TRAFFIC NOISE AND ANNOYANCE IN WINDSOR, ONTARIO: COMMUNITY TOLERANCE LIMITS AND EFFECTS OF CONTEXT ON NOISE RESPONSES

Tor H. Oiamo
Western University, London, Ontario
Isaac N. Luginaah
Western University, London, Ontario

Introduction

Recent research on the impacts of environmental noise on health and wellbeing can be broadly categorized by three themes. The first theme is the enduring concept of soundscapes or the sonic characteristics of indoor and outdoor environments in situated locales. Health researchers consider soundscapes as context dependent, within which perceptions of sounds can be modified by individual and social factors and consequently affect health (Lercher et al. 2013). The second theme of noise and health research is related to soundscapes, but pursues a generalizable understanding of cognitive appraisals of noise as measured by annoyance or disturbance in relation to exposures, which are predominantly from road, rail and air transport. For example, research in this area is concerned with establishing reliable dose-response relationships between traffic noise and different levels of annoyance (Miedema and Oudshoorn 2001). Annoyance and sleep disturbance are perhaps the most important moderator of adverse health outcomes associated with noise exposure and lead to the third theme concerning direct measurements of health. Cardiovascular diseases including hypertension and myocardial ischemia are the most severe outcomes identified, but research has also demonstrated links to auditory development and cognitive performance among other health measures (Babisch 2008, Matheson et al. 2010, van Kempen et al. 2010, Chang and Merzenich 2003, Shepherd et al. 2013).

Traffic noise was identified as a public health hazard nearly a century ago, but industrialized countries including Canada did not begin regulating community noise until the rapid post-WWII increase in road freight and passenger vehicles became an apparent problem during the late 1960s and 1970s. Amendments to the Canadian Ministry of Environment's *Environmental Protection Act* in 1975 provided municipalities the legislative authority to adopt noise by-laws. In 1978 the Ontario Ministry of Environment (MOE) published the "Guidelines for Noise Control in Land use Planning," in which a model by-law recommended that equivalent (L_{eq}) sound levels for indoor exposure should not exceed 40 A-weighted decibels (dB(A)) for bedrooms and 45 dB(A) for living rooms. Recommended outdoor exposure limits were set to 55 dB(A) during daytime hours (7:00am-11:00pm) and 50 dB(A) during nighttime hours. In 1997, the MOE updated its policies with the "Noise Assessment Criteria in Land Use Planning: Requirements, Procedures and Implementation" and outdoor exposure levels were set to 55 dB(A) during all hours while indoor exposure limits remained the same. The most recent MOE guidelines from 2013 (NPC-300) maintain these limits but provide more details on assessment methods and differentiate between land uses and sound sources. For reference, normal conversation becomes difficult with background sound levels above 50 dB(A).

The "Guidelines for Community Noise" by the World Health Organization (WHO, 1999) suggests that 30 dB(A) for continuous noise and 45 dB(A) for single noise events should not be exceeded to avoid sleep disturbance. The guideline states that outdoor living areas should not exceed 55 dB(A) for continuous noise to protect the majority of people from being seriously annoyed and 50 dB(A) to protect the majority of people from being moderately annoyed during the daytime.

An extension of this document that focused specifically on night noise guidelines were published by the WHO Regional Office for Europe in 2009, in part to inform further development of the 2002 European Union Environmental Noise Directive. This Directive requires cities with populations greater than 250,000 to assess and manage environmental noise across their entire regions. The new night noise guidelines reflect advancements in research and recommend that the yearly exterior or facade L_{night} does not exceed 40 dB(A), the lowest observed adverse effect level (Kim and van den Berg 2010). This level sets a precautionary standard that protects vulnerable groups such as children and the elderly, and allows for sleeping with a window slightly opened, which reduces the noise from outside to inside by roughly 15 dB. The WHO estimates that 40% of the population in EU countries is exposed to facade noise levels above 55 dB(A), and more than 30% is exposed to levels exceeding this value at night.

