Response to change in noise exposure: an update

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ABSTRACT

Environmental appraisals of transport infrastructure plans are generally conducted in situations where there will be an abrupt change in noise exposure. In 2009 we reviewed the literature on response to step changes in exposure. Theweight of evidence was that for road traffic studies with changes in exposure, there is a change effect in addition ton exposure effect. In a subsequent paper we cataloged and reviewed the different explanations for this excess reaction to change. This paper provides a partial update of the two reviews by considering more recent change studies. The focus is on further evidence for the existence of the change effect and its explanations. Also, while the focus of our earlier reviews was on adverse effects of the acoustic environment, here we extend the concepts to include community response to changes in the acoustic environment resulting from measures designed to enhance positive experiences e.g. soundscaping projects).

INTRODUCTION

In 2009, Brown and van Kamp (2009a, 2009b) reviewed literature covering three decades of studies of response to a step change in transport noise exposure. Step changes in transport noise occur, for example, where:

- new roads and railways are constructed or existing ones closed;
- there are major increases or decreases in road, rail or air traffic;
- noise mitigation measures are implemented;
- new airport runways are constructed, or existing ones closed;
- there is a major change in the mix of vehicle types or rearrangements of flight paths.

These types of changes are usually significant for the community affected, and understanding how it responds is an important part of noise assessment in such situations. The 2009 reviews were of studies which included both increments and decrements in transport noise exposure levels, but all were focused on assessing community response to the change in terms of annoyance or similar negative reaction. In this paper we revisit the importance of studying human response under situations of change and provide an update, to the extent possible, by examining the limited number of change studies that have been reported since the 2009 reviews.

CHANGE IN NOISE EXPOSURE

A step, or an abrupt, change in noise exposure may occur through three different mechanisms. Type 1 changes result from a new or eliminated source, or change in intensity of the source – a large number of transport change studies are Type 1, resulting from changes in traffic flow rates, road bypass construction or change in runway configurations. Type 2 changes result from some mitigation intervention, usually in the propagation path (e.g. noise barriers beside roadways) and, in these types, there are no changes in the transport source flow rates or source noise emissions, just in exposure of the respondents. Another possible Type 3 change is where an individual may relocate from one dwelling to another that has a different noise exposure. Type 3 changes would usefully be included in future studies seeking to investigate the nature of human response to change.

Dimensions of the change in exposure include the direction of the change – increment or decrement - the magnitude of the change; and whether the change is a step change or gradual and, if gradual, the rate of change. Some noise exposure changes, such as shutting a runway for maintenance, may be temporary.

THE CHANGE EFFECT

Brown and van Kamp (2009a, 2009b) built their work on several previous reviews of response to changes in community noise exposure, particularly those of Horonjeff and Robert (1997), Schuemer and Schreckenberg (2000), and Fields, Erlich and Zador (2000). They concluded that there is sufficient, though not always consistent, evidence that human response to changed transport noise exposure includes both an exposure effect and a change effect. The change effect is manifest as an excess response to the new noise exposure over that predicted from steady-state exposure-response curves (which predict the exposure effect). Excess response was found, unambiguously, for changes in road traffic noise, in noise annoyance responses though not in activity interference responses, where the change in exposure resulted from an increment or decrement in source levels (Type 1 changes) rather than from the insertion of barriers or other path mitigation interventions (Type 2 changes).

The results for the airport studies were, in general, quite different to those for the roadway studies. The change effect in the airport studies was very small - in some cases, an under-reaction - compared to the predominance of excess response in the roadway studies. While this may demonstrate a difference in response to change between aircraft noise and roadway noise, the more likely explanation is that the difference is an artefact of the nature of noise changes that occurred at most of the airports studied. These included either temporary changes, or small changes of 3 dB or less, in noise exposure, and some airport change studies were of gradual change in noise exposure over years rather than a step change. As Fields et al. (2000) have previously noted, these are very different situations to where there is an abrupt or step change in exposure and, because of these differences, it would be inappropriate as yet to draw conclusions that response to change around airports is different to response to change from roadway sources.

