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NOISE CONTROL FOR QUALITY OF LIFE

Annoyance to traffic noise and annoyance to air pollution: an orthogonal or co-varying relationship in noise-sensitive individuals?

Kim N. Dirks[1], Daniel Shepherd[2], David Welch[1], David McBride[3]

[1] School of Population Health,
The University of Auckland, Auckland, New Zealand
[2] Department of Psychology, School of Public Health,
Auckland University of Technology, Auckland, New Zealand
[3] Department of Preventive and Social Medicine,
University of Otago, Dunedin, New Zealand

ABSTRACT

Noise-sensitive individuals can be described by two key characteristics. Firstly, they are more likely to pay attention to sound and evaluate it negatively (e.g. as threatening or annoying). Secondly, they have stronger emotional reactions to noise, and consequently, greater difficulty habituating. It has been noted that noise sensitivity correlates with negative effect, a dispositional tendency to negatively evaluate situations and the self. Individuals high in such traits are more likely to report negative features for their environment, and those reporting high levels of noise sensitivity may report greater sensitivity to other sensory stimuli such as smell and scent, bright light and pain. Research investigating the relationship between noise sensitivity and chemical sensitivity, however, failed to uphold the expected relationship between the two classes of stimuli if a common underlying trait such as negative effect is assumed to cause them. Here we report data which examines the relationship between noise sensitivity and annoyance to noise and air pollution. Our results suggest that noise exposure itself drives annoyances ratings in noise sensitive individuals, and not some other non-noise related factor such as personality.

Keywords: Noise, Air Pollution, Sensitivity, Quality of Life

1. INTRODUCTION

The quality of the physical environment in which we live has been shown to impact on human health and health-related quality of life. New Zealand is known internationally for its green-clean image, yet Aucklanders' have a history of high reliance on private vehicles for commuting and Auckland transport policy has tended towards the development and expansion of the road network to cater for the increasing demand for private transport (cars) rather than the development of public transport and its associated infrastructure. Moreover, poor town planning decisions have meant that many people live in very close proximity to busy roads and motorways (the 'road corridor') so are vulnerable to the adverse effects of road traffic, including noise and air pollution as well as potential degradation in quality of life.

There is now extensive evidence linking air pollution to adverse impacts on human health [1]. Many studies have focused specifically on urban areas and vehicle-generated pollution in particular as road vehicles are one of the major sources. In the city of Auckland (New Zealand) alone, despite its relative modest levels of air pollution compared to many urban centres worldwide, air pollution is estimated to cost $1 billion and contribute over 300 premature deaths a year [2]. Increased admissions to hospital in Auckland for respiratory and circulatory causes are also associated with periods of elevated levels of air pollution [3].

In addition to traffic-generated air pollution, the noise vehicles create is an issue; traffic-related air pollution is strongly correlated with traffic noise levels [4-5]. In urban areas, air pollution concentrations are typically highest along busy road corridors, environments in which the traffic noise levels are also typically the highest. A high exposure to road traffic noise has been linked to cardiovascular disease, hypertension, and ischemic heart disease and can also result in sleep disturbance [1]. Therefore, those living in close proximity to major roads (and within the road corridor) can be expected to experience adverse health outcomes due to both vehicle-generated air pollution and environmental noise.

While there is mounting epidemiological evidence, less is known about the psychological processes involved in noise and air pollution exposure, and how they moderate the risk of adverse health outcomes. Noise annoyance, defined as a feeling of displeasure, nuisance, disturbance, or irritation caused by a specific sound [6], is one of the most well documented consequences of unwanted noise, and can compromise positive well-being and health-related quality of life [7].

The extent to which people are annoyed by sounds has been found to be correlated with noise sensitivity [8-9]. In fact, noise sensitivity, a stable personality trait, invariant across noise level, has been found to be a strong predictor of noise annoyance [10-12]. Those sensitive to noise are more likely to pay attention to sound and evaluate it negatively (e.g. find it threatening or annoying). In addition, they tend to have stronger emotional reactions to noise, and consequently, greater difficulty habituating. It is not clear whether this is the same in relation to air pollution though there is evidence to suggest that people habituate to some extent, at least to the smell of air pollution.

