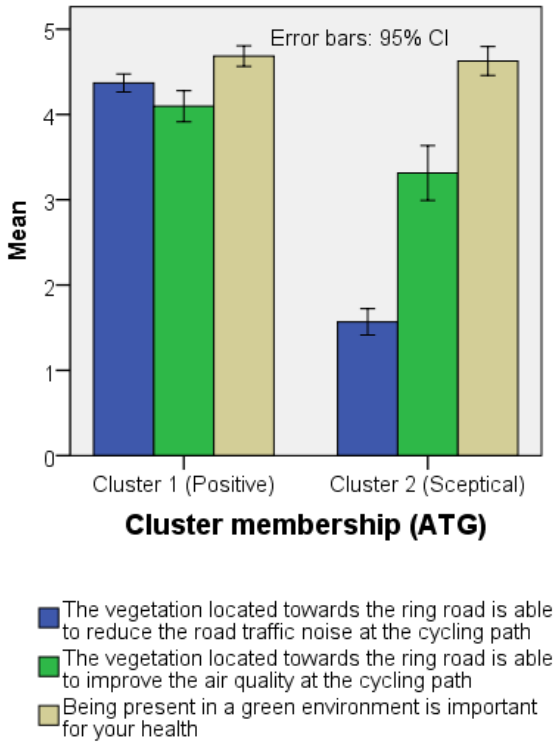

Figure 2. Mean scores (and 95% C.I.) of the three ATG items, as a function of cluster membership.

Regarding the Perceived dominance of Sound source's types, statistically significant differences emerged for the items Road traffic from the Ring and Natural sounds (Figure 4). For Road traffic from the Ring, the scores of the Positive group ($M = 4.55$, $SD = 0.88$) were lower than the Sceptical group ($M = 4.85$, $SD = 0.53$), $t(179) = -2.508$, $p = .013$. Conversely, for the Natural sounds item, although hardly present in the zone under study, the scores of the Positive group ($M = 1.83$, $SD = 0.90$) were higher than the Sceptical group ($M = 1.49$, $SD = 0.79$), $t(179) = -2.572$, $p = .011$.
No statistically significant differences ($p > .05$) were observed between the two ATG groups for all the other variables.

4. Discussion

In this study, the perception of the acoustic environment of a cycling path highly exposed to road traffic noise was analysed by means of a social survey submitted to 181 passers-by during daytime, in a typical working week.
Previous studies have shown that sound perception is likely to be modulated by several non-acoustical factors, and this is particularly true when acoustic environments are experienced in urban green areas. In general, the visibility of greenery features is a helpful component in reducing noise annoyance (and/or increasing perceived tranquillity) [11–13]. This seems to be confirmed by the data collected during this campaign, since, in spite of the very high noise levels experienced along the path, participants were relatively positive when assessing the "Overall experience of walking/cycling between Stenenbrug and Lippenslaan" ($M = 7.48$, $SD = 1.74$).

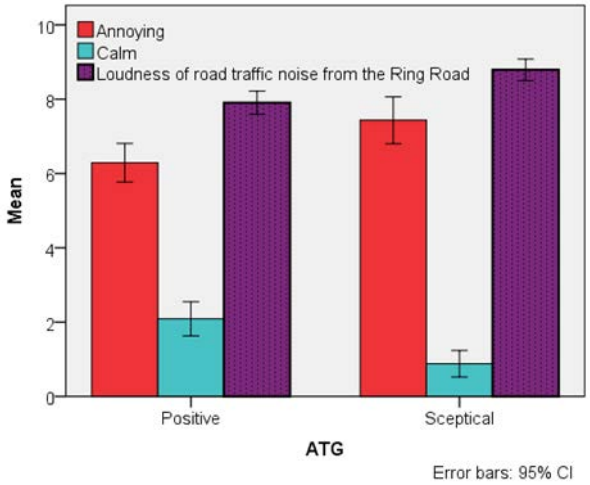

Figure 3. Mean scores (and 95% C.I.) of the two Soundscape dimensions items, and the Perceived loudness item (greyed), as a function of cluster membership

Regarding the items used to determine the ATG variable, it is worth noticing that the third item (i.e., "*Being present in a green environment is important for your health*") was not so important; that is: all people tended to (moderately/strongly) agree with this statement (which could be seen as "socially desirable"), regardless of their attitude towards greenery. On the other hand, by comparing the mean scores in Figure 2, it can be observed that the first item (i.e., "*The vegetation located towards the ring road is able to reduce the road traffic noise at the cycling path*") was more important a factor than the second item (i.e., *The vegetation located towards the ring road is able to improve the air quality at the cycling path*") in

defining the ATG variable. This circumstance points out that greenery features are perceived as being more effective at reducing noise, than at improving air quality. This is particularly interesting, because a more detailed sound propagation analysis conducted on the area revealed that the above-ground greenery hardly influenced sound propagation from the Ring road to the cycling path [14]. Therefore, it can be assumed that audio-visual interactions are playing a role in the overall (i.e., holistic) assessment of the place.

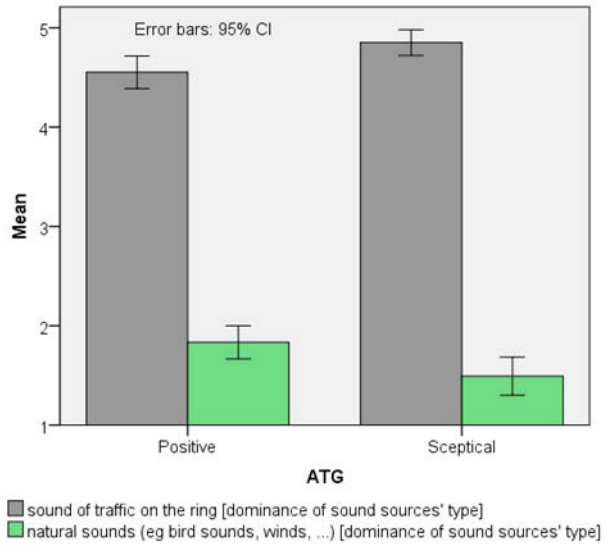

Figure 4. Mean scores (and 95% C.I.) of the two Perceived dominance of Sound source's types items, and the Perceived loudness item (greyed), as a function of cluster membership.

5. Conclusions

The long-term purpose of this study will be to document the current perception of the acoustic environment between Stenenbrug and Lippenslaan, before and after the refurbishment of the cycling path and the installation of a berm. Thus, the main conclusions will be drawn by comparing the two situations at a later phase. Nevertheless, when looking at differences between groups within the current sample of participants, the main conclusions of this (part of the) study are: (1) people having a positive attitude towards greenery experienced the soundscape along the cycling path as being less annoying and more calm than the group having a sceptical attitude; similarly, (2) people having a positive attitude towards greenery perceived the traffic noise coming from the Ring road as being less loud than the sceptical group.

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