For Type 1 change studies of roadway sources only, Brown and van Kamp (2009a) demonstrated that all available change studies exhibit, with remarkable consistency, an excess response in situations of both increments and decrements of noise exposure. Respondents whose noise exposure has increased report more annoyance than expected from steady-state studies; respondents whose noise exposure has decreased report less annoyance than expected from steady-state studies. The effect is present even for quite small changes in noise exposure.

The reader is referred to Figures 1 and 2 in Brown and van Kamp (2009a) for the magnitudes of the changes in noise exposure reported in the studies reviewed (these ranged from decrements of 18dB to increments of 15dB, with more than half of the changes in the range -5dB to +5dB, including some in the range -1dB to +1 dB). The same figures also show the magnitude of the decibel-equivalent change-effect associated with these changes in exposures. For Type 1 road traffic noise changes, the magnitude of the excess response change effect: was always in the same direction as the change in noise exposure; was always non-zero; and ranged from +14dB to -22dB, tending to be greater, often much greater, than the change in noise levels itself.

There is some evidence that people may respond differently in Type 2 changes, reporting less response and little or no change-effect. While Fields et al. (2000) concluded that studies aimed at evaluating the effect of noise-shielding interventions (barriers, double glazing), rarely lead to findings of an excess response, evidence of the presence and direction of change effects in Type 2 studies to date is ambiguous. A reasonable conclusion at this stage is that the results of Type 1 and Type 2 studies should be separated in future analysis of change studies given the mixed evidence regarding excess response in Type 2 changes.

IMPLICATIONS OF THE CHANGE EFFECT

Response to a change in noise levels

Conventional wisdom is that human response to a step change in transport noise should be able to be predicted from existing synthesized exposure-response curves. However most, if not all, of the human response measurements used in these syntheses would have been conducted at sites at which the prevailing noise environment had changed little over preceding years. Exposure-response curves derived from these studies thus reflect human response to noise in situations of effectively steady-state exposure. As environmental appraisals are generally conducted in situations where there will be a step change in noise exposure, the presence and magnitude of the excess response warrants consideration of a change-effect in assessing the impact of such changes, and in policy making with respect to them.

The evidence of the magnitude, and the persistence over time, of the change effect, and the existence of plausible explanations for it, suggest that it is a real effect and needs to be taken into account in assessing the response of communities in situations where noise levels change. Within the limitations of existing evidence on change (for example, the available evidence is primarily from road transport sources) communities that experience an increase in noise exposure are likely to experience greater annoyance than is predicted from existing exposure-response relationships, and communities that experience a decrease in exposure experience greater benefit than predicted. Policy makers need to be informed of these potential change effects, particularly as situations in which noise levels increase are always likely to be contentious. To do otherwise would be to deny them important information regarding potential community response in these contexts. There is no evidence that the change effect is transient, and it is likely to be present until the normal turnover of residents in any particular community results in newcomers replacing those who experienced the change.

Explanations of the change effect

A wide range of explanations had been put forward for the change effect and Brown and van Kamp (2009b) tested these against the available evidence. Their analysis grouped the residual plausible explanations into three categories, each representing a different mechanism. These mechanisms were: change effects resulting from a change in variables modifying the exposure-response relationship before and after the change, differential scaling criterion for the annoyance scale at different levels of exposure, and retention of coping strategies following a change.

While there is insufficient evidence to choose between these categories (this remains the case even after examination of several new studies below) if the mechanism of change in modifying variables, either alone or in combination with other mechanisms, is the reason for the change effect, there is the potential for considered interventions to be used as instruments to change the annoyance response of affected populations. Evidence of the existence of change effects suggests that actions that result in changes to known modifiers such as attitudes to the source/authorities, or overall attitudes to a neighbourhood, should not be perceived merely as manipulative public relations, but bona fide and positive contribution to managing the magnitude of the annoyance responses of the community subject to the change.