Experientially, noise-sensitive individuals characteristically suffer from noise-induced irritability, stress-related disease, headaches, and poor sleep, all of which strongly negate good health and quality of life. Noise sensitivity is an identifiable reaction modifier to noise that is currently well described but as yet sufficiently explained. This lack of aetiological progress is likely caused by the fact that noise sensitivity mechanisms may be multifactorial in nature, with factors influencing the degree of noise sensitivity acting independently or interactively. Candidate mechanisms are listed in Table 1, along with associated disorders in which noise sensitivity frequently occurs and their implicated brain regions. The purpose of Table 1 is to emphasise the possible multifactorial nature of noise sensitivity, and demonstrate its likely biological basis, at least in part [13]. Note however, that while some clinical populations exhibit noise sensitivity as a characteristic symptom, the presence of disease, disorder or disability is not a precondition of noise sensitivity, and indeed, at the population level, individuals report a wide range of different responses to noise ranging from highly tolerant to highly sensitive.

Given the high prevalence of noise sensitivity in both general and clinical populations, it is of interest to further investigate the candidate mechanisms. It has been noted that noise sensitivity correlates with negative affect, a dispositional tendency to negatively evaluate situations and the self. Individuals high in such traits are more likely to report negative features of their environment, and those reporting high levels of noise sensitivity may report greater sensitivity to other sensory stimuli such as smell and scent, bright light and pain. Thus, a question which remains unanswered is the extent to which a complaint about the quality of air or noise represents a unique psychological reaction to a particular exposure or whether it is just an inherent quality of the respondent (i.e., a personality trait such as ‘negative affect’). Research investigating the relationship between noise sensitivity and chemical sensitivity, however, failed to uphold the expected relationship between the two classes of stimuli if a common underlying trait such as negative affect were assumed to cause them.

Table 1 - Potential explanations for noise sensitivity, examples of associated disorders, and implicated brain regions.

Proposed Mechanism	Disorder	Implicated Brain Region
Hyperacusis	Autism [14]	Peripheral Auditory System
Hyper-vigilance	Anxiety Disorder [15]	Stria terminalis / Amygdala
Personality	Traumatic Brain Injury [16]	Frontal Lobes
Sensory Overload (bottom up)	Schizophrenia [17]	Thalamus
Sensory Overload (top down)	Major Depressive Disorder [18]	Prefrontal cortex

Here we report data examining the relationship between noise sensitivity and annoyance to noise and air pollution in two distinct urban locales: low and high traffic exposure areas. If noise sensitivity simply reflects an underlying trait of negative affect, then the average annoyance ratings can be expected to be similar across area, as it will likely be internal processes (e.g., personality) and not external factors driving the response.

2. METHODS

2.1 Sample

Data for this study were collected in Auckland New Zealand. The ‘Motorway’ group (n=373) consisted of residents living within 50 m of Auckland’s motorway system. The noise levels in the Motorway area was estimated to be approximately 76 dB(A) LDN. The ‘Control’ group (n=253) consisted of residents from two areas within the Auckland Region located at least 2 km away from any significant source of environmental noise (e.g. industry or roads) and with noise levels estimated to be around 55 dB(A) LDN. The Motorway and Control groups were socioeconomically matched (middle to high deprivation) and were from suburban neighbourhoods.

2.2 Data collection

Each of the participants completed the WHOQOL-BREF, a 26-item version of the WHOQOL-100 assessment. This instrument offers composite measures of physical (7 items), psychological (6 items), and social (3 items) HRQOL, an additional 8 item domain measuring environmental QOL and two ‘generic’ items asking about general health and overall quality of life. The scale items were presented by way of a five-point scale with appropriate descriptors anchoring each end. In addition, seven items were included relating to annoyance due to environmental factors including air pollution (‘air pollution from traffic’, ‘air pollution from household chimneys’, ‘other, specify’ as well noise (‘noise from traffic’, ‘noise from other neighbours’, ‘other noise, specify’). These items were also presented by way of a five-point scale ranging from ‘not annoyed at all’ to ‘extremely annoyed’. Each house received two copies of the questionnaire, delivered in their postbox and included a post-replied envelope. The title of the survey, the ‘Wellbeing and Neighbourhood Survey’ was designed to mask the true intent of the study. The surveying of both the Motorway and the Control groups was carried out in July 2010. Data analyses were carried out using SPSS Version 18 and consisted of chi-square tests and ANOVA.

