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RESEARCH METHODOLOGY - NOISE ANNOYANCE AND HEALTH

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ABSTRACT

The possibility that excessive residential exposure to general environmental noise over the longer term might contribute to clinical health effects in addition to annoyance in susceptible individuals is becoming an issue of public concern. There is an implied hypothesis that chronic annoyance is a type of stress which might contribute to long term adverse health effects, but this hypothesis is difficult to define in scientific terms. Our understanding of any possible aetiological mechanisms is incomplete, and many research findings and interpretations in this area remain controversial. Given these uncertainties, we suggest that future research should focus on mechanism rather than on prevalence. Small scale but carefully controlled experiments could be more enlightening than cross-sectional epidemiology which cannot establish causality even where statistically significant associations between variables are obtained.

1 - INTRODUCTION

There is convincing scientific evidence about the damaging effects of many types of chemical pollution on human health which is sufficient to justify significant expenditure on pollution control. There is less of a consensus regarding the possible damaging effects of community noise. It is important to note that noise pollution is not like chemical pollution because sound is not directly toxic and does not accumulate either in the body or in the environment. Many people voluntarily seek out high sound levels in discotheques and similar places without apparent ill-effects (with the exception of potential hearing damage at really high sound exposure levels). The levels of physical energy in community noise are mostly so small that there are no measurable heating effects or physical distortions of the tissues. If there are long term effects on clinical health, these can only arise through some maladaptive and probably delayed psychological or endocrine response of the organism to sensory stimulation and not through any direct tissue damage caused by the physical energy present in the noise.

Of course, and depending on the context in which it is heard, unwanted sound can be extremely annoying, particularly if it masks speech, interferes with some desired activity or contributes to sleep disturbance. Speech interference can be easily quantified at the time that it occurs, but to some extent at least, the possible damaging effects which might be measured by a loss of message intelligibility or reduced communication effectiveness can be overcome by increased talker and listener effort or by repeated messages. Activity interference can also be measured objectively but is very much dependent on the type of activity and on the precise nature of the interference caused and may or may not be 'damaging'. Sleep disturbance can be very complicated. The noise level thresholds at which short term or transient physiological responses to intrusive noise events might contribute to more significant next day effects such as day-time sleepiness or other measurable performance decrements are presently unknown. Given that there is continuing uncertainty about the precise biological function of sleep, it is hardly surprising that the potential health effects of chronic sleep disturbance caused by noise are not understood. The available evidence suggests that most people habituate to familiar sounds to some considerable extent, and that subjective reports of awakenings can be unreliable.

Any or all of these effects can contribute to annoyance, which could equally arise from feelings that the noise is inappropriate, or that the noise maker is acting unreasonably. Reported annoyance has become the de facto standard indicator against which many authorities attempt to judge physical noise exposure, but since it is well known that different individuals can be more or less 'annoyed' about many different things, it is difficult to achieve any consistency in what is considered 'acceptable' and what is not, except by imposing what are essentially entirely arbitrary standards. Since it is unlikely that there could be any clinical health effects at noise exposures below the threshold of significant annoyance, in cases where reported annoyance on its own is considered sufficient to justify noise control action the question of clinical health effects is largely academic, because noise control action is taking place anyway. However, in cases where even significant reported annoyance alone is not considered sufficient to justify noise control action, it could be important to establish to what extent noise exposure might (or might not) contribute to more insidious clinical health effects over the longer term. If it could be shown that chronic noise annoyance as a form of stressor can contribute to clinical health effects then this relationship, or even a simple association, would probably justify higher priorities for noise control action. On the other hand, excessive or unjustified noise control action could have equally adverse consequences through diverting economic resources away from more effective forms of health care or by unreasonably restricting social and commercial activity. An over-precautionary approach in the field of noise control could have more severe consequences in other areas than the noise effects which it was intended to avoid.

2 - MECHANISMS

Why do people respond to noise in different ways? Different types of sound have different meanings depending on the context in which they are heard. The meaning or information conveyed by the sound can be more or less valuable to different individuals. On the other hand, unwanted noise can mask wanted speech and other signals. This could interfere with communication, or it could occupy limited neural processing capacity, or it could require some additional effort by the listener to overcome the masking effect. Different listeners will have different priorities for collecting information of different types and for overcoming masking. Anecdotal evidence suggests that this even applies when people are asleep, indicating that parts of the brain involved in sub-cognitive appraisal can still be active. It appears that maintaining a sub-conscious level of interest in the surrounding auditory environment even while asleep confers a biological advantage in helping to respond positively to threatening situations.

