

## CHAPTER 8

# *Non-auditory Effects of Noise: Physiological and Psychological Effects*

GERD JANSEN AND ECKHARD GROS

### 8.1 INTRODUCTION

Physiologically adverse noise effects (e.g. alterations in the peripheral blood circulation) still pose the question whether noise causes extra-aural diseases besides noise-induced hearing loss. This question can not be answered in the affirmative until now. However, noise was found a health hazard in combination with other stressors.

Regarding the psychologically adverse noise effects, it is to be said that the stressor noise mainly affects performance and detracts from people's individual and social wellbeing. *Direct* noise effects are disturbances in auditive and non-auditive performance, communication, information-processing, rest and relaxation. *Indirect* noise effects are impairment of people's wellbeing: windows have to be closed, people reduce their speech communication or refrain from it, they change their dwellings or dwelling areas. Various social-scientific investigations harmonize in a high degree in their result regarding the quantity of environmental noise pollution and ensuing main psychic effects (comprised by the term 'annoyance').

The presented noise effects are to be seen as mean reference values fluctuating in dependence on the individual's characteristics. Application of moderator variables can considerably improve the accuracy of predictability of noise effects.

Acoustical-defined guidelines and limit values are intended to protect the average population. Allowances have to be made therefore, for critical groups who need special protection due to their enhanced sensitivity to noise.

### 8.2 PHYSIOLOGICAL EFFECTS OF NOISE (Gerd Jansen)

Besides the affections to the inner ear, some other vegetative and physiological effects of noise are known (Welch and Welch, 1970; Jansen, 1972). The

question is: Can these physiological effects already occur below the level at which noise-induced hearing loss is to be expected? This question is definitely to be answered in the affirmative. At sound levels of 50 and 60 dB(A) vegetative responses can already be observed. First reactions become manifested by monitoring electroencephalographic (EEG) responses even at 35–40 dB(A) (evoked potentials).

Do these reactions already signify illness? This question has concerned us for a long time. Before going into the details it can be stated: Hitherto no noise-induced trauma — in addition to hearing loss — has been found and there is no indication that a 'noise-disease' exists (cf. WHO, 1980).

But how is the dilatation of the pupils to explain what is shown in Figure 8.1? Strictly speaking, this is a 'reaction' only. Every organism has to stand some stress day after day and reacts to the stressors. Even to get out of bed is stress! From the responses can be learned that certain physiological processes take place. In response to a sound stimulus the pupils dilate. Other investigations have shown that the activity of the salivary as well as the perspiratory glands becomes affected. Also the peripheral circulation, the gastric-intestinal movements, liquor pressure and many other functions have been proved affectable by noise (summarized by Jansen, 1980). But in all these cases we can only speak of 'reactions' and not of 'diseases'. Of course, there is another question: Bearing in mind the range of sound levels which cause hearing loss — would not, nevertheless, the physiological effects of noise signify illness if there were not already a noise-induced hearing loss? For, hearing loss protects the organism in a certain degree from the transmission of sound energy, thus preventing it from obvious physiological responses.

At present, it can already be stated that noise below the threshold value of 90 or 85 dB(A) cannot be proved to be a health hazard. Yet it would serve our purpose to have an objective criterion which could be used as a reference measuring value. Thus, we could find out whether there is any quantity to recommend for the determination of an approximate value. If there were levels of risk below the threshold value which is given to protect people from noise-induced hearing loss we would not have to investigate this problem any more, as an unacceptable level or a limit of unreasonableness would have been established long ago. But that is not the case.

Another noise-related effect is the affection of the peripheral circulation. Figure 8.2 illustrates the effects of an artificial sound. At rest circulation is normal. Application of broad-band noise results in a reduction of blood supply which is to understand as vasoconstriction. The physiological response to noise ends simultaneously with noise exposure. The degree of circulation disturbances depends on the different noise sources, for example, straightening machine for small iron parts, pressing of a pneumatic hammer, noise of turbines and broad-band noise. In all these cases the responses are rather

