Human annoyance response to a step change in noise exposure following opening of a new railway extension in Hong Kong

Kin-che Lam*, Wai-hong Au

Department of Geography and Resource Management, Chinese University of Hong Kong, Shatin, NT., Hong Kong SAR

* corresponding author: e-mail: kinchelam@cuhk.edu.hk

ABSTRACT

A study was undertaken to determine the change in exposure of households to road traffic and railway noise and the residents' annoyance reactions in a new town in Hong Kong following the opening of an 11.4-km railway extension line. The acoustic changes were determined by noise mapping and validated by field measurements. Social surveys were performed six months before, three months following, and one year after operation of the railway. The results show that despite introduction of railway noise had resulted in a small increase in total noise exposure, the annoyance of the residents decreased over time during the study period, indicating that annoyance was not significantly related to noise exposure levels or the magnitude of change in noise exposure. A separate but parallel questionnaire survey for a different cohort of residents was undertaken to determine if annoyance reaction could be modified by bias in the available information and use of the new railway service. The results from these two surveys provide circumstantial evidence to indicate that the attenuation of annoyance over time could be partly attributable to media sensitization around the time of railway opening and the gradual adoption of the rail as a mode of transport by local residents. Findings of these surveys should have implications in environmental management.

INTRODUCTION

This study investigated the change in acoustic environment of a new town in Hong Kong following the opening of a new railway extension. The literature abounds with examples showing that changes in the acoustic environment may cause changes in human annoyance reactions and performance in undertaking daily activities. However, these studies also show that there is no simple relationship between human annoyance reactions and the magnitude of acoustic change (Miedema & Vos 1998), particularly when the change is sudden. Based on a comprehensive review of the literature, Brown and van Kamp (2005) suggested that there is as yet no conclusive evidence to show that people overreact to such step changes and the purported response may attenuate over time. They called for further investigations on human noise-annoyance responses in dynamic acoustic situations using a multi-stage framework to collect the data needed to determine if overreaction indeed exists and persists.

Many studies have shown that annoyance reactions are shaped not only by the absolute noise level but also by the magnitude of acoustic change, the shift in the dominant noise source, as well as many other non-acoustic factors (Lambert 1998; Joncour et al. 2000; Lam et al. 2008) that may provoke noise responses even more intense than those induced by acoustic ones (Job & Hatfield 1998). The interactions among acoustic and non-acoustic factors and their effects on noise annoyance can be very complicated and merit in-depth investigations. Among the various non-acoustic factors, the literature shows that people are generally more annoyed if they believe that noise could have been avoided or reduced by the authorities (Schreckenberg et al. 1998). Availability and accessibility of information about noise abatement procedures have also been shown to have a significant influence on people's noise annoyance (Solberg 2005). Increased media coverage of a new project can also sensitize the affected local community and provoke greater negative reactions (Hume et al. 2004). Whether or not the respondents make use of the noise-emitting infrastructure can also possibly affect annoyance reactions. However, not many studies have focused on the interactions among these non-acoustic factors and their effectiveness in shaping human noise response. Nor has any study tried to relate these non-acoustic factors to an exaggerated noise annoyance response under a step-change in noise exposure.

An opportunity arose in Hong Kong when an extension was added to an existing railway network in 2004. Recognizing that the railway extension may bring about acoustic changes and consequential human annoyance responses, the present study attempted to determine the mode and magnitude of acoustic change and to gauge the change in human annoyance reactions. Known as the Ma On Shan Railway (MOSR), the new railway extension was constructed and opened in December 2004 (Figure 1) to provide train services to the Ma On Shan (MOS) New Town with a population of around 250,000 who had previously relied on road transport to commute to the city.

