NOISE AND HEALTH: WHY WE NEED MORE RESEARCH

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Abstract
This paper will examine research on noise and health and suggest new topics and methods of investigation. First, it will discuss noise exposure and argue that new approaches need to be considered. Secondly, it will examine possible underlying mechanisms and show that it is inappropriate to use stress as a model for effects of noise on health. The next section will suggest that it is important to examine combined effects of noise and other risk factors rather than considering noise in isolation. Similarly, the importance of individual differences will be emphasized and the need for an objective measure of noise sensitivity discussed. Finally, a new model of an effect of noise on health will be presented. This will be based on the speculation that exposure to noise in childhood may reduce intelligence which will not only have an effect on cognitive functioning but will increase the risk of future health problems.

Keywords: Noise exposure, health, stress, combined effects, noise sensitivity, intelligence.

1 Introduction

The aim of this paper is to present some reasons why we need further research on the effects of environmental noise on health. Following this, suggestions will be made about the form that this future research should take. It is not the intended to review the present literature on noise and health but the views expressed here do suggest that current reviews may not present a correct view of the associations between noise and health, mechanisms underlying these effects nor the practical implications for society. The paper starts by considering current approaches to noise exposure and argues that these may not be considering key parameters. The next section considers noise annoyance and shows that this is only partially due to the noise. Individual variation in annoyance has often been explained in terms of differences in noise sensitivity but, again, it will be seen that this involves more than just sensitivity to noise. Noise and sleep will then be considered and again gaps in our knowledge will be identified.
The next section of the paper will consider how we explain the effects of noise on health. It is often argued that noise increases stress and that it is the stress that is responsible for subsequent health outcomes. Noise and cardiovascular disease will then be used as an example of why it is important to examine combined effects of noise and other risk factors. The effects of noise on cognitive functioning will then be discussed. It will be suggested that there is an interaction between habitual exposure and acute exposure. Chronic exposure to environmental noise (e.g. aircraft noise) may impair the intellectual abilities of children. This effect may also be important in the development of chronic disease and a new theory will be proposed that can account for both effects of noise on cognitive functioning and subsequent chronic disease. Finally, it will be argued that recently developed methodologies will allow us to obtain greater information about possible effects of noise on health.

2 Noise exposure

There have been criticisms of the descriptive approaches seen in epidemiological studies which attempt to relate effects to overall exposure indicators without including available knowledge on the possible underlying mechanisms [1]. Indeed, an alternative approach based on the hypothesis that long term perception of environmental sound is determined primarily by short notice-events (an instance of consciously perceiving sounds) has been able to mimic many of the noise annoyance effects [1]. For example, it is possible to develop a model that includes processes such as gating, habituation and attention focusing. Known differences in annoyance (e.g. railway noise being less annoying than traffic noise) can also be explained by this model. In the future it will be important to record noise exposure for individuals. These databases will then allow detailed analysis of a wide range of key parameters.

3 Annoyance

Although clear exposure-response relations have been identified [2,3] it is clear that there are large individual differences at each noise level. Factors such as attitudes to noise, perceptions of control over the noise and the trait of noise sensitivity have all been shown to be important determinants of annoyance. However, the concept of noise sensitivity often reflects the more general trait of negative affectivity [4]. Those who are high in noise sensitivity report more annoyance because this is a general feature of neurotic individuals. Noise sensitivity-annoyance relationships may also reflect “common method variance” (both are measured by self-report) and in the future we need to have an objective indicator of noise sensitivity.

4 Noise and sleep

A number of dose-response relationships between noise exposure and the reaction of the sleeper (e.g. behavioural awakening or EEG awakening) have been suggested [5,6,7]. However, there is no consensus on which dose-response relationship should be used to inform about adverse health effects. In addition, there is no evidence that sleep disturbance caused by noise has any long term health effects. Practical measures to reduce effects of noise on sleep can also sometimes make things worse. For example, in the case of night flights and sleep one often gets habituation to the noise after several flights. Reduction of the
number of flights may paradoxically increase sleep disruption because of the removal of the habituation.

5 How do we explain effects of noise on health?

5.1 Noise and stress

It has been argued that noise increases stress and it is this increased stress that is responsible for the effects of noise on health [8]. However, three main features of the stress-health process do not appear to be present in the noise literature, namely changes in cortisol, suppression of the immune system and mental health problems. These will now be considered.

5.2 Noise and cortisol

Increased cortisol is an indicator of chronic stress and has been linked to immunological changes associated with disease. A review of the noise-cortisol literature shows no conclusive evidence for consistently increased cortisol in noise exposed individuals. For example, some studies [9] have found no association between aircraft noise exposure and free cortisol or catecholamines.

5.3 Noise and immune-suppression

A recent review [10] showed no clear evidence of noise exposure being linked to suppression of the immune system.