RECENT LITERATURE ON RESPONSE TO CHANGE

A literature search of papers published after first submission of the 2009 reviews, making use of the same search profile, yielded 19 papers – including 12 peer reviewed articles and 7 conference papers. Two of these were rejected as they did not directly address change, though they did make reference to the change reviews. Papers below include: studies of the effects of step changes in exposure; those dealing with factors modifying the exposure-response relationship relevant to change studies (including interventions aimed at community involvement and behavioral change); documentation of a future change study; and several others pertinent to step changes in noise exposure – the latter included an additional review paper. The number of new studies quantifying the change effect was insufficient to add to the previous quantitative estimates (Brown, van Kamp, 2009a) of the magnitude of excess response.

Changes in exposure: new evidence

A study by Brown et al. (2006) to manage road traffic noise exposure involved a traffic management intervention to reduce trucks using an urban road corridor in Brisbane (a Type 1 change). This was one of the first studies to be designed according to the protocol for change studies suggested by Brown and van Kamp (2005). The traffic management strategy affected only the night-time truck flows on the corridor; truck traffic in the day-time hours and other vehicle traffic at all hours would remain unchanged. A longitudinal panel study was used to measure residents' responses to the changed noise environment, using four successive rounds of interviews, from prior to the change to twelve months after the change. The initial panel had 99 respondents, reducing to 45 by the fourth interview. The change in exposure was in its night-time truck noise load only - respondents remained exposed to otherwise high levels of road traffic noise exposure. The panel benefitted far more from small reductions in night-time truck flows (hence small reductions in night-time noise events from heavy vehicles, even if not in Lnight) than would be predicted from the resultant changes in conventional noise exposure measures. This represented a strong change effect with highly significant and enduring reductions in noise annoyance as a result of the intervention - both for night-time annoyance and for overall annoyance. This was remarkable, given that reductions in the frequency of truck movements at night was relatively small, and conventional measures of their road traffic noise exposure (eg Leq, and even Lnight) showed no movement with the traffic management intervention. In this study, many residents would have been aware that attempts were being made to reduce their problems associated with living on a major urban corridor. The results of the study fit with previous findings of a large change effects being associated with Type 1 changes in road traffic noise.

Amundsen et al. (2011) evaluated the large scale implementation of a façade insulation program for road traffic noise in Norway that yielded, on average, an indoor noise reduction of 7 dB. The study measured before (637 respondents) and after (415 respondents) annoyance responses of a target group (161 respondents with high exposure were eligible for the insulation and participated in both before and after surveys), a control group (high exposures, but not high enough to receive insulation) and a supplementary low exposure group (112 respondents). Results show that most of the residents were still annoyed by the indoor road traffic noise level after the noise reduction, but to a much lesser degree than before the insulation installation. The change in indoor noise levels achieved a reduction of the percentage of people highly annoyed by noise inside their dwellings from 42% to 16%. The authors concluded that the average annoyance reduction could be adequately explained by the average reductions in noise levels. That is, the changes in annoyance from noise reduction due to the façade insulation were in accordance with what would be expected from the exposure-response curves obtained indoors in the before-situation (based on the whole sample of target, control and supplementary respondents) – in short, no change effect was observed. The absence of a change effect is in line with the findings in the review by Brown and van Kamp (2009a) in which change effects had not been observed in studies of Type 2 changes where change was due to building insulation or barriers. However, Amundsen et al. (2011) also reported unexplained differences in annoyance scores between the target group and control group in the before-situation and between the first and second round of surveys of the control group – and suggested these may be due to modifiers such as attitudes to the authorities who were seen to be taking action, or a desire to encourage authorities to insulate their premises. At the time of the before studies, most target and control respondents had received information that their dwellings were under consideration for façade insulation, but most not informed if they would actually receive it.