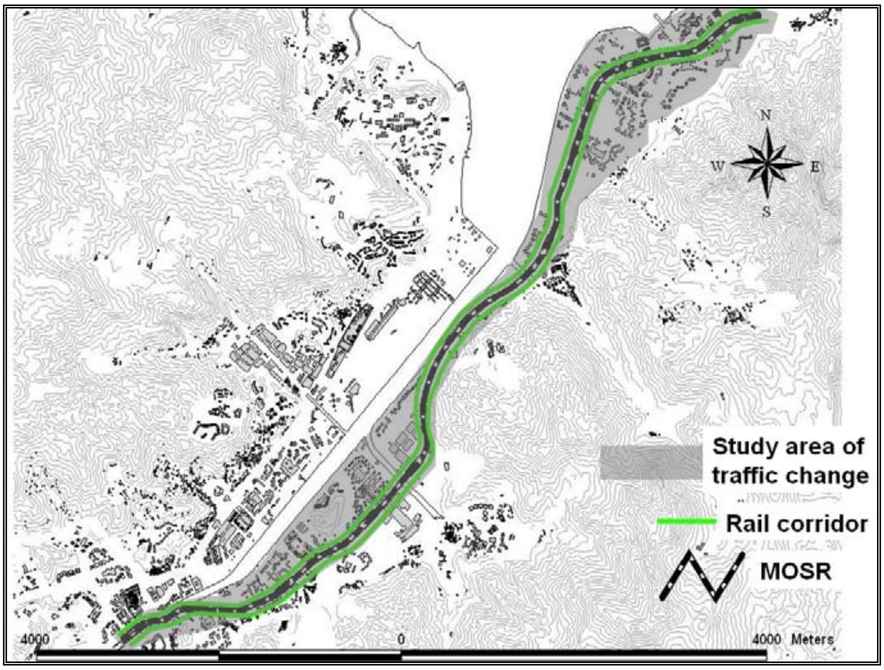

Figure 1: Map of the Ma On Shan Railway (MOSR) extension line in Hong Kong

This new railway extension, 11.4 km in length, run for most of its part along existing roadways with small sections (16 % of total length) encroaching on housing developments in relatively quiet areas. The extension has changed the traffic mode of the residents in MOS by providing them with an alternative transport mode and at the same time bringing a new noise source to the new town. Railway noise in Hong Kong is controlled by the Noise Control Ordinance which stipulates a maximum of 65 dB (LAeq, 30 min) for most parts of the new town and 60 dB (LAeq, 30 min) for the quieter areas. The potential railway noise impact attracted a lot of attention in the news media lasting for several months before and shortly after opening of the railway. The debate focused on the adequacy of noise mitigation measures provided by the railway operator.

METHODS

This research adopted a three-pronged approach to the research questions. Firstly, the change in acoustic environment, in terms of both noise level and sound sources, due to the operation of the MOSR was ascertained by noise mapping validated by field noise measurements. Secondly, noise annoyance response of local residents of MOS and its change over time was monitored by questionnaire surveys conducted before and after the operation of the MOSR. Finally, a "control experiment" was conducted to unravel possible non-acoustical factors affecting annoyance reaction by manipulating the information provided to the residents. It is hoped that results of this study can provide valuable information on the understanding of human noise annoyance response and insightful implications on how to minimize noise annoyance reactions towards new noise emitting infrastructure.

To ascertain the acoustic changes in the study area, a traffic impact study of the MOSR was undertaken (Lam & Au 2008), using road traffic and railway operation data obtained from official sources, traffic counts in the field and information from the bus and minibus operators on the rescheduling, rerouting and cancellation of bus services. These data were also used for noise exposure mapping using the software LIMA version 5.0 estimating the façade LAeq during peak hour of the day following the Calculation of Road Traffic Noise (CRTN) and Calculation of Railway Noise (CRN) methods respectively. Field measurements showed that the predictions were accurate to ± 2 dB(A) in about two thirds of sites (Lam & Au 2006). Changes in the exposure to road traffic and railway noises were determined, both separately and combined, before and after operation of the railway extension. A total of 74,860 dwelling units were covered in the noise mapping exercise.

To gauge the human annoyance reactions to the railway noise, over 6,000 invitation letters were dropped off at the mailboxes of all dwelling units in high-rise buildings of 18 housing estates which are in direct line of sight with the MOSR. Appointments were then made with those who accepted the invitation and whose age was 16 or above for a questionnaire interview at their dwellings. This was a follow-through study lasting for 18 months comprising of three separate phases. The first was a face-to-face interview before opening of the MOSR. Following the first interview, the respondents were contacted for a follow-up face-to-face interview immediately after opening of the MOSR and also a telephone interview one year later. In addition to ascertaining the respondents' level of annoyance towards the overall transportation noise using a 7-point numeric scale, the survey also obtained information on (a) residents' satisfaction with their living environment; (b) impact of noise on their daily activities; (c) their attitude towards road traffic and railway as a mode of transport; and (d) whether or not they rode on the new MOSR.