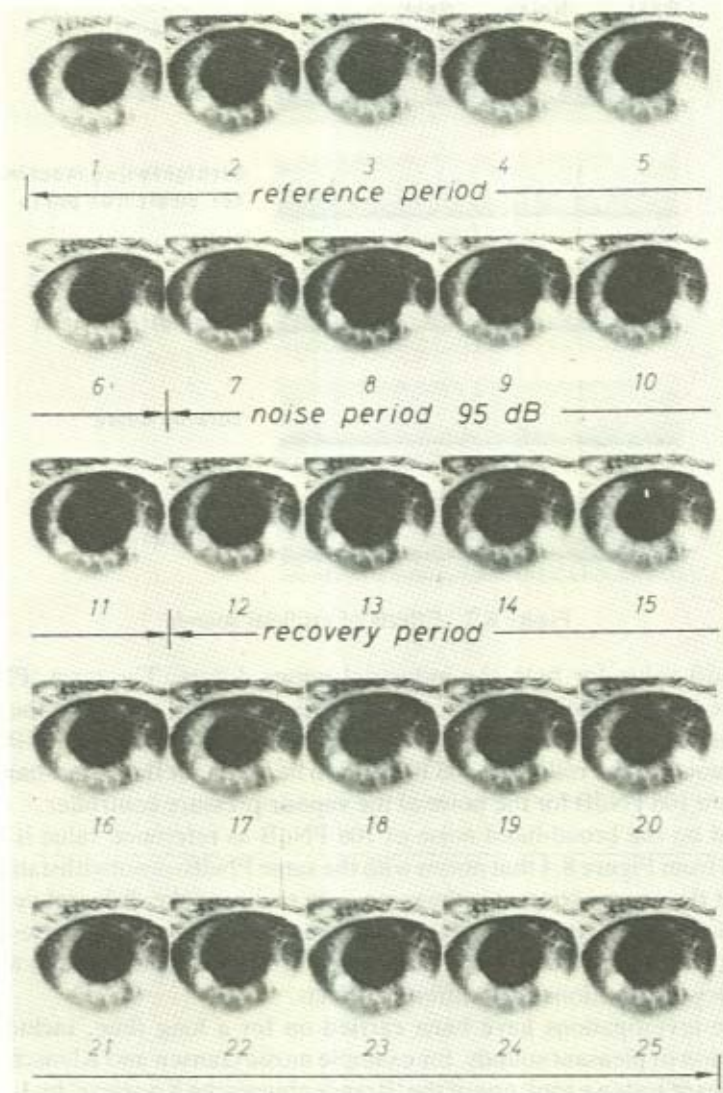


Figure 8.1 Original photograph of pupil

similar. By that the question arises, are all the mentioned different noise sources of the same effectiveness or is there still a differentiation possible?

In the beginning of our studies on noise we tested already the effects of three noises in comparison namely, broad-band noise, and those emanating from a rolling mill train and a vapour-pressure controller of a turbine-driven ship. These noises, demonstrated in Figure 8.3, are of the same energetic content but

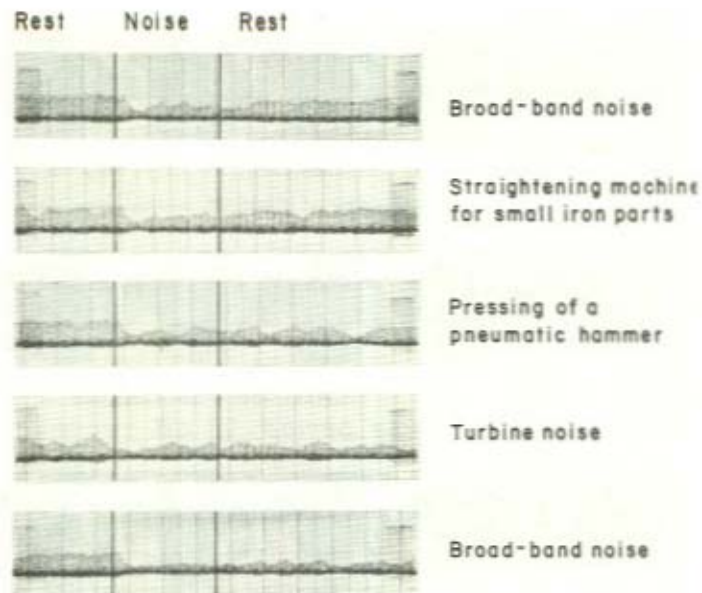


Figure 8.2 Effects of artificial sounds

the PNdB-value for both the industrial noises differs. The term 'PNdB' = Perceived Noise Decibel was proposed by Kryter (1970) to denote the level at which annoyance arises from the perceived noisiness. If we assume 100 PNdB for the noise of the rolls then 108 PNdB is to be taken for the broad-band noise and again 108 PNdB for the noise of the vapour-pressure controller.

