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Year : 1999 | **Volume** : 1 | **Issue** : 3 | **Page** : 45-56

Personal and social variables as co-determinants of noise annoyance

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Abstract
Introduction
Conclusion
References
Article Figures
Article Tables

Abstract

This paper starts with the fact that noise annoyance is partly due to acoustic factors, partly due to so-called moderating variables, i.e. personal and social aspects of the residents. Noise annoyance is considered to be the (long-term) negative evaluation of living conditions with respect to noise. This evaluation is not simply dependent on past disturbances, but on attitudes and expectations, too. The personal factors influencing the evaluation and described here are: Sensitivity to noise, fear of harm connected with the source, personal evaluation of the source, and coping capacity with respect to noise. The social factors described here are: General (social) evaluation of the source, trust or misfeasance with source authorities, history of noise exposure, and expectations of residents. For most of these variables, data from different community studies are used in order to illustrate the respective moderating effect on annoyance. In addition, some of the moderators are presented as possible tools in order to reduce noise annoyance. It is expected that a significant decrease in a negatively moderating variable is as effective in reducing noise annoyance, as is a significant decrease in noise level.

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Introduction

It is well known that annoyance reactions of residents exposed to environmental noise are determined partly by acoustical features of the environment, partly by features of the residents. At best, about one third of the variance of annoyance reactions can be "explained" by the variance of acoustical features, another third by the variance of personal or social variables. This paper deals with the latter, using field studies of noise annoyance and using a wide variety of personal and social features of the respondents in a conceptual framework related to the moderator approach in statistical analyses.

Firstly, the reaction variable "annoyance" should be defined. Generally, noise annoyance is seen as a negative evaluation of environmental conditions, but its connotations are rather broad and diverse. The concept is associated with disturbance, aggravation, dis-satisfaction, concern, bother, displeasure, harass-ment, irritation, nuisance, vexation, exasperation, discomfort, uneasiness, distress and hate. We will not discuss the conceptual and methodological problems of the annoyance concept here, this was done elsewhere (Guski 1997). For the purpose of this paper, those selfrated variables are called "annoyance" which express a certain degree of long-term dissatisfaction, disturbance, or bother with respect to the acoustic environment. Often, this variable is created as a sum (or average) of several negative aspects of the acoustic environment, as rated by the respondents, e.g., rated disturbance of communication plus rated disturbance of recreation plus rated dissatisfaction with the acoustic environment. Sometimes, there is just a single item, e.g., the rated degree of annoyance by environmental noise.

Moderator or mediator?

The term "moderator" or "moderating variable" goes back to Saunders (1956) and denotes a feature or an attribute

of persons that changes the degree of the effect of an independent variable (the so-called stimulus variable, e.g., the noise level in a community) on a dependent variable (the so-called reaction variable, e.g., the noise annoyance, as expressed in interviews). Baron & Kenny (1986) point out the distinction between moderating and mediating variables: Moderating variables are independent of the stimulus, but they covary with the reaction variable - that is: moderating and reaction variables may depend on each other. Mediating variables can be seen as "primary reactions", they depend on the stimulus variable, and they also influence the "secondary reaction" see [Figure - 1]. For instance, if a person's age influences the degree of annoyance expressed in an interview, age is a potential moderator, because it is sure that the age variable does not depend on the noise level at the person's home. The question, whether it really is a moderator, can be tested by different procedures. Their applicability depends on metric properties of the variables involved. With continuous variables, the use of Multiple Regression Analysis is advocated (see Baron & Kenny 1986).

A conceptual model of long-term noise effects

This paper introduces a conceptual model of noise effects that may be useful in order to understand the long-term reactions of residents with respect to environmental noise see [Figure - 2]. Generally, it considers long-term noise effects, like annoyance, or somatic effects, to be secondary reactions, mediated by short-term reactions, and moderated by personal and social factors. In the course of the history of a resident's noise exposure, the individual resident will undergo immediate, short-term (primary) reactions, like actual interference with intended activities (e.g., communication), or vegetative reactions, like an increase of blood pressure. Usually, these effects can only be seen in the laboratory, sometimes we can observe them in field studies using portable measurement equipment, e.g., hand-held computers registering short-term annoyance judgments during overflights of aircraft (cf. Schomer & Wagner 1996; Felscher-Suhr et al. 1996), or short-term vegetative reactions towards aircraft (Guski 1978) or traffic noise (Guski 1980). Some of these reactions have been shown to depend on the maximum noise level, and partly on personal factors, like age, noise coping capacity, sensitivity to noise, and vegetative liability - for the last three variables, see below.

