COMMUNITY REACTION TO NOISE

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Sydney NSW 2006

ABSTRACT: Community reaction to noise is an important effect of noise exposure which may harm health. Amelioration of community reaction requires that it be understood. We offer methodological recommendations in order to improve the validity and reliability of the reaction data upon which this understanding is based. Evidence is presented to indicate that reaction is influenced by features of the person hearing the noise and the situation in which the noise is heard, as well as features of the noise itself. Consistent with this claim, the relationship between noise and exposure is found to be stronger when based on grouped rather than individual data. Given the critical influence of human factors (including psychological variables) on whether a sound is perceived as noise, and on the reaction it produces, we argue that development of solutions to the noise problem should not be focused exclusively on noise abatement measures. Psychological approaches to overcoming the noise problem, as well as issues for future research are suggested.

1. INTRODUCTION

The global trends towards larger cities and reduced proportions of populations living in rural settings have concentrated people in more noisy areas. At the same time, industrialisation and transport mechanisation have created substantial increases in noise production. The confluence of these factors has resulted in a substantially increased proportion of the population being exposed to noise from outside sources while in or around their homes. The noise may arise from transportation (motor traffic, aircraft, trains, boats), factories, construction, mining, power plants or electrical transmission lines, wind turbines, music or television, air-conditioning units, or neighbours and their pets.

People may have a range of reactions to this noise, amongst them dissatisfaction, annoyance, anger, frustration, disappointment, and/or distress [1]. These responses to noise are generally known as community reaction. Community reaction is important for three reasons. First, it is one of the undisputed effects of noise generally, and is one of the two undisputed effects of residential noise in particular (the other being sleep disturbance [2,3,4]). Second, it is in its own right a significant factor in human quality of life and health. People who have their daily activities (eg. conversation, listening to music, watching television, reading, sleeping) disturbed, and who are dissatisfied and annoyed, clearly have reduced quality of life. Thus, community reaction constitutes a negative health factor within the World Health Organisation's definition of health (as well-being, not just the absence of disease). Third, community reaction may contribute to other putative effects of noise such as elevated blood pressure [5] and mental health problems such as anxiety and depression [6,7]. Indeed, several studies have identified reaction to noise as a better predictor of several noise-related health effects than is noise exposure itself (eg. anti hypertensive treatment [8]; psychosocial well-being [9]; nervous stomach [10]; and general health ratings [11,12]). While these studies were observational and so do not provide compelling evidence for causality, noise, via the reactions it generates, remains the most likely causal agent (for review see [4]).

This paper reviews socio-acoustic studies of community reaction to noise, focussing on the measurement of reaction to noise, and noise-, person- and situation-related factors which influence reaction. Unresolved issues are identified for future research.

2. THE MEASUREMENT OF REACTION

The measurement of community reaction inevitably relies upon subjective report. Residents must tell us about their reactions. This methodology has difficulties, including the possibility of inaccurate or incomplete recall, as well as response biases. However, since most socio-acoustic surveys refer to the recent past, memory is unlikely to present a problem. Psychological data suggests that people so not lie in surveys [13]. Further, whilst people may be motivated to give inaccurate reports of their reaction, this may be minimised with appropriate questionnaire construction (eg. see point 3 below), and by stressing the importance of accuracy to respondents. Many response biases can be also controlled with considered questionnaire construction. The quality of the data collected in studies of community reaction may be improved through a number of specific methodological refinements:

1. Ensuring random sampling of households and of residents within households, to provide an unbiased sample.
2. Minimising refusal rate through the use of experienced interviewers [14] and payment of incentives for participation [15, 16].
3. Not revealing the focus of the survey on reactions to noise until at least one critical reaction question has been asked, hidden among questions on other aspects of the neighbourhood [17,18,19,20].
4. Using several questions to assess reaction, rather than a single question, in order to improve reliability [14,21,22]. When several questions are used the measure is not as susceptible to random fluctuations in response and is thus more reliable.

5. Employing the best questions for a valid and reliable measure of reaction. Reaction to noise has typically been assessed in terms of "annoyance". However, there are many possible reactions to noise besides annoyance: for example, anxiety, distraction, exhaustion, anger, frustration, disappointment and fear. Empirical data indicate that overall reaction to noise is captured better by a general scale of reaction (involving questions such as "how much are you affected by [noise]" and "rate your dissatisfaction with [noise]") than by simple annoyance measures [23,1]. Thus, these general questions appear to be more valid measures of reaction. They have also been shown to be more reliable both with respect to internal consistency and stability. Internal consistency refers to the extent to which the questions within one measure tap the same underlying variable; responses to general reaction questions have been shown to be more consistent with each other than are responses to annoyance questions (for review see [24]). Stability (or test-retest reliability) refers to the extent to which questions tap the same variable from one measurement occasion to the next; responses to general reaction questions are more similar across time than are responses to annoyance questions [24]. Thus, socio-acoustic surveys would benefit from the measurement of general reaction to noise in addition to measurement specifically of annoyance with noise.