A separate "control experiment" involving the manipulation of information and targeting a different cohort of respondents was conducted in parallel with the social survey just mentioned. At about three months after opening of the new rail line, letters were mailed to thousands of residents of housing estates in line-of-sight with the railway, inviting them to participate in this study and to return a consent form in which they also reported their annoyance rating of the noise from the MOSR on a 7-point scale and their frequency of riding the train. About 2,500 completed consent forms were received. After eliminating those with missing data, those completed by individuals under the age of 16, those who spent less than 2 waking hours at home each day and those who reported extreme annoyance ratings, only 500 participants were left in the pool for subsequent surveys. They were randomly assigned to two groups of 250 matched in annoyance rating: Group N (the negative group) and Group P (the positive group). Respondents in these two groups were provided with fact sheets containing different information. For Group N, the fact sheet listed all the additional noise mitigation measures that could be, but had not yet been, employed to further reduce the noise from the MOSR; for Group P, the fact sheet listed all the noise mitigation measures that had already been employed to reduce noise from the MOSR. Both sets of information were obtained from publicity materials published by the Government and Railway Corporation and from extensive newspaper review. To ensure that respondents of both groups had read the information provided, they were asked to pick the most important five items from the information sheets. They were then requested to return a questionnaire indicating their level of satisfaction with the mitigation measures already employed. 103 and 128 completed questionnaires were returned from Groups N and P respectively.

A month later, another questionnaire was sent to the 231 participants who had responded to the fact sheets. This questionnaire contained 11 questions which assessed their noise annoyance response in different aspects of life and a question asking about their adaptation to the noise from the MOSR. This questionnaire was the same for both Group N and Group P. A total of 103 and 128 respondents in Group N and Group P respectively returned their completed questionnaires. To ascertain the validity of the returns, an attrition analysis was undertaken and there was no evidence to show that the respondents in later phases were biased samples of earlier ones.

RESULTS

Traffic and noise impacts

The information collated from various sources and field counts indicates that the traffic impacts were different for the main and secondary roads in the township. On the main roads, the total vehicular flow increased because of natural growth in population and increasing demand for transportation link with other towns and the city. On the secondary roads, the opening of the MOSR has resulted in some reduction in traffic flow probably because of a change in transport mode of the residents. It is noteworthy that the percentage of heavy vehicles decreased both on the main and secondary roads as a result of the cancellation of franchised bus and minibus services after opening of the MOSR.

Results of the noise mapping indicate that the noise exposure of dwellings in the study area increased only slightly immediately after opening of the railway and there was a further small increase one year later (Lam & Au 2008). About 30 % of the dwellings in MOS, located mostly along the railway corridor, experienced 2 to 4 dB(A) increase in noise level after opening of the MOSR; and majority of the rest experienced an increase of less than 1 dB(A). The greatest increase took place in housing estates located in relatively quiet parts of the new town where the background was less than 55 dB(A).

In addition to changes in noise exposure, the study also shows that the sources of transportation noise have changed. Road traffic was the only source of transportation noise in the past. After opening of the MOSR, about 40 % of the dwellings were exposed to varying levels of railway noise on top of the pre-existing road traffic noise. Since the railway was mostly constructed alongside roads, railway noise was the dominant source (railway noise > road traffic noise by at least 5 dB(A)) in only 0.2 % of all dwelling units. These results suggest that the original noise from road traffic together with the small increase of traffic flow on the main roads overwhelmed the noise from MOSR in most parts of the town.

Change in noise annoyance reactions

As afore-mentioned, the questionnaire surveys had been conducted in 3 stages. The first survey was administered about 2 to 6 months before opening of the railway, followed by subsequent surveys conducted 3 months, and one year after operation of the MOSR. The results in Table 1 indicate that despite the small increase in noise exposure after operation of the railway, the mean reported annoyance score dropped by 0.37 on the 7-point scale (P < 0.001) after railway opening. The annoyance scores dropped further by another 0.65 (P < 0.001) about one year later.

Analysis of the survey data shows that neither the noise exposure level nor the magnitude of change was a significant determinant of noise annoyance. Results of the same data by regression and path analyses show that while the acoustic measurements were insignificant, some other factors, such as disturbance on sleeping and perceived noisiness, were better predictors of annoyance level (Lam & Au 2008). Such results were not unexpected as the change in noise exposure from one phase to the next was small in magnitude.