In contrast, long-term retrospective annoyance measurements are made using personal or mailed questionnaires, sometimes during telephone interviews. In these situations, the respondents are expected to integrate their short-term and long-term experiences with the noise situation and their disturbances of intended activities due to noise. At present, we do not know if and how this integration over time takes place, e.g., whether the respondents recall the most severe disturbances during the last year, or just "average" all the disturbances they can remember. There is no simple transformational rule that could put long-term and short-term annoyance in an easy equation. For instance, in the study of Felscher-Suhr et al. (1996), the short-term annoyance was rather low and only to a limited degree connected with energy-based measures of the short-term noise exposure, while the long-term annoyance was rather high and showed a clear relation to long-term energybased measures of the noise exposure. However, as long-term noise annoyance variables are judgments, i.e., no simple "sensations" or "perceptions" - if such things could be measured at all -, they belong to the class of "verbal behaviour" and depend on a number of personal and social factors that will be described next.

Personal and social factors moderating annoyance

In this paper, personal factors are variables which are linked tightly to an individual, show a considerable stability over time and situations, and vary between individuals considerably. Social factors are linked to situations and are shared to a considerable degree between individuals of a society. For instance, age, sex and socio-economic variables (like education or income) are linked to individuals, they are considered as personal variables. On the other hand, the social evaluation of a noise source, as well as the social evaluation of noise abatement authorities, are considered as social factors. For instance, in our society, railway systems are generally evaluated more positive than airlines, because railways are less dangerous to the general public. In addition, a publication of a recent aircraft crash is a social factor, and will influence the evaluation of all airlines to a considerable degree.

Personal factors are thought to be the result of the individual development of a person, while social factors are thought to be the result of social developments, shared by larger groups of the society. Of course, there is no clear-cut distinction between personal and social factors, because the individual development usually takes place within a certain society.

Personal and social factors may vary within a group of residents in the vicinity of a noise source, but they are not dependent on the level of noise. On the other hand, personal and social factors depend on each other, and mostly we find personal variance within social factors. But there is at least one reason for discussing them separately: While personal factors cannot be used for noise abatement programs, social factors can. For instance, if residents mistrust source authorities, they will not trust their respective noise abatement programs, and noise annoyance will stay high. But if they trust independent authorities and see that these are controlling the noise abatement program, the same program will be much more effective in reducing the annoyance.

Personal factors moderating annoyance

In former times, so-called "personality traits" have been identified, which were considered to moderate the influence of noise, e.g., the wellknown concepts of "extraversion vs. introversion", or "neuroticism". None of the general personality traits proved to be useful in explaining the variance of noise annoyance judgments. Instead, there are few person variables which are more specifically related to environmental exposures but still are no reaction variables (which would covary with the degree of environmental exposure in a cross-sectional study). We will consider (1) sensitivity to noise, (2) fear of harm connected with the source, (3) evaluation of the source, and (4) capacity to cope with noise.

Sensitivity to noise

In one of the earliest major studies on aircraft noise annoyance, McKennell (1963) used a single question for assessing the sensitivity of the respondents to noise: "Would you say you were more sensitive or less sensitive

than other people are to noise?" (Q.33), and the respondents had 4 options: "more sensitive / less sensitive / same / don't know". This question was put after a long set of questions concerning aircraft noise, and we do not know whether the respondent's reactions to this question covary with noise exposure or not. Anyway, McKennell (1963) showed that the self-reported degree of sensitivity to noise has two specific effects on annoyance judgments: (1) At the same level of noise exposure, sensitive persons generally show significantly more annoyance than non-sensitive persons. (2) The covariation between noise exposure level and annoyance is rather shallow in persons at both extreme ends of the sensitivity scale, whilst the covariation is steep for persons lying in the middle of this scale cf. [Figure - 3].

In several other studies, noise sensitivity has been defined more explicitly and measured with somewhat greater care. For instance, most of the German field studies I know of use a set of items describing individual feelings in noisy situations, and the respondents are asked to rate the agreement with each item (Likert format). If possible, these items should be presented before discussing effects of noise in a residential area. Here are examples of the items proposed by Guski et al. (1978): "I am disturbed, if doors clap all the time", "I can't stand listening to several radio or television sets at the same time", or "I get nervous if a dog barks all the time". Noise sensitivity is then calculated as the average of all respective items.

A prominent sensitivity scale has been published by Weinstein (1978) and uses 21 items in a Likert format, e.g., "I am more aware of noise than I used to be", "At movies, whispering and crinkling candy wrappers disturbs me". Unfortunately, the whole set of items is too long in order to be used in big samples, but a subset of 9 items will probably do, as has been shown with a German translation of the Weinstein scale by Zimmer & Ellermeier (1998).