Oka et al. (2012 compared community response to noise and vibration before and after the opening of the Kyushu Shinkansen line (see also Tetsuya et al. (2011) that ran largely parallel to a conventional rail line. The purpose of this study was to examine the change in community response to changing noise and vibration exposures as the rail system and line configurations changed. Noise and vibration exposures were slightly decreased after the opening due to lower levels from the high speed Shinkansen than from the conventional trains. Results showed a decrease of percentage highly annoyed after the opening of the Kyushu Shinkansen line, but unfortunately no observations were made with respect to whether there had been a change effect.

Krog et al. (2010) examined data from a 1998 study based on telephone surveys of a panel of visitors to recreational areas near Oslo. The two study areas were affected by the relocation of the main Norwegian airport. In one area, recreationists' aircraft noise exposures (in terms of each of LAeq, proportion of time over 55 dB, and proportion of time aircraft noise was heard) decreased. In the other area, aircraft noise exposure increased. In the panel studies, interviews were conducted for each area, questioning respondents on their experience of use of the study areas for recreation, both before and after the changes. The noise effects measured was annoyance, over a season, with aircraft noise whilst using a recreational area (different to most other change studies where noise effects are those when at home). The authors reported a very large change in visitors' noise annoyance, in both the area where exposure decreased and the area where exposure increased. They were not able to examine if this effect attenuated over time (habituated). Apart from it being a study of noise effects away from the home, this is one of the first change studies in which large change effects had been reported for aircraft noise.

Also of interest in this work was that the authors (Krog, et al, 2010) used their data to examine potential change-effect explanations summarised by Brown and van Kamp (2009b). They could not rule out that a differential response criteria could explain the observation of a large change effect in response to aircraft noise, though this would not explain the systematic changes they also observed in annoyance with other area factors which did not change in conjunction with the change in aircraft noise annoyance. Krog et al. (2010) suggested the latter might be explained by a cognitive consistency theory, whereby individuals seek internal coherence in their evaluations of the various components of a situation - components influencing the experience of the whole, but overall impression also influencing perception of the parts. They also suggested that the changes in noise exposure in their study may have affected both a broader set of visitors' experiential dimensions that interact with noise annoyance, and their general impression of the area. This is, in effect, an alternative construction of the surrogate effect (or area-wide or halo effect) explanation. In the latter explanation, actual changes in other environmental dimensions directly influence overall opinion – compared with Krog and Engdahl's finding (2010) that a change in noise exposure leads to changes in perception of other, non-acoustic, environmental dimensions of the area. In either case, the overall opinion of the area changes with the changing noise exposure. The authors note that this fits into the Brown and van Kamp (2009b) category of explanation of change-effect based on a change in a variables modifying the exposure-response relationship.

An intervention study by Gidlöf-Gunnarson et al. (2010) , in a residential area exposed to high sound levels from road traffic, used several intervention measures (filling gaps between buildings, renovation of the dwelling,s and the erection of a noise barrier) to create courtyards and sides of dwellings with lower levels of noise exposure. Although the Swedish criterion for a "quiet side" (LAeq,24h <45 dB, free field value) was not reached in every case, the interventions resulted in considerable noise reductions of levels - of 5-10 dB at the most traffic exposed side and of 4-10 dB at the less noise-exposed side. Reactions were measured before and after the interventions (five year interval) by means of postal questionnaires. Of the original study population, 61% participated in both surveys. While these were Type 2 changes from road traffic sources, the reduction in noise level exposure resulted in a large change effect, with a much lower proportion annoyed after the change (25% annoyed after the change compared with 84% annoyed before the change) than would have been predicted from known exposure-response curves. Gidlöf-Gunnarson et al. (2010) ascribe this change effect to change in variables modifying the exposure-response relationship, viz overall opinion of the neighbourhood (measured to have increased positively), surrogate effects from other physical changes (such as the general improvement of area by placing new playground, flowers, measures to improve traffic safety as well as the construction of a new shopping center) and also presumably to attitude to authorities who had implemented the physical changes to improve residents' environment.