Table 1: Change in annoyance scores at different stages of the survey

Pair	Mean annoyance score	Standard deviation	Difference between 2 phases	N	Sig of Paired t-test
Before MOSR opening	3.38	1.633	-0.37	361	.000
3 months after MOSR opening	3.01	1.720			
3 months after MOSR opening	3.44	1.853	-0.65	68	.000
1 year after MSOR opening	2.79	2.057			

(Mean annoyance score scale - 1: Not at all annoyed; 7: Very much annoyed)

Effects of information bias and riding frequency

Given that the change in annoyance scores could not be accounted for by acoustic factors such as the noise exposure level and noise source, the study investigated other possible non-acoustic factors. Realizing that opening of the new railway extension attracted a great deal of media attention and public debate on the adequacy of noise mitigation measures, a “control experiment” was launched to determine the extent to which biased information and riding frequency may affect annoyance ratings (Chan & Lam 2008).

Table 2 shows the results of the ANOVA comparing the reported ratings between Group N and Group P. Since the group members were assigned randomly, the reported noise annoyance was initially not significantly different between the two groups. It is therefore reasonable to assume that any differences between groups in subsequent phases were induced by the biased information provided.

Table 2: Results of ANOVA comparing the responses between Group N and Group P

Phase	Question	Sample size	Mean	Std. dev.	F value	P value (2-tailed)
1	Noise annoyance caused by MOSR	N = 249 P = 251	N = 3.76 P = 3.73	N = 0.793 P = 0.793	0.096	0.757
2	Satisfaction with noise mitigation measures	N = 103 P = 128	N = 3.48 P = 4.48	N = 1.195 P = 0.955	50.04	0.000*
3	Adaptation to noise from MOSR	N = 81 P = 100	N = 2.89 P = 2.73	N = 1.151 P = 1.145	0.858	0.356

* Significance detected with 95 % confidence interval

It can be seen that Group P was significantly more satisfied with the noise mitigation measures employed than Group N (P < 0.001) in Phase 2, due to the effect of information bias. In Phase 3, the adaptation rating reported by Group N was higher than that reported by Group P, but the difference between the two groups was insignificant (P > 0.356).

To ascertain the effect of frequency of riding on the railway on noise annoyance, an ANOVA was undertaken comparing the reported annoyance scores among non-riders, occasional riders and regular riders of the MOSR (Table 3). In Phase 1, the difference among the three groups was significant (P < 0.001). In Phase 2, the difference among the three groups was no longer significant (P > 0.73). In Phase 3, the adaptation also showed no significant difference among the three groups (P > 0.31).

Table 3: Results of ANOVA comparing the responses on questionnaires among non-riders (N), occasional riders (O) and regular riders (R) of MOSR

Phase	Question	Sample size	Mean	Std. dev.	F value	P value (2-tailed)
1	Noise annoyance caused by MOSR	N = 50 O = 361 R = 89	N = 4.08 O = 3.71 R = 3.69	N = 0.804 O = 0.785 R = 0.777	5.119	0.006*
2	Satisfaction with current noise mitigation measures	N = 26 O = 171 R = 34	N = 4.00 O = 4.01 R = 4.18	N = 1.296 O = 1.181 R = 1.086	0.306	0.737
3	Adaptation to noise from MOSR	N = 21 O = 133 R = 27	N = 3.14 O = 2.77 R = 2.67	N = 1.459 O = 1.091 R = 1.144	1.155	0.317

* Significance detected with 95 % confidence interval

To ascertain whether there are interactions between information bias and MOSR riding frequency in Phase 3, a MANOVA was undertaken using a 2 (rider x non-rider) x 2 (information bias x riding frequency) between subject factorial design (Chan & Lam

2008). The results indicate that both information bias ($P < 0.01$) and riding frequency ($P < 0.02$) significantly affected respondents' noise annoyance reactions, but no interaction was observed between the two factors ($P > 0.40$).

DISCUSSION AND CONCLUSIONS

The objective of this study was to unravel factors affecting noise annoyance response when there is a sudden increase in noise exposure following the introduction of a new railway extension. More specifically, the study attempted to determine whether or not non-acoustic factors play a role in shaping noise annoyance response. The opening of a new railway extension in the MOS new town offered an opportunity to monitor changes in the acoustic environment and human response over a two-year period using noise mapping technique, repeated social surveys and an experiment to gauge human reactions given different information about the railway project.