Determinants of Noise Annoyance

Previous research identified traffic as the most annoying source of environmental noise in Canada. Approximately 9% of Canadians are highly annoyed by traffic noise, while this number is significantly higher at 18% for people who live within 30m of a heavily travelled road (Michaud et al. 2008, Michaud et al. 2005). In general, there is strong evidence for consistent dose-response curves between sound levels from different sources of transportation noise and high annoyance (Miedema and Oudshoorn 2001, Schultz 1978). However, noise levels alone explain less than half the variance in noise annoyance based on survey response data (Schomer et al. 2013). Furthermore, discrepancies in the prevalence of high annoyance in different communities with similar noise levels suggest that the position of the dose-response curve depends on a given community's soundscape. Community tolerance levels (CTL) that correct for these differences can be calculated by comparing the predicted and observed prevalence of high annoyance based on noise assessments and surveys (Schomer et al. 2012).

Many alternative acoustic and non-acoustic variables have been proposed to predict the unexplained variance in community responses to noise. Proposed acoustic modifications include different dB weighting scales, tone corrections and different ways to incorporate single noise events. However, high correlations between previously proposed noise metrics and the standard day-night level (DNL) and day-evening-night level (DENL) utilized in North America and Europe, respectively, suggest that a better metric in the future is unlikely (Schomer et al. 2013). Non-acoustic variables include noise sensitivity, attitudes towards the noise source and population characteristics such as age and income. Schomer et al. (2013) suggest that non-acoustic variables can be divided into community and individual contexts. Within this framework the CTL provides a metric expressed as a DNL for specific community contexts that moderate noise responses. Therefore, the CTL provides an opportunity to understand how specific attributes of communities affect their soundscapes, in other words the perception of sonic environments. This is a departure from traditional noise research focused on negative impacts as measured by annoyance, because community attributes may be found to increase *or* decrease tolerance levels, thereby providing knowledge on how to improve health rather than decrease health risk. Urban form represents one such community attribute and recent research demonstrates how different forms influence noise exposures (Silva et al. 2014, Lam et al. 2013, Montalvao Guedes et al. 2011). These are important contributions to the literature, but only represent physical aspects of urban form. Additional knowledge on how urban forms influence soundscapes and community expectations about their sonic environments will be equally if not more important to promote sustainable urban development.

Study Objectives and Methods

The current study investigates traffic noise exposure and annoyance in Windsor, Ontario. This study site provides several unique opportunities to advance environmental noise research because of its urban form and geographic context. Few studies have examined traffic noise annoyance in a low-density urban environment such as Windsor, which is representative of small and medium sized cities in North America. The Windsor-Detroit Gateway is also a crucial trade corridor that depends on the busiest border crossing in North America, the Ambassador Bridge, to support the movement of goods, services and people between the US and Canada. Until recently, most of the traffic to and from the Ambassador Bridge followed a signalized road through a mix of suburban residential and commercial areas in Windsor. This was an unusual configuration for a border-crossing corridor, but more interestingly from an environmental noise perspective were the high volumes of commercial and passenger vehicles through neighbourhoods with relatively little to no noise mitigation measures such as berms, walls or freeway buffers.

The objectives of this study are as follows: (i) Model traffic noise exposure surrounding the border crossing corridor and in a control area in east Windsor to predict levels of residential noise annoyance (ii) Compare predicted and observed levels of annoyance to determine Community Tolerance Levels in the corridor and control study areas (iii) Identify potential predictors of the hypothesized difference in CTLs between the corridor and control areas.

Residential facade levels of traffic noise were modeled with SoundPLAN 7.2 noise simulation software based on Traffic Noise Model (FHWA) emission standards, which are very similar to the ORNAMENT methods developed by the MOE. The Cross-Border Institute produced all traffic data for the noise model. Traffic inputs for the crossing corridor were computed from City of Windsor intersection counts, the US Bureau of Transportation Statistics, Transport Canada, the Detroit River International Crossing Study and hourly counts from video cameras provided by the Ontario Ministry of Transportation in 2009 (Nameghi et al. 2013). Traffic inputs for the remainder of the road network were based on a simulation for 2006 within the COMMUTE urban modeling system (Maoh et al. 2013). Community health and traffic impact surveys were administered to residents in census tracts surrounding the corridor in 2009 (N=442) and 2013 (N=267), as well as eight census tracts in the control area in 2013 (N=344) that were matched to the corridor based on age and income distributions. The surveys measured noise annoyance and disturbances, health and wellbeing, attitudes towards the community and environment, travel habits and demographic characteristics.