Based on the broad-band noise of 108 PNdB as reference value it is to be learned from Figure 8.4 that noises with the same PNdB — notwithstanding the fact that the energy content is the same — in reality evoke different vegetative responses. Hence, it can be stated that what we know about noise-induced hearing loss is also true for the physiology of noise effects namely, different frequency distributions elicit different effects.

These investigations have been carried on for a long time, including the application of pleasant sounds, for example music (Jansen and Klensch, 1964). In a series of tests we took one of the 'Brandenburgische Konzerte' by J. S. Bach and at the same time made our measurements (Figure 8.5). Here it is also illustrated that sound levels of about 90 dB(A), independently whether they emanate from music or broad-band, have the same general effect on the cardiac output (supplied blood volume per heartbeat), pulse frequency, minute volume and blood pressure; but there are, nevertheless, some differences. The effect of music is, as a rule, not so considerable. The blood pressure, for example, shows a slight increase under the influence of broad-band noise but such an increase is scarcely recognizable if music is the stimulating sound.

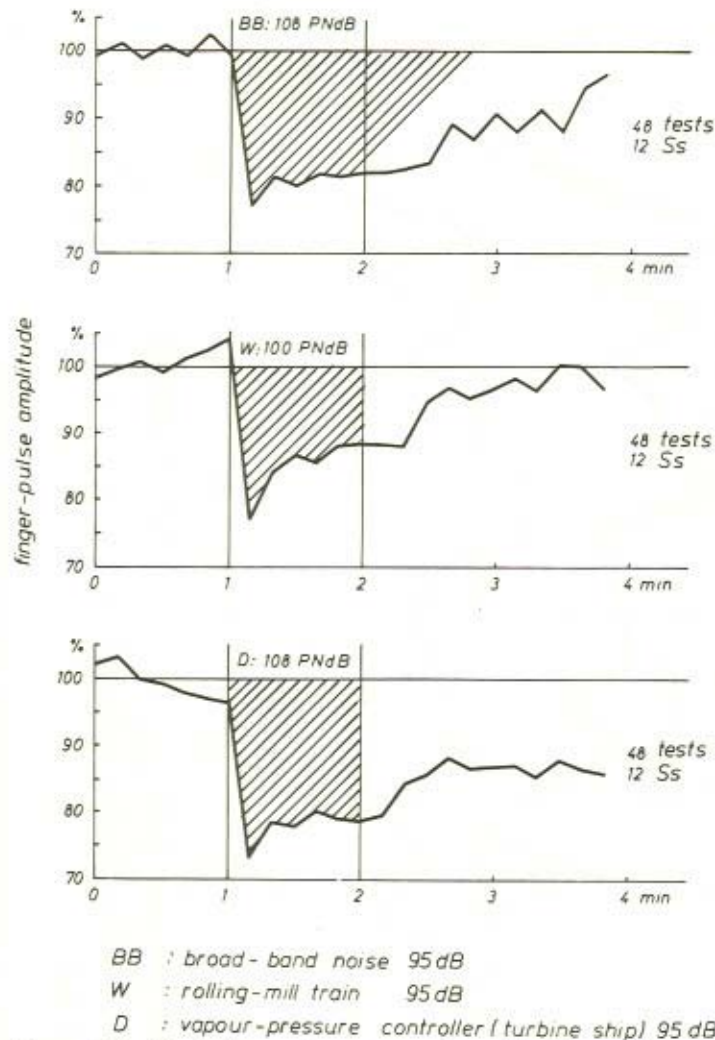
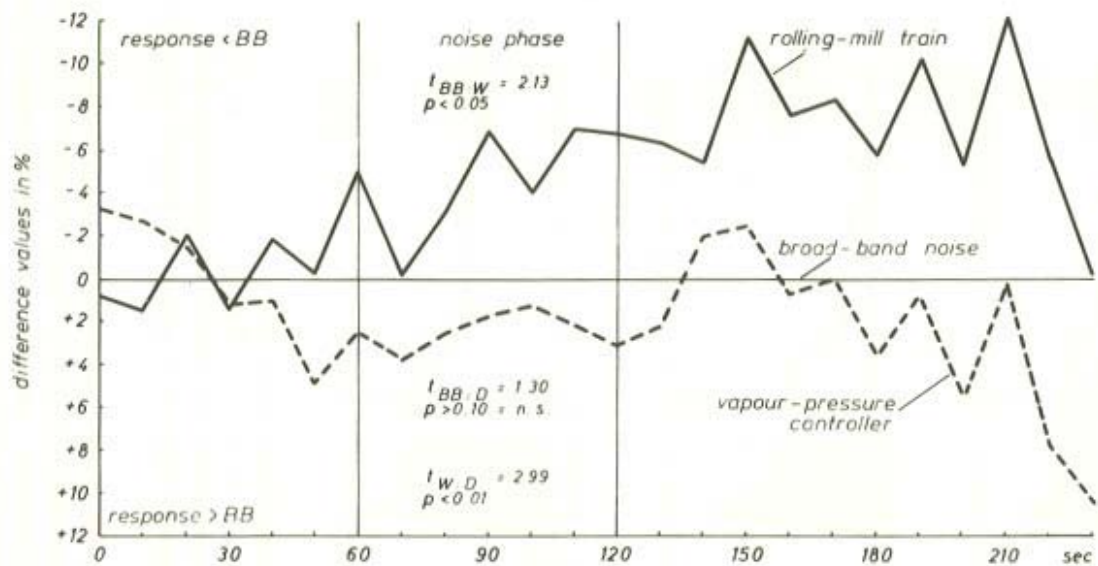