For this type of study, it would be ideal to adopt the framework proposed by Brown and van Kamp (2005) which requires the first social survey to be conducted well in advance of the operation of the railway extension. This was unfortunately not feasible in this study due to time and resource constraints. Nevertheless, findings of the repeated social surveys undertaken in this study six months before, three months following, and one year after, operation of the railway do provide some insight into how local residents react to the sudden change in acoustic environment. Findings of the social survey reveal a statistically significant decline in noise annoyance reactions over the study period despite a small increase in noise levels caused by the new railway noise source.

The current experimental setup does not allow all non-acoustic factors that might possibly affect annoyance response to be fully explored. However, realizing that opening of the new railway extension also coincides with a phase with heightened media attention, intense public debate and possible change in the habit of transportation, the present study incorporated a "control experiment" attempting to investigate how two non-acoustic factors, namely information bias and riding frequency, can affect the annoyance response of local residents exposed to the noise created by the new railway line. Findings of the experimental study show that information bias, depending on which side of the coin is revealed to the recipient, can have quite opposite effects. Respondents receiving only information on positive measures taken by the authority to reduce noise emission are more tolerant of the noise impact, but those receiving only critical views tend to be more annoyed because they feel that not all measures to reduce noise have been employed. The effect of information bias may start very strong and then decrease in magnitude but stay significant for at least a few weeks. Regular riders were more tolerant of the new railway noise than occasional riders and non-riders, but this effect, which is relatively stable over time, could be overwhelmed by that of information bias.

The study of noise annoyance reactions towards step-changes of noise exposure has attracted considerable attention in recent years. Findings of this study confirm that significant changes in annoyance response can occur shortly after the introduction of a new noise-emitting infrastructure and such change cannot be ascribed entirely to changes in the acoustic environment. Among the many possible factors that may account for the temporal shift in annoyance reactions, the effects of media sensitization, information bias and the habit of transportation cannot be overlooked.

ACKNOWLEDGEMENT

This research was substantially supported by a grant from the Research Grants Council of the Hong Kong SAR Government (Project No. CUHK 4248/03H).

REFERENCES

Brown AL, van Kamp I (2005). Towards a design for studies of response to a change in noise exposure. In: Proceedings of InterNoise 2005 (CD-ROM), Rio de Janeiro, Brazil.

Chan TC, Lam KC (2008). The effects of information bias and riding frequency on noise annoyance to a new railway extension in Hong Kong. Transportation Res, Pt. D 13: 334-339.

Hume KI, Morley H, Thomas C (2004). Community response to a new runway: preliminary results. In: Proceedings of Inter-Noise 2004. Prague, Czech Republic.

Job RSF, Hatfield J (1998). Community reaction to noise. Acoust Austral 26: 35-39.

Joncour C, Gautier C, Lambert J (2000). Annoyance due to combined noise source. In : Proceedings of Internoise 2000 (CD-ROM), Nice, France.

Lam KC, Au WH (2006). Quantifying the spatial and temporal variations in the urban soundscape by noise mapping. In: Starrett SK, Hong J, Lyon WG (eds.): Environmental science and technology 2006, Vol. 2. Proceedings from the 2nd International Conference on Environmental Science and Technology, held August 19-22, 2006 in Houston, Texas, USA (pp 380-384). Houston, TX: American Science Press.

Lam KC, Au WH (2008). Human response to a step change in noise exposure following the opening of a new railway extension in Hong Kong. Acta Acust Acust (in press).

Lam KC, Chan PK, Chan TC, Au WH, Hui WC (2008). Annoyance response to mixed transportation noise in Hong Kong. Appl Acoust (in press).

Lambert J (1998). Assessing the railway bonus: the need to examine the “new infrastructure” effect. In: Proceedings of Internoise 1998 (CD-ROM), Christchurch, New Zealand.

Miedema HME, Vos H (1998). Exposure-response relationships for transportation noise. J Acoust Soc Am 104: 3432-3445.

Schreckenberg D, Schuemer R, Schuemer-Kohrs A, Griefahn B, Moehler U (1998). Attitudes toward noise source as determinants of annoyance. In: Fastl H, Scheuren J (eds.): Euronoise 98. Designing for silence. Prediction, measurement and evaluation of noise and vibration. Proceedings, Vol. I (pp 595-600). München.

Solberg S (2005). Giving people control of their noise problem – techniques to prevent annoyance. In: Proceedings of Forum Acusticum 2005. Budapest, Hungary.