3. FACTORS WHICH INFLUENCE REACTION

Many factors have been identified as influencing reaction. It should be noted that often these factors have only been identified in observational (usually correlational) studies, which thus do not identify the direction of causality. However, in many instances some causal accounts can be eliminated. For example, because the weak relationship between gender and reaction could not arise from the noise influencing gender, it is taken to indicate that gender influences reported reaction, although the mechanism of such an effect is not obvious. In other instances, laboratory studies suggest the causal sequence [2,4] or the nature of the observational data suggest an interpretation [25].

Features of the noise itself which influence reaction to noise include: the noise energy level, with greater energy associated with greater reaction [21,26]; the number of events, with more events influencing reaction above and beyond total noise energy exposure [27,28]; the frequency distribution of the noise, with lower frequency leading to more reaction [29]; tonality, with more pure tone components causing more reaction [2]; impulsivity, with more impulsive noise causing considerably more reaction (an effect equal to 20-30dB [28]); changes in noise exposure, which yield the exaggerated changes of greatly reduced reaction when the noise exposure drops and over-reaction when the noise exposure increases [30,31].

Features of the person hearing the noise also influence reaction: more negative attitudes to the noise source are associated with more reaction [2,21]; more noise sensitive residents show more reaction [2,21]; those who own their own home show perhaps slightly more reaction [21]; expectations of the level of future noise influence reaction, with those expecting an increase in noise showing more reaction [32]. Personality influences reaction [2] often in a manner consistent with the health risks of different personality types

TABLE 1: Correlation (r) of noise and reaction based on individual (ind) versus grouped (grp) data for a range of noise sources studied in several countries.

STUDY	COUNTRY	NOISE SOURCE	SAMPLE SIZE	r (ind)	r (grp)
Baugham & Huddart (1993), NPHP	U.K.	Road			0.94
Bertoni et al (1993), NPHP	Italy	Road	908	0.67	
Bjorkman & Rylander (1993), NPHP	Sweden	Road	918		0.77
Borsky (1983), NPHP	U.S.A.	Aircraft	942	0.58	
Bottom (1971), JSV	U.K.	Aircraft/Road	315		0.96
Bradley (1992), JASA	Canada	Air-conditioner	550	0.19	0.99
Bradley (1983), Internoise	Canada	Neighbourhood	98	0.35	
Bradley (1978), NPHP	Canada	Road	1150	0.50	0.85
Bradley & Jonah (1979), JSV	Canada	Road	300	0.49	
Brown (1978), Aust. Road Research Board Rpt.	Australia	Road	818	0.27	0.79
Buchta (1990), JASA	Germany	Rifle range	392	0.44	0.90
Buchta (1990), JASA	Germany	Road	322	0.70	0.91
Bullen et al (1986), JSV					
Hede & Bullen (1982), NAL Rpt.	Australia	Aircraft	3575	0.36	0.84
Bullen et al (1991), NCE					
Job et al. (1991), Internoise	Australia	Artillery	1626	0.22	0.57
Cook et al (1994), NAL Rpt.	Australia	Artillery	231	0.44	
Cook et al (1994), NAL Rpt.	Australia	Artillery	54	0.66	
Cook et al (1994), NAL Rpt.	Australia	Artillery	56	0.72	
Cops et al (1978), Internoise	Belgium	Road	1800	0.86	
Dankittikul et al (1993), NPHP	Japan	Road	96	0.49	
Dankittikul et al (1993), NPHP	Thailand	Road	138	0.40	
Dankittikul et al (1993), NPHP	Thailand	Road	94	0.23	
Diamond & Walker (1986), Internoise	U.K.	Aircraft			0.82
Dixit & Reburn (1980), Internoise	Canada	Railyard	523		0.71
Fidell (1978), JASA	U.S.A	Urban	2037		0.70
Fidell et al (1983), JASA	U.S.A.	Quarry blast	992		0.66
Fields & Powell (1987), JASA	U.S.A.	Aircraft	330	0.20	0.95
Fields & Walker (1982), JSV	U.K.	Railway	1453	0.46	
Foreman et al (1974), JSV	Canada	Neighbourhood			0.91
Gambart (1981), Psychologia Belgica	Belgium	Road	617	0.48	