Lam and Au (2008) examined annoyance reactions beside an 11.4 km railway line extension in Hong Kong, with surveys at six months before, and at three months and at one year after, opening. Respondents reported some reduction in annoyance with railway noise over the successive interviews, but while one third of the respondents experienced a small increase in rail noise of 2 to 4 dB(A) with the rest an increase of less than 1 dB(A), overall, the noise from another source, road traffic, overwhelmed the noise from the rail noise for most respondents. This makes it impossible to utilise the results of this work to examine the effects of this Type 1 change in rail noise.

Changes in contextual and personal factors: new evidence

In nearly all of the change studies discussed above, the authors referred to the potential for, or in some cases measured, change in variables that could modify the exposure-response relationship between the before and after conditions – and these have been discussed above in the context of being a possible explanation for the existence of the change effect. Chan and Lam (2008) also attempted to investigate how non-acoustic factors modified response to noise resulting from the opening of the rail line extension reported in Lam and Au (2008). Given the potential for these modifying variables to be used as instruments to change the annoyance response of affected populations in their own right, several relevant papers outside of the context of change studies have also been examined.

Vos (2010) reviewed experimental and field studies of the effect of such modifying factors on annoyance. He examined studies of the effects of: attitude towards the quality of noise management; availability of information about noise mitigating measures; information exchange; equity in the distribution of noise load; and having a voice in decision-making. Whilst all these non-acoustic factors (except the last) had a systematic effect on annoyance, he notes that most of the studies had methodological imperfections which prevented firm conclusions being drawn. Schlachter et al. (2012) put individual behavioral changes forward as potential strategy for noise reduction. Current governmental information about noise pollution and its health effects have so far not been very successful in creating awareness of the noise problem and have not lead to changes in noise behavior at the individual level. The potential for noise reduction using individual motivation for noise-reducing behavior can be increased significantly when the interventions are tailored to the target group, since major differences were found between groups based on age, gender and other characteristics.

New study into the change effect of an airport expansion

The NORAH study (2011) is a current major before-and-after study associated with expansion of Frankfurt Airport, and includes comparative studies of change at Berlin Brandenburg International Airport and steady-state conditions at two other German airports. The NORAH study will provide an opportunity to study noise annoyance and health-related quality of life effects (aircraft, road and rail sources), effects of transport noise on hypertension and cardio-vascular disease (participants will be trained to assess their own blood pressure), effects of changing nocturnal noise exposure on sleep, and noise effects on children's' cognitive performance. The NORAH study has been designed in the knowledge that change effects are likely to be associated with changes in noise from Frankfurt airport, and though no specific hypotheses have been formulated concerning change because of the complex multiple configurations that will occur as the airport expands, the study should shed light on change effects, not just in annoyance, but also in other noise outcomes such as sleep disturbance and cardiovascular effects.

Other new papers relevant to step changes in exposure

We note that there has been a literature review, subsequent to those by Brown and van Kamp (2009a, 2009b) of change studies by Laszlo et al. (2012). This duplicates much of the previously reported work, and while it does document changes in outcomes, other than annoyance, to changed noise conditions, it does not provide additional insights into the nature and magnitude of change effects or potential mechanism of change effects.

None of the previous change literature has dealt with economic valuation of noise effects as a result of change. Veitsen et al. (2012) note that their economic valuation of noise attenuation (attenuation of quiet side noise levels) was based on steady state exposure-response relationships - but imply, in their discussion, that change situations resulting from interventions may produce different results.

Finally, Stack et al. (2010) reported a 3 dB(A) step change in noise exposure, but in this case the change was in the levels of human-generated sound, and achieved by experimental management actions (educational signs of quiet days or quiet zones) encouraging quiet behavior amongst visitors to a US national park. While the acceptability of the management interventions to visitors was assessed, the effect of the reduction in sound levels on human enjoyment of the park was not – thus no observations were made on the existence or otherwise of a change effect in this context. We mention this study here because we are of the opinion, though without evidence as yet, that our findings on "response to change" in the acoustic environment may prove as relevant to interventions designed to enhance positive experiences of the acoustic environment as they are to interventions designed to change negative experiences of noise.