Preliminary results suggest that there are significant differences in levels of traffic noise annoyance in the control and corridor areas, but the association between noise and annoyance depends on whether respondents consider residential versus neighbourhood soundscapes. These results are based on noise modeled from peak morning traffic volumes, while DNL exposures will provide valuable insight on the influence of nighttime traffic through the corridor. Furthermore, notable differences in noise sensitivity between the study areas indicate that residents surrounding the border corridor may be desensitized due to high levels of noise and traffic exposure, but calculating Community Tolerance Limits will be necessary to understand the implications of these observed differences.

References

Babisch, W. 2008. Road traffic noise and cardiovascular risk. Noise and Health. **10**(38): 27-33.
WHO. 1999. Community guidelines for noise. Eds. Berglund, B., Lindvall, T., Schwela, D.H. World Health Organization.
Chang, E.F., and Merzenich, M.M. 2003. Environmental noise retards auditory cortical development. Science. **300**(5618): 498-502.
Kim, R., and van den Berg, M. 2010. Summary of night noise guidelines for Europe. Noise & Health. **12**(47): 61-63.

Lam, K., Ma, W., Chan, P.K., Hui, W.C., Chung, K.L., Chung, Y.T., Wong, C.Y. and Lin, H. 2013. Relationship between road traffic noisescape and urban form in Hong Kong. Environ. Monit. Assess. **185**(12): 9683-9695.
Lercher, P., Evans, G.W. and Widmann, U. 2013. The ecological context of soundscapes for children's blood pressure. J. Acoust. Soc. Am. **134**(1): 773-781.
Maoh, H., Khan, S., Anderson, W.P. and Su, Y. 2013. Assessing the impacts of a major highway infrastructure project: The windsor-essex parkway. Cross Border Transportation Centre, University of Windsor.
Matheson, M., Clark, C., Martin, R., van Kempen, E., Haines, M., Barrio, I.L., Hygge, S. and Stansfeld, S. 2010. The effects of road traffic and aircraft noise exposure on children's episodic memory: The RANCH project. Noise & Health. **12**(49): 244-254.
Michaud, D.S., Keith, S.E. and McMurchy, D. 2008. Annoyance and disturbance of daily activities from road traffic noise in Canada. J. Acoust. Soc. Am. **123**(2): 784-792.
Michaud, D.S., Keith, S.E. and McMurchy, D. 2005. Noise annoyance in Canada. Noise Health. **7**(27): 39-47.
Miedema, H.M., and Oudshoorn, C.G. 2001. Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals. Environ. Health Perspect. **109**(4): 409-416.
Montalvao Guedes, I.C., Bertoli, S.R. and Zannin, P.H.T. 2011. Influence of urban shapes on environmental noise: A case study in Aracaju - Brazil. Sci. Total Environ. **412**: 66-76.
Nameghi, H.M., Xu, X., Lee, C. and Henshaw, P. 2013. Sensitivity to input parameters of Mobile 6.2/AERMOD simulated emissions and concentrations. Int. J. Environ. Pollut. **53**(1): 24-45.
Schomer, P., Mestre, V., Schulte-Fortkamp, B. and Boyle, J. 2013. Respondents' answers to community attitudinal surveys represent impressions of soundscapes and not merely reactions to the physical noise. J. Acoust. Soc. Am. **134**(1): 767-772.
Schomer, P., Mestre, V., Fidell, S., Berry, B., Gjestland, T., Vallet, M. and Reid, T. 2012. Role of community tolerance level (CTL) in predicting the prevalence of the annoyance of road and rail noise. J. Acoust. Soc. Am. **131**(4): 2772-2786.
Schultz, T.J. 1978. Synthesis of social surveys on noise annoyance. J. Acoust. Soc. Am. **64**(2): 377-405.
Shepherd, D., Welch, D., Dirks, K.N. and McBride, D. 2013. Do quiet areas afford greater health-related quality of life than noisy areas? International Journal of Environmental Research and Public Health. **10**(4): 1284-1303.
Silva, L.T., Oliveira, M. and Silva, J.F. 2014. Urban form indicators as proxy on the noise exposure of buildings. Appl. Acoust. **76**: 366-376.
van Kempen, E., van Kamp, I., Lebret, E., Lammers, J., Emmen, H. and Stansfeld, S. 2010. Neurobehavioral effects of transportation noise in primary schoolchildren: A cross-sectional study. Environ. Health. **9**: 25.