3. RESULTS

Table 2 shows the frequency distribution of noise sensitivities in the Motorway group and the Control group. No significant differences were found in the distributions of noise sensitivities between those living in quiet areas and those living within 50 metres of the motorway ($\chi^2(8) = 9.786$, $p = .280$). Based on this sample, 37% of the population rate themselves as ‘not noise sensitive’, 52% as ‘moderately noise sensitive’ and 11% as ‘highly noise sensitive’.

Table 2 - Frequency distribution of noise sensitivities

	Sensitivity		
Area	Not Noise Sensitive	Moderately Sensitive	Highly Noise Sensitive
Motorway	98	125	26
Control	91	139	31
TOTAL	189 (37%)	264 (52%)	57 (11%)

Figure 1 shows the mean noise annoyance and air pollution annoyance for both the Motorway group and the Control group as a function of noise sensitivity. For a given noise sensitivity, there are significant differences in the mean noise annoyance scores between the Motorway group and the Control group (p<.001), but not the mean air pollution annoyance scores (p>.05), with the exception of the moderately noise sensitive group (p=.003). Note that in all four groups (motorway and control and air pollution annoyance and noise annoyance), the mean annoyance scores in the 'moderately noise sensitive' group lies almost exactly halfway between the mean scores for the least noise sensitive group and the highly sensitive group. This suggests that the scale is appropriate/robust.

There are significant differences in the mean noise annoyance scores between levels of noise sensitivity for the motorway group ($F(2)$ = 5.888, p = .003) but not for the control group ($F(2)$ = 0.376, p = 0.687). *Post hoc* tests revealed significant differences in mean noise annoyance ratings between the least and moderate sensitivity groups (p=.004), and the least and the highly sensitive group (p<.001) in the motorway locale. The same pattern is found when annoyance to air pollution is the dependent variable, with significant differences at the motorway locality ($F(2)$ = 6.403, p = .002), but not at the quiet locality ($F(2)$ = 2.448, p = .089). Here *post hoc* testing resulted in significant differences in mean air pollution annoyance ratings between the least and moderate sensitivity groups (p=.024), and the least and the highly sensitive group (p=.003) in the motorway locale. Note that interaction effects were all non-significant (p<.05).

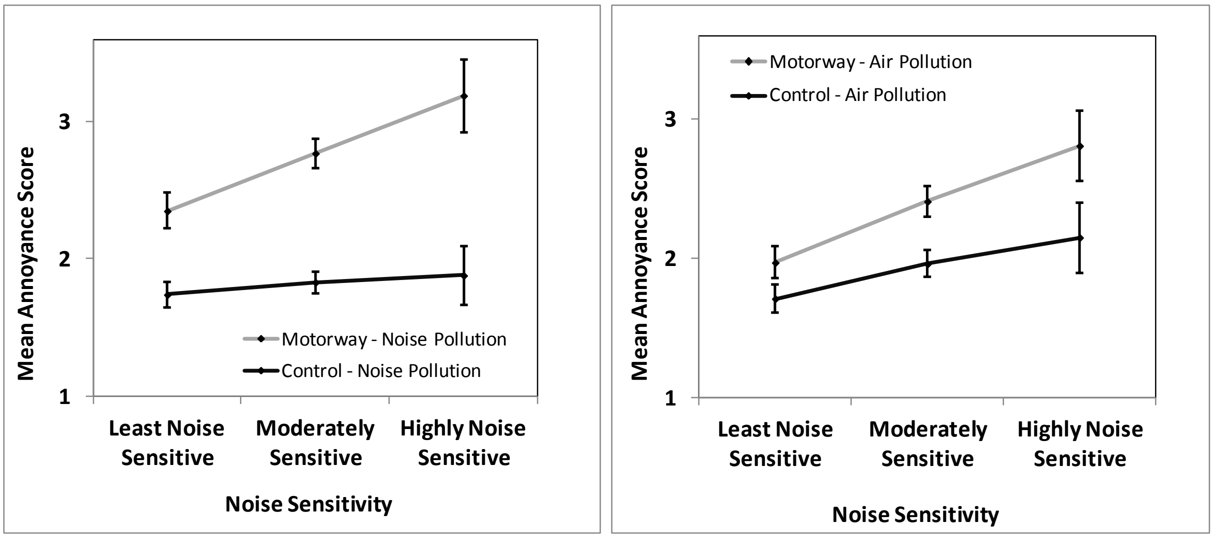

Figure 1 - Mean annoyance scores across sensitivity groups for the motorway and the control group for a) noise pollution annoyance, b) air pollution annoyance. The error bars represent the standard error of the mean (SEM).