DISCUSSION AND CONCLUSIONS

It has been demonstrated (Brown, van Kamp, 2009a) that a change-effect is unequivocally present for road traffic noise studies where the intensity of the road traffic source changes (Type 1 changes). For these change situations, the decibel-equivalent magnitude of the excess responses (both the excess benefit arising from reductions in exposure, and the excess disbenefits arising from increases in exposure) can be greater than the change in noise levels itself. For changes resulting from the insertion of barriers or other path mitigation interventions (Type 2 changes) the evidence for a change effect is not clear (Brown, van Kamp, 2009a). Similar consistent evidence of a change effect for aircraft noise and railway noise changes is lacking, but this is most likely due to limitations in the change studies available for these transport modes.

This evidence regarding response to change has application in all noise management interventions because: (a) the relevance to intervention studies arises directly from the existence of a change effect when exposure levels change. Excess response warrants consideration in assessing impact, and needs to be part of the information available to decision-makers, and (b) relevance to interventions also arises from the possibility that the change effect is caused by changes in exposure-response modifiers such as attitudes to the source/authorities, or overall attitudes to a neighbourhood. This suggests that interventions not specifically directed at achieving a change in noise exposure, but instead directed at consultation, community education and behavior modification, or at other positive changes in the environment, can be bona fide and positive contribution to managing the magnitude of the annoyance responses of the community.

The results of intervention and change studies conducted since the original reviews generally confirm, certainly do not conflict with, the above observations - though the number of new studies quantifying the change effect was insufficient to add to the previously quantitative estimates of the magnitude of excess response (Brown, van Kamp, 2009a). There is now eveidence from one study (Krog et al. 2010) (albeit of annoyance during recreational activities) of a large change effect for aircraft noise. The likely existence of excess response in change studies has begun to influence both the design of further studies (e.g. the NORAH study) and the analysis of data sets where change has occurred. Several of the recent studies (e.g. Krog et al., 2010) have also attempted to empirically test the alternative explanations for the existence of the change effect. At this stage, each of the different explanations canvassed by Brown and van Kamp (2009a) remains plausible.

Finally, since the 2009 reviews, there has been growing interest in soundscapes. We suggest, though without empirical evidence from appropriate studies as yet, that our findings on "response to change" in the acoustic environment may prove as relevant to interventions designed to enhance positive experiences of the acoustic environment, such as through soundscape projects, "quiet sides", green areas, and similar, as they are to interventions designed to change negative experiences of noise. If so, one would look in future studies for excess effects in outcomes such as restoration, enjoyment, recreation and enhanced (social) quality.

REFERENCES

Amundsen, A.H., Klæboe, R. and Aasvang, G.M., *The Norwegian Façade Insulation Study: The efficacy of façade insulation in reducing noise annoyance due to road traffic*, J. Acoust. Soc. Am. 129 (3), 1381–1389 (2011).

Brown, A.L. and van Kamp, I. *Response to a change in transport noise exposure: a review of evidence of a change effect*, J. Acoust. Soc. Am., 125 (5) 3018-3029 (2009a).

Brown, A.L. and van Kamp, I. *Response to a change in transport noise exposure: competing explanations of change effects*, J. Acoust. Soc. Am., 125, 905-914 (2009b).

Brown, A.L., *A longitudinal study of response to night-time traffic load*, Proc. INTER-NOISE 06, Honolulu, (2006).

Brown, A.L., van Kamp, I., *Towards a design for studies of response to a change in noise exposure*, Proc. INTER-NOISE 05, Rio de Janeiro, 2958-2967 (2005).

Chan, T.C. and Lam, K.C., *The effects of information bias and riding frequency on noise annoyance to a new railway extension in Hong Kong*, J. Transportation Res Part D, 13, 334-339 (2008).