5.4 Noise exposure and psychological health

Associations between noise and psychological health have been examined in studies of hospital admissions, psychological symptoms, psychiatric morbidity in the community and use of medication or health services. In general, environmental noise exposure does not lead to the changes in mental health that would be predicted by a noise-stress model. For example, a recent study [11] found no association between aircraft noise change and mental health (as measured by the GHQ-12).

6 Noise and cardiovascular disease

A number of studies have examined dose-response relationships between environmental noise exposure and cardiovascular disease. These studies often show different functions and a feature of recent results has been that there are individual differences (e.g. gender differences) in the effects of noise [12] and that noise effects may reflect other features of the environment such as air pollution [13]. In addition, the effects of noise exposure on cardiovascular disease may depend on the level of annoyance induced by the noise. For example, a recent study [12] has shown that exposure to aircraft noise only increased the risk on hypertension in those annoyed by the noise.
7 Noise and cognitive function

There have been a number of studies of both the effects of acute exposure and chronic noise exposure on the cognitive function of children [14] and adults [15]. A major factor in producing negative effects of acute noise exposure is the extent to which the noise level or other parameters of the noise change. For example, effects are greatest for unpredictable rapidly changing noise and even decreases in noise level can produce negative effects. Negative effects of irrelevant speech have also been explained in terms of the changing nature of the exposure. Prolonged exposure to the same noise can lead to habituation and negative effects on performance may then disappear. Individuals perform better when the acute exposure matches their normal exposure. This suggests that individuals regularly exposed to noise will do worse in quiet than those from quiet environments, whereas the reverse will occur if the two groups are tested in noise. Such results have been obtained [16].

8 A new theory of effects of long term noise exposure on health

It is possible to identify a number of mechanisms that possibly underlie effects of noise on cognition. Many environmental noise sources will influence several different mechanisms and effects will reflect the precise combination induced by the specific mechanisms. For example, some acute effects of noise probably reflect changes in noise (notice events) in combination with stochastic resonance [17]. Chronic effects of noise have been demonstrated in children tested in quiet [14] and these may actually reflect interference with speech perception [18] which may lead to reduced cognitive functioning [19]. The outcome of long term exposure to noise may be a reduction in intelligence. Recent research [20] has shown that reduced intelligence is one of the biggest risk factors for long term health problems and mortality. The mechanism underlying this could be an increase in bio-markers that reflect the metabolic syndrome [21]. This theory now needs to be tested by first demonstrating that noise impairs auditory perception and that this underlies the poorer reading comprehension found in children in noisy schools. Long term follow up of those living in a noisy environment also needs to be done in order to examine whether these people are at greater risk of developing the metabolic syndrome.

9 Further research

The present paper has presented evidence suggesting that past and current approaches to the effects of noise on health need to be modified in order to provide a greater understanding of the area that will be of relevance to policy and practice. It is also important to use new methods to address the old question of what are the effects of noise on health. For example, it is important to examine the effects of noise on gene expression as this may give a strong indication of future health effects. Similarly, noise and cognitive functioning can now be studied using a variety of brain imaging methods that can provide plausible mechanisms for observed behavioural effects. These new approaches must be combined with different methods of measuring noise exposure. Individual differences in noise sensitivity need to be refined to separate general biases in perception and response from those which are specific to noise. Noise exposure is usually combined with exposure to other risk factors (e.g. traffic noise is combined with air pollution). Future research must not only control for other factors but investigate the combined effects of noise and other agents.
10 Conclusions

This paper has considered reasons why further research on noise and health is required. The first topic discussed is measurement of noise exposure and it is argued that current methods may miss key parameters which may be better predictors of health outcomes. It is recommended that future approaches involve recording of the noise so that we establish databases from which multiple parameters can be extracted. Subjective responses to noise also require further development and we need a measure of noise sensitivity that is independent of general biases such as negative affectivity. Mechanisms underlying effects of noise on health also require further attention. For example, it is clear that noise can interrupt sleep but there is little agreement about the function that best describes this process or whether noise disturbed sleep has any impact on long term health. Effects of noise on health have often been described in terms of noise increasing stress and this stress having a negative effect on health. If this model is correct one would expect noise to lead to an increase in cortisol, increase suppression of immune functioning, and be associated with more mental health problems. The current literature shows little support for these views. Epidemiological studies of noise and cardiovascular disease show that effects are modified by other agents (e.g. air pollution) and individual differences (e.g. gender; annoyance). The combined effects of noise and other factors must surely form the basis of future practice and policy. The paper suggests a new theory that may provide a mechanism linking long term exposure to noise to health effects. Noise exposure impairs cognitive functioning due to an effect on auditory perception. This reduction in intelligence has been shown to have long term health effects and may be one mechanism through which noise exposure in childhood affects later health.

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References