In comparing 7 old field studies of aircraft noise, Schuemer (1974) considered the sensitivity (or susceptibility) to noise often to be the third best predictor of aircraft noise annoyance - after exposure and fear of aircraft crashing. While the correlations between individual noise exposure level and individual annoyance were in the order of 0.25 - 0.68, the correlations between sensitivity and annoyance were in the order of 0.23 - 0.28. The reviews of Job (1988) and Fields (1992) come to similar conclusions: noise sensitivity usually shows significant covariation with annoyance judgments, the order of correlation coefficients varying between 0.15 and 0.48. Some sensitivity scales tend to be influenced by the level of environmental noise and thus may reflect a reaction; this should be avoided in order not to strain the statistical assumptions of the moderator model.

Given a zero correlation between sensitivity and noise exposure level, and given a significant correlation between sensitivity and annoyance, how does sensitivity increase the explained variance of annoyance? This question is very hard to answer globally, because the published methods of establishing the amount of variance vary widely. The often used Multiple Regression Analyses pose a special problem if they contain more than one moderator at the same time. In these cases, the weight of each moderator is adjusted in order to reflect the influence of other variables. If we use just noise sensitivity as the only moderator between exposure and annoyance, the explained variance of annoyance will typically raise in the order of 10 per cent.

Fear of harm connected with the source

Several aircraft noise studies have shown that the (subjective) fear of an aircraft crashing in the neighbourhood is related to noise annoyance.

Also, the general belief that the noise source - not the noise itself - has some detrimental effect on health, often shows significant correlations with non-aircraft noise. From my knowledge, the respective history starts again with McKennell (1963, 1973). He asked two questions related to aircraft effects: "Would you say that the aircraft have any effect on your own health?" (Q.18a), and "Do you think they have any effect on other people's health?" (Q.18b). It seems to be quite typical that many people deny harmful effects for themselves, but agree with the second question, assuming harmful effects for other people. When using the answers to the second question as a moderator, it turned out that those residents who believed in harmful source effects showed significantly greater noise annoyance than those who did not believe it. Moreover, the covariation between level and average annoyance was significantly greater for the latter group see [Figure - 4]. It should be remembered that this aspect does not ask for the potential harmful effects of noise, but instead for the harmful effects of the source.

In his early review, Schuemer (1974) noted the fear variable to be the most important nonacoustical variable to be mentioned in aircraft noise studies, followed by noise sensitivity. This evaluation relies on the fact that in 4 of the 5 publications which showed correlation coefficients, the fear variable correlated more strongly with the individual annoyance than did the acoustic variable. Similarly, Fields (1992) calls the fear variable to be the most important non-acoustic variable related to annoyance in most of the 282 field studies on noise of different origin. It should be noted, however, that the theoretical status of the fear variable is not always clear. For instance, Leonard & Borsky (1973) present a path model (i.e., the result of a statistical causal analysis of empirical data) using fear as mediating annoyance, while in several other studies, the data fit better to fear as a moderator.

Evaluation of the source

A related, but distinct topic is the general attitude to the source. This is partly a social factor, because large groups of noise exposed or nonexposed residents share the common attitude that some sources are more valuable than others. For instance, most people believe railroad traffic to be somehow "better" than road traffic or aircraft transportation. Still, I like to discuss this potential moderating variable also under the heading of "personal factors", because there is sometimes considerable variance of evaluations between residents affected by the same source.

We know both from everyday experience as well as controlled experiments, that persons who are convinced of the importance and necessity of the source show less noise annoyance than persons who are not convinced of the importance. In one of the earliest military aircraft noise studies, Borsky (1961) found correlations between source evaluation and noise annoyance in the order of -0.25; this covariation is still higher with annoyance by private airplanes (Rohrmann 1976).

Capacity to cope with noise

The theory of psychological stress, as proposed by Lazarus (e.g., Lazarus & Launier 1978; Lazarus 1991) states that psychological stress is the consequence of a person's inability to effectively cope with demands from the environment. Central to the coping concept is the belief and confidence of an affected person that he/she will somehow manage the problem. The coping strategy can be direct (e.g., in turning off the noise source, or negotiating with the people responsible for the stress) or indirect (mostly via cognitive control, e.g., by means of an exact knowledge of the time schedule of the noise source). Mostly, environmental noise sources cannot be turned off directly, but they could be negotiated, and indirect coping strategies can also be very effective in reducing the noise annoyance. Most readers will be familiar with the laboratory experiments of Glass & Singer (1972) showing significantly less noise effects with subjects who either knew the time structure of the noise, or knew that they could eventually stop the noise.