4. DISCUSSION

The results suggest that noise sensitive individuals are not less likely to live in close proximity to a motorway. Therefore the choice of house location is not influenced by an individual's self-rated noise sensitivity as one might expect. Both the mean annoyance rating to air pollution and road traffic noise were found to increase with increasing noise sensitivity. Individuals that are noise sensitive are more likely to be adversely affected (annoyed) by the motorway located in close proximity to where they live. Additionally, for a given noise sensitivity, those living in the Control area are less annoyed by both road traffic noise and air pollution.

One proposed causal mechanism for sensitivity to noise is that belligerent personality types, reflecting an over-willingness to complain about objects and events beyond ones' control, lead to an exaggeration of the impacts of noise exposure [19]. However, individuals consistently exhibiting negative traits (i.e., negative affect) would be expected to be consistently annoyed by sources of pollution in their environment, irrespective of its dose. This notion of critical tendencies influencing an individual's responses to self-report scales allowed a number of hypotheses to be derived. First, mean noise annoyance ratings would be consistent across the high noise sensitive group, irrespective of locality, reflecting a tendency to complain rather than noise exposure *per se*. Second, and for the same reasons, the same pattern would hold for air pollution annoyance. Third and fourth, there will be significant differences in mean air pollution ratings across the three noise sensitive groups, for either area, again indicating that negative disposition maybe influencing rating. Our results show that only one of the four hypotheses is supported, specifically, there is a mean difference in air pollution annoyance across the three noise sensitivity groups for the motorway condition, with larger means associated with larger degrees of noise sensitivity. Even so, there is more than one explanation for this difference, which somewhat attenuates the support for personality factors as influencing responses to environmental pollutants. Pertinently, those who report greater sensitivity to noise may do so because, given their living environment, they are more exposed to noise and more aware of their sensibilities. Consequently, they may be more exposed to air pollution.

Our finding that noise sensitivity itself is not a sufficient precondition to predict strong annoyance responses to both noise and air pollution supports previous work in this area [13] differentiating noise sensitivity from chemical sensitivity. Indeed, the data in Figure 2a make a powerful statement that it is noise exposure itself that drives annoyances ratings in noise sensitive individuals, and not some other non-noise related factor such as personality. However, the large differences in noise annoyance ratings seen between non-sensitive and sensitive individuals still require an explanation. Current, biological-based, explanations can be derived from clinical populations experiencing noise sensitivity (see Table 1). The likely mechanism, in isolation or in tandem with other processes, cannot be elucidated from the current study. There are, however, a number of promising candidates, including sensory overload and hypervigilance.

One of the limitations of this study the sample size of the groups. In particular, there was a low number of individuals in the 'highly noise sensitive' group (26 in the Motorway group and 31 in the Control group). This precluded us from being able to compare the correlations between noise annoyance and air pollution annoyance across groups. Also, no measurements of air pollution were made during the sampling period, either for the Motorway group or the Control group. Air pollution concentrations in Auckland are typically low but highly variable, because of the complex wind patterns across the city As such, we have no way of knowing whether the air pollution levels were sufficiently high to cause any physiologically-based reactions, even in sensitive individuals.

A suggestion for a future study would be to compare the results of a survey carried over two time periods: one in the presence of high air pollution (due to an extended period of stagnant atmospheric conditions) and one in low air pollution conditions, both in the presence of road traffic noise. If noise-sensitive individuals reporting high levels of noise annoyance rated annoyance to air pollution low during the low air pollution period and high during the high air pollution period, this would further support the hypothesis that it is the noise exposure that drives annoyances ratings in noise-sensitive individuals.

5. CONCLUSIONS

The results of this study suggest that noise sensitive individuals are not less likely to live in close proximity to a motorway. Therefore the choice of house location is not influenced by an individual's self-rated noise sensitivity as one might expect. Individuals that are noise sensitive are more likely to be adversely affected (annoyed) by the motorway located in close proximity to where they live compared to those that are least noise sensitive. Noise exposure itself drives annoyances ratings in noise-sensitive individuals, and not some other non-noise related factor such as personality. Further research in this area would be beneficial.

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