What does reported noise annoyance actually mean? Reported noise annoyance can only be precisely defined by the wording of any questionnaire in which it is measured, but this does not really explain what any particular noise annoyance rating actually means to the respondent at the time. Except perhaps for very high sound levels, certain unpleasant high frequency sounds, or sounds associated with a particular noise maker against whom the respondent has severe negative feelings, it should not be assumed that a standard descriptor such as the percentage of 'highly annoyed' respondents [1] always represents a state of high psychological arousal or rage against the noise in question. For many people, reporting a high value on any given noise annoyance scale merely represents a high but essentially abstract degree of unwantedness within, or against, the context [2] in which the noise is heard. It should not be assumed that this particular degree of unwantedness can always be simply related to any equivalent degree of 'annoyance' expressed against any other aspect of their lives. For example, it is usually difficult or impossible to identify to what extent any particular noise annoyance rating might be influenced by subjective expectations of how the results of the survey in question might influence future noise management policy by authorities.

Because noise annoyance is essentially an attitude, it seems unlikely that any particular degree of reported noise annoyance could be easily related to any underlying physiological state of the organism which might then be measurable as some form of clinically observable stress. It might be safer to assume that noise annoyance ratings essentially represent reports of the relative degree of unwantedness of some component of a particular noise environment against the context of alternative noisier and quieter environments which the respondent either has experience of or can imagine. This is not the same as relative loudness which does not have the same connotations of general unwantedness as 'annoyance', but it should not be assumed that noise annoyance ratings would have the same rank orderings if people both fully appreciated and were taking into account the full socio-economic costs of noise control action when making their judgements. In this context, it is dangerous to assume that reported noise annoyance is automatically an indication of some kind of psychological or physiological stress where it may in fact be little more than a strategic response to a potential quality-of-life enhancing opportunity. So how else might we measure the kind of physiological stress that might result from excessive community noise and that might be seen as a predictor of more insidious clinical health effects?

It seems medically plausible that chronic psychological stress, perhaps arising through frustration that either no or ineffective action has been taken against an ongoing cause for complaint, could contribute to persistently elevated levels of 'stress' hormones in the bloodstream. Clinically elevated stress hormone levels have been associated with known diseases [3], [4]. The problem is to devise an experiment or experiments which might test this hypothesis under strictly controlled conditions, and in relation to noise exposure without undue influence by other environmental stressors. Whereas in-situ field trials have direct face validity against real-life conditions, it is often impossible to control for the numerous potential confounding factors which might influence the results. We suggest that carefully controlled experiments carried out in the laboratory might be able to shed some light on these possible mechanisms and thereby inform the design of future in-situ field trials that might have some chance of being able to resolve these issues. In the first instance, if we make the two assumptions that clinically identifiable health effects are only likely to arise in the most susceptible minority of the most noise exposed sections of the population; and that the most susceptible minority might be identified by some abnormal persistence of the normal transient endocrine response to unexpected noise stimuli, then we have the basis of an experiment which might be able to make a small but significant contribution to this debate. The rationale for such an experiment is based on assuming that the main function of any delayed endocrine response is to maintain an elevated arousal level after a potentially threatening noise event for longer than could be maintained by neuronal interconnections alone, but that if the delayed endocrine response is maintained for too long, then this could become maladaptive with potential long term clinical health consequences.

3 - DETAIL DESIGN

In detail, we would be looking for individual differences in the persistence of delayed endocrine responses to unexpected noise stimuli, rather than in the absolute magnitude of those responses. Laboratory methods allow for controlled comparisons between different noise exposure conditions for different individuals that would not be feasible under in-situ field trial conditions. If reliable individual differences in the persistence of delayed endocrine responses can be found, then this might form the basis for subsequent in-situ field trials that could include the persistence of delayed endocrine responses as an input variable. More detailed work using questionnaires about noise sensitivity, negative affectivity or other potentially relevant psychological variables might expose some other factor that could be used as a predictor for persistent delayed endocrine response. Given the strong likelihood that only the most susceptible minority from any noise exposed population would be likely to suffer clinically measurable health effects, then unless this minority can be identified independently, their results are likely to be swamped by the general error variance arising in any study as a whole. The proposed laboratory experiment might point the way towards independent identification of susceptible minorities. On the other hand, if any such potentially susceptible minorities cannot be identified in advance, then the chances of success of any open-ended cross sectional epidemiology in this area are probably quite small.

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