In an attempt to measure the self-rated coping capacity of subjects exposed to environmental noise, Guski et al. (1978) constructed a scale, containing items that reflect successful or unsuccessful coping strategies, like "If it is too loud outside, I simply close the windows, and then I am no longer disturbed", or "I know that I can protect myself quite well against noise". The sum of 6 items turned out to be the most efficient moderator in a field study on the effects of 7 different noise sources (Finke, Guski & Rohrmann 1980).

It should be noted that people or authorities responsible for a noise source could see this factor as a means of reducing annoyance; for instance, in the public discussions about a new runway at Frankfurt/Main Airport, a so-called "mediation procedure" is installed, during which residents, airlines, and airport manager come together and try to reduce the conflicts by means of guided communication. A central part of this discussion is the cognitive control: if the residents are sure that the air traffic will not increase indefinitely, and that the airport authorities will do everything they can do in order to avoid unnecessary noise, then annoyance will decrease.

Social factors moderating annoyance

It has already been stated that the distinction between personal and social factors moderating annoyance is somewhat arbitrary, because personal factors depend to a certain degree on social situations. Still, I like to discuss social factors separately, because they could sometimes be used by institutions responsible for running the source in order to reduce noise annoyance. This does not mean that there is no further need to reduce the noise immissions - on the contrary, immissions should be reduced in cooperation with respondents, taking into account shared attitudes of a community. Some residents may think that taking into account social factors is an unethical and "cheap" way of reducing the annoyance. But since we know that part of the annoyance is due to personal and social factors, we should try to reduce annoyance by means of reducing both the immissions and the social factors contributing to annoyance. We will discuss 4 social factors: (1) the general evaluation of the noise source, (2) trust or misfeasance with the source authorities, (3) the history of noise exposure, and (4) expectations of the residents.

General evaluation of a noise source

Most citizens have an "image" of different noise sources, even if they have never lived near one of them. For instance, railroad traffic has the image of an old, reliable, and rather harmless means of transportation that is under the control of a public institution. In contrast, road traffic is seen as dangerous and under private control, and air transportation is also seen as dangerous and under the control of an institution that makes money and tries to gain as much money as possible. On the other hand, the acoustic features of these three noise sources are different. Therefore, it is not easy to tell why aircraft noise annoyance usually is greater than road traffic noise annoyance, and railroad noise annoyance is usually less than road traffic annoyance at the same energy levels. But a field study comparing 7 different noise sources (Finke et al. 1980) proposed that the general (non-acoustic) evaluation of a noise source contributes much to the noise annoyance. For instance, the evaluation of a source as being unhealthy was the most important non-acoustic predictor for all important annoyance reactions, and its standardised regression coefficient proved to be higher than that of the energy-based exposure variable in 3 of the 5 tests.

In several other field studies, the "importance of the source" was used as a potential moderator. For instance, it was believed that residents near an airport, who accept the economic importance of air transportation, and hope to have a direct economic benefit from it in the long run, would show less annoyance than residents who do not believe in the airport importance. Typically, the correlations between "importance" and annoyance judgments were in the order of -0.15 to -0.28, but the moderating effect was rather low.

Trust or misfeasance with source authorities

The concept of trust or misfeasance goes back to Borsky (1961). He called the degree to which residents felt that the source agents do everything in order to avoid unnecessary noise, "consideratedness". Similar terms have been used by McKennell (1963, "preventability"), Schuemer (1974, "trust in the good will of responsible people"). This paper uses the term "misfeasance", as proposed by TRACOR (1970), because it denotes the current situation at several airports and railroad tracks at least in Germany. The residents know that they cannot control the noise emissions, they fear that the noise source and/or the noise itself does some harm, and they usually assume that an institution supposed to be under public control is not really controlled by the public, and it certainly does not give priority to public health. This attitude contributes to noise annoyance. For instance, the residents at Duesseldorf Airport are well known in Germany, because the usually produce higher annoyance scores than residents at other comparable airports. This is not only due to a very active group that opposes to the unrestricted increase of the air traffic, but also due to the behaviour of the county administration, which used to own the airport and recently sold it to a private company which spent some million German Marks more in order to get permission for a further increase in aircraft movements in the order of 30 per cent.