Fields, J.M., Ehrlich G.E. and Zador, P., *Theory and Design Tools for Studies of reactions to abrupt changes in noise exposure*. (NASA-CR-2000-210280. Hampton, VA: NASA Langley Research Center, 2000).

Gidlöf-Gunnarsson, A., Öhrström, E. and Kihlman, T., *A full-scale intervention example of the 'quiet side-concept' in a residential area exposed to road traffic noise: effects on the perceived sound environment and general noise annoyance*, Proc. INTER-NOISE 10, 403-412 (2010).

Horonjeff, R.D. and Robert, W.E., *Attitudinal response to changes in noise exposure in residential communities*. (Harris, Miller, Miller and Hanson Inc., Burlington, MA USA. NASA CR-97-205813, 150pp. National Aeronautics and Space Administration, Washington D.C, 1997.

Krog, N.H., Engdahl, B. and Tambs, K., *Effects of changed aircraft noise exposure on experiential qualities of outdoor recreational areas* Int. J. Environ. Res. Public Health, 7(10), 3739-3759 (2010).

Lam, K.C. and Au, W.H. *Human annoyance response to a step change in noise exposure following the opening of a new railway extension in Hong Kong,* Acta Acustica united with Acustica, 4, 553-562 (2008).

Laszlo, H.E., McRobie, E.S., Stansfeld, S.A. and Hansell, A.L., *Annoyance and other reaction measures to changes in noise exposure - A revie,*Sci. Total Environ., 435–436, 1, Pages 551–562 (2012).

Oka, S., Tetsuya, H., Yano, T. and Murakami, Y., *Community response to a step change in railway noise and vibration exposures by the opening of a new Shinkansen* Line, Proc. INTER-NOISE 12, 3251-3262 (2012).

Schlachter, I., Meloni, T., Moser, S., Lauper, E., Fischer, M. and Kaufmann-Hayoz, R., *Reducing road traffic noise – how to design effective individual-based interventions*, Proc. INTER-NOISE 12, 8761-8767 (2012).

Schreckenberg, D., Eikmann, T., Faulbaum, F., Haufe, E., Herr, C., Klatte, M., Meis, M., Möhler, U., Müller, U., Schmitt, J., Seidler, A., Swart, E., Zeeb, H., zur Nieden, A. and Guski, R. *NORAH – Study on Noise-Related Annoyance, Cognition and Health: A transportation noise effects monitoring program in German* Proc. ICBEN 2011, 390-398 (2011).

Schuemer, R. and Schreckenberg, D, *Anderung der Larmbelastung bei massnahme bedingter stufenweise veranderter gerauschbelastung – Hinweise auf einige Befunde und Interpretationsansatz*, (The effect of stepwise change of noise exposure on annoyance), ZfLärmbek, 47 (4) 134-143 (2000).

Stack, D.W., Newman, P., Manning, R.E. and Fristrup, K.M., *Reducing visitor noise levels at Muir Woods National*

Monument using experimental management, J. Acoust. Soc. Am. 129 (3), 1375–1380 (2010).

Tetsuya, H., .Murakami, Y., Oka, S. and Yano, T., *Community response to noise and vibration from conventional railway lines before the opening of Kyushu Shinkansen Line,* Proc. INTER-NOISE 11, 923-928 (2011).

Veisten, K., Smyrnova, Y., Klæboe, R., Hornikx, H., Mosslem, M. and Kang, J. *Valuation of green walls and green roofs as soundscape measures: Including monetised amenity values together with noise-attenuation values in a Cost-Benefit Analysis of a green wall affecting courtyards,* Int. J. Environ. Res. Public Health, 9, 3770-3788 (2012).

Vos, J., *On the relevance of nonacoustic factors influencing the annoyance caused by environmental sounds - a literature study* Proc. INTER-NOISE 10, 8, pp. 6168-6177 (2010).