Gambart et al (1976), Applied Acoustics	Belgium	Road	247	0.61	0.94
Garcia (1983), Internoise	Spain	Road	430		0.56
Garcia et al (1993), JSV	Spain	Aircraft	1800	0.30	0.92
Gjestland et al (1990), Rpt. ST4 40 A90189	Norway	Aircraft	1554	0.37	
Graeven (1974), J. Health & Soc. Behav.	U.S.A.	Aircraft	552		0.40
Grandjean et al (1973), NPHP	Switzerland	Aircraft	3939	0.59	0.95
Grandjean et al (1973), NPHP	Switzerland	Road	944	0.43	
Griffiths & Langdon (1968), JSV	U.K.	Road	1000	0.29	0.88
Griffiths et al (1980), JSV	U.K.	Road	222	0.44	0.86
Groeneveld (1981), Internoise	Netherlands	Industrial	597	0.35	
Hall et al (1979) [book: McMaster University]	Canada	Aircraft (commercial)	673		0.68
Hall et al (1979) [book: McMaster University]	Canada	Aircraft (general)	292		0.84
Hall et al (1979) [book: McMaster University]	Canada	Road	292		0.56
Hall et al (1978) , Internoise	Canada	Road			0.89
Hall et al (1983), Internoise	Canada	Aircraft		0.31	
Hall & Taylor (1977), JSV	Canada	Road		0.92	
Hede & Bullen (1982), JSV	Australia	Rifle range	201	0.29	0.95
Hiramatsu et al. (1987), Internoise	Japan	Aircraft	6080		0.94
Job et al. (1991), Internoise	Australia	Aircraft (military)	624	0.58	
Job & Hede (1989), Internoise	Australia	Power station	301	0.49	
Kamperman (1980), Internoise	U.S.A.	Sonic boom	2000		0.96
Ko et al (1976), JSV	Hong Kong	Aircraft	552		0.80
Ko et al (1976), JSV	Hong Kong	Road	552		0.72
Kono & Sone (1988), JSV	Japan	Road	147	0.70	
Kurra (1983), Internoise	Turkey	Road	525		0.86
Langdon (1976), JSV	U.K.	Road	1359	0.21	0.85
Langdon et al (1983), JSV	U.K.	Neighbour	709	0.24	0.36
Langdon et al (1981), JSV	U.K.	Neighbour	917	0.40	0.84
Large & Ludlow (1975), Internoise	U.K.	Construction	535	0.52	
Large & Ludlow (1975), Internoise	U.K.	Road	535	0.38	
Lercher & Widmann (1993), NPHP	Austria	Road	1966	0.27	0.92
Lopez-Barrio & Carles (1993), NPHP	Spain	Road	800	0.30	
May (1972), JSV	Germany	Sonic boom		0.39	
May (1971), JSV	U.K.	Sonic boom	14	0.62	
McKennell(1978), NPHP	U.K	Aircraft		0.26	
McKennell(1963/73), NPHP	U.K.	Aircraft	1731	0.46	0.99
MIL Research (1971), Her Majesty's Statnry Off.	U.K.	Aircraft	4699	0.40	
Moehler & Knall (1983), Internosie	Germany	Railway	525		0.94
Moehler & Knall (1983), Internosie	Germany	Road	525		0.66
Murray & Avery (1984), WIlkinson-Murray Rpt.	Australia	Quarry blast	170	0.29	0.89
Nemecek et al (1981), JSV	Switzerland	Road		0.49	0.93
Nivison & Endresen (1993), J. Behav. Med.	Norway	Road	82	n.s.	
Oehrstrom (1993), NPHP	Australia	Rifle range	309	0.06	
Oehrstrom (1993), NPHP	Sweden	Road	434		0.90
Persson & Rylander (1993), NPHP	Sweden	Home	93		0.91
Putra & Lawrence (1991), Internoise	Australia	Road	426	0.55	
Rohrmann et al (1973), NPHP	Germany	Aircraft	660	0.58	
Rylander et al (1993), NPHP	Sweden	Artillery	1483		0.52
Rylander et al (1980), JSV	Sweden	Aircraft	3746		0.96
Rylander et al (1976), JSV	Sweden	Road	811		0.78
Rylander et al (1972), JASA	Sweden	Aircraft	2900		0.78
Rylander et al (1972), JASA	Sweden	Sonic boom	33		0.85
Sato (1993), NPHP	Japan	Road	584	0.29	
Schield & Zhukov (1993), NPHP	U.K.	Light rail	149		0.59
Schomer (1983), JASA	U.S.A.	Aircraft	231		0.89
Schuemer & Schuemer-Kors (1983), Internoise	Germany	Railway	1516	0.46	
Schuemer & Schuemer-Kors (1983), Internoise	Germany	Road	1516	0.52	
Seshagiri (1981), JSV	Canada	Drop forging	609	0.31	0.63
Seshagiri (1981), JSV	Canada	Road	609	0.19	
Shibuya et al (1975), Internoise	Japan	Road	939	0.36	
Sorensen & Magnussen (1979), JSV	Sweden	Rifle range	323		0.99
Spickett et al (1983), Dpt Cons. & Env., W.A., Bull.	Australia	Aircraft	140	0.46	
Taylor et al (1980) [book: McMaster University]	Canada	Aircraft	21	0.40	
TRACOR Inc. (1971), NASA Rpt.	U.S.A.	Aircraft	3590	0.37	
Vallet et al (1978), JSV	France	Road	900		0.80
van Dongen (1980), Int. Congress Acoustics	Netherlands	Road	220	0.30	
Wolsink & Sprengers (1993), NPHP	Denmark/				
Germany/					
Netherlands	Wind turbine	574	0.09		
Yano et al (1993), NPHP	Japan	Road	201	0.30	
Yano et al (1991), Internoise	Japan	Road	147	0.27	
Mean			916.74	0.42	0.81
s.d			1094.16	0.17	0.15
Number of cases			89	65	53