The degree of misfeasance is often measured on a scale containing items concerned with "the people who run the

airlines", "the airport officials", "the government officials", "the pilots", "the designers and makers of airplanes", and "the community leaders" (Leonard & Borsky 1973). The summated ratings show correlations with annoyance variables in the order of 0.250.36, and regression analysis showed "misfeasance" to contribute to annoyance to a significant degree, even after controlling for "fear" and "health attitudes". See [Table - 1] for results of an (uncontrolled stepwise) Multiple Regression Analysis of Leonard & Borsky (1973). This analysis can be questioned because of methodological reasons, but the importance of misfeasance can clearly be seen - it is well above the importance of the acoustic variable CNR. This variable will increasingly play a major role in environmental psychology.

Misfeasance attitudes by residents might likely be reduced by actions of the noise authorities which show (a) clear data about the acoustic situation and it's development, (b) an acceptance of the existence of harmful effects of noise, (c) clear data about noise abatement programmes, and (d) a willingness to communicate and cooperate with the residents.

History of noise exposure

In land use planning, the history of the land use is often seen to be important. For instance, if a road transportation company wants to settle in a residential area, it will not be allowed to do so in Germany, because it does not fit to the history of the area. If the company is already located in the vicinity of a residential area and wants to expand in the direction of the residents, it will be much easier to get a permission, because transportation noise is already there. On the other hand, many residents live about 10 to 20 years in the same area in Germany. They tend to say that their living area has become louder in the past years and that the amount of noise does not fit any more to the original character of the area. With aircraft noise, this impression stands in sharp contrast to the observation of acousticians who state in general, the energy-based measures of global exposure have decreased. It seems that the residents do not react to global energy, but instead to noisy events, i.e., to the amount, distribution, duration, levels and the meaning of acoustic immissions. Therefore, it is not surprising that residents near an airport say the noise has grown louder. They probably mean that the number of aircraft increased, and the duration of relatively calm epochs decreased. In addition, the increase of the number of aircraft movements does not fit to the history of the area. A similar idea has been expressed by Fidell (1987), suggesting that the prediction of noise annoyance should take into account the historical distribution of noise levels. Unfortunately, we don't have any empirical test of this idea yet, but if it is true, then plans for new noise sources, or expanding the noise immission area to residential areas which have not been exposed before, should be considered with great caution.

Expectations of residents

This aspect has much to do with the history aspect, but also with subjective control and misfeasance: residents in the vicinity of motorways, long-distance railroads, and airports have seen that the noise increased during the past years. More often, they fear that this increase will go on, and they don't see effective means for stopping this "progress". The German Noise Abatement Society (DAL, personal communication, see also Schick 1986) has often found this aspect to be the major source of motivation for residents' complaints near airports and railroads. These people are disturbed by noise, but they are also annoyed because they expect an increase in the amount of disturbances without having any influence on the development. There are no meaningful data on this topic, but the noise annoyance will probably decrease if the residents know that the future level of noise exposure (not only the level of sound energy) and its distribution in their living areas will at least not increase any further.

Conclusion

Noise abatement programmes are effective only insofar as they can mitigate noise effects. That is, noise abatement programmes should be annoyance abatement programmes. In view of the multifold moderating relations of annoyance to personal and social factors that have been shown in this paper, it seems attractive to consider personal and social factors as tools which can help reducing residential annoyance. Of course, there are personal factors which cannot be influenced by actions of the source authorities or by public relations campaigns - for instance, noise sensitivity, and the personal style of coping with noise. But there are still a number of factors which possibly could be changed, e.g., some aspects of the fear variable, the evaluation of the source, some aspects of coping with the noise, trust / misfeasance with respect to authorities, and expectations with regard to the development of noise. For instance, initial noise annoyance can probably be reduced by establishing (or re-establishing) trust, i.e., by means of communication and cooperation between source authorities and residents. This would mean (a) that the source authorities should provide information about the necessity of noise, about actions taken in order to reduce the noise, and about future plans to handle the noise problem. In addition (b) residents should get the opportunity to control some aspects of the noise, e.g., be involved in discussions about the most effective noise abatement programme, and to have choice which way to go. Of course, it is difficult to communicate if there was no communication for years - this usually means hard frontiers at both sides. In these cases, independent agencies could help to start the communication process.

In a similar vein, even the fear of harm connected with the source can probably be reduced by means of visible actions of the authorities. For instance, the fear of cars crashing into pedestrians could be reduced by concrete stakes at the rim of walkways. These stakes don't have any acoustic effect, but they may reduce noise annoyance by means of reducing the (moderating) fear aspect.[26]

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Figures

[Figure - 1], [Figure - 2], [Figure - 3], [Figure - 4], [Figure - 5]

Tables

[Table - 1]