KEY:
NPHP: Proceedings of the International Congress on Noise as a Public Health Problem
JASA: Journal of the Acoustical Society of America
JSV: Journal of Sound and Vibration
Internoise: Proceedings of Internoise

being related to stressful reactions to noise [33]; and, finally, knowledge and beliefs regarding the health effects of noise may influence reaction [34].

The circumstance in which the noise is heard also influences reaction, with more reaction occurring if the noise is experienced: from a noise source which is visible from the residence, during a quiet activity which requires concentration [2,18], or at night [35].

4. CORRELATIONS

As outline above, reaction to noise is influenced by a number of features of the individual hearing the noise. Thus, reaction to a given level of noise exposure could be expected to vary from person to person, and correlations between noise exposure and reaction are low when they are based on individual data. However, noise and reaction may be averaged across individuals within groups (say, across individuals living in a particular area) in order to remove the effects of individual differences before the correlations are assessed (using the grouped data). A considerably higher association between noise exposure and noise reaction could then be expected [21]. We conducted an extensive review of the relevant literature, selected studies which reported a noise-reaction correlation, identified whether each correlation was based on individual or grouped data, then calculated the average correlation for individual and for grouped data [see Table 1]. The average noise-reaction correlation is greater when based on grouped rather than individual data. However, it should be noted that on average noise exposure still accounts for only 65.6% of the variance in community reaction to noise. Nonetheless, this percentage would be a slight underestimation due to errors of measurement (in both noise exposure and reaction) and the assumption of a linear relationship between the variables in a correlation despite the reported dose-response curves being curvilinear [26].

5. THE FUTURE

Many important theoretical issues relating to noise reaction remain to be resolved and practical solutions to the noise problem which recognise the importance of noise reaction and other psychological variables need to be developed.

For example, has the population become more sensitive to noise with the "greening" of many other environmental arenas, and if so how? Of those variables thought to modify noise reaction, which have a genuine causal role, which are themselves influenced by reaction, and which are components of reaction? How does personality affect reaction, and what implications does this have for self-selection of residents in higher noise areas? How is reaction related to other possible health effects of noise? Such issues should not be ignored in our ever increasing focus on the immediate benefits of any research expenditure. The history of science shows that better understanding of the exact causal sequences involved in negative reactions to noise will help the process of combating its detrimental effects on people.

The belief that a silent world would be the ideal solution to the noise problem is misguided. Much sound is not unwanted, and therefore, by definition, not noise. Both the practical aim of zero sound and the naive epidemiological assessment of the effects of sound in terms of the dose-response relationships between total sound exposure and effects (such as reaction or health), ignore psychological reality. Much sound is desired, and is thus unlikely to be stressful, arouse negative reaction, or harm health.

Focus on reduction or elimination of noise emissions as a solution to the noise problem should not preclude the development of other viable measures to alleviate the problem. Alternative solutions which may be fruitfully researched or implemented include: changing features of the noise other than its energy level in order to reduce reaction; understanding and resolving negative reactions to home noise insulation; promoting positive attitudes towards relevant noise sources; and use of positive sound environments.

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