Figure 8.3 Vegetative responses to noises with different frequency spectrum

We examined not only the effects of music but also those of everyday noise, traffic and aircraft noise as well as noise with Doppler-character (change from high to deep sounds and vice versa, simultaneously becoming louder or lower). We applied, also, the so-called 'wobble-noise' and it became again evident that the responses differed, but were partly dependent on the psychological constitution of the subjects. Figure 8.6 shows at the right a column 'information bearing, 95 dB'. In that case the applied sounds were of industrial origin or gave a feeling of annoyance. In consequence of psychological tests the subjects had



BB = broad-band noise 95 dB  
 W = rolling-mill train 95 dB 100 PNdB  
 D = vapour-pressure controller 95 dB 108 PNdB  
 12 Ss 48 tests

ns - not significant

to Jansen

Figure 8.4 Differences between the values of the PNdB test series

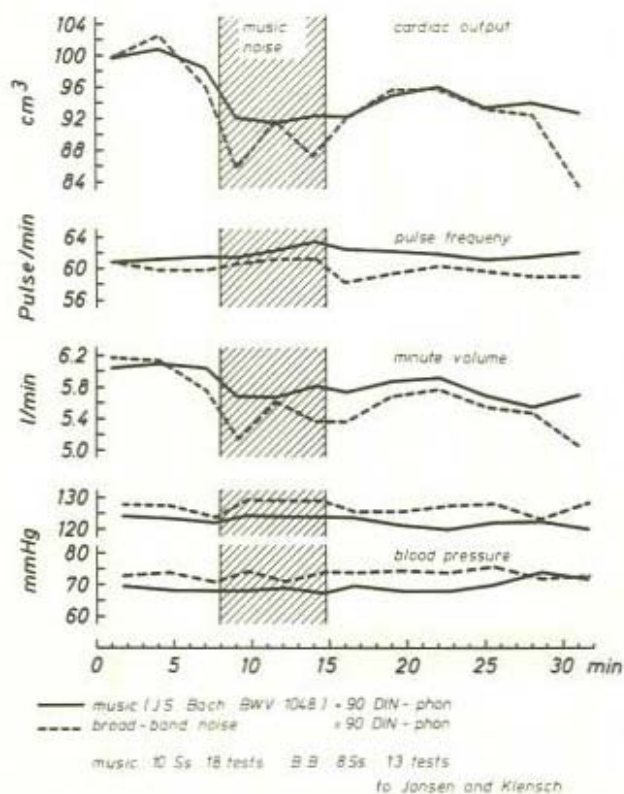


Figure 8.5 Peripheral blood circulation at music and noise

been divided in two groups namely a so-called 'labile' and a 'stable' group (neurotics and non-neurotics). Both types of human beings are always easy to find in populations. There are people really unaware of noise (e.g. seamen who sleep in their cabins being exposed to 90 dB(A)) whereas others wake-up at the slightest sound (for example, when a lorry passes in the distance). Such people are extremely sensitive and — as is to be seen in Figure 8.6 — they are the 'labile' group who, in fact, shows the stronger physiological responses to information-bearing noises.

This cannot only be proved by the finger-pulse amplitude but also by some other vegetative responses. The responses are similar if music is offered as the sound stimulus. Here again the 'labiles' respond intensely whereas the 'stables' are, one could say, not at all responsive. The subjects exposed to music and noise (shown in Figure 8.5) are categorized in the 'stable' group. This evidence shows that the frequency distribution nevertheless plays a role.

What we have observed is that some subjects who have been exposed to broad-band noise as well as industrial noise daily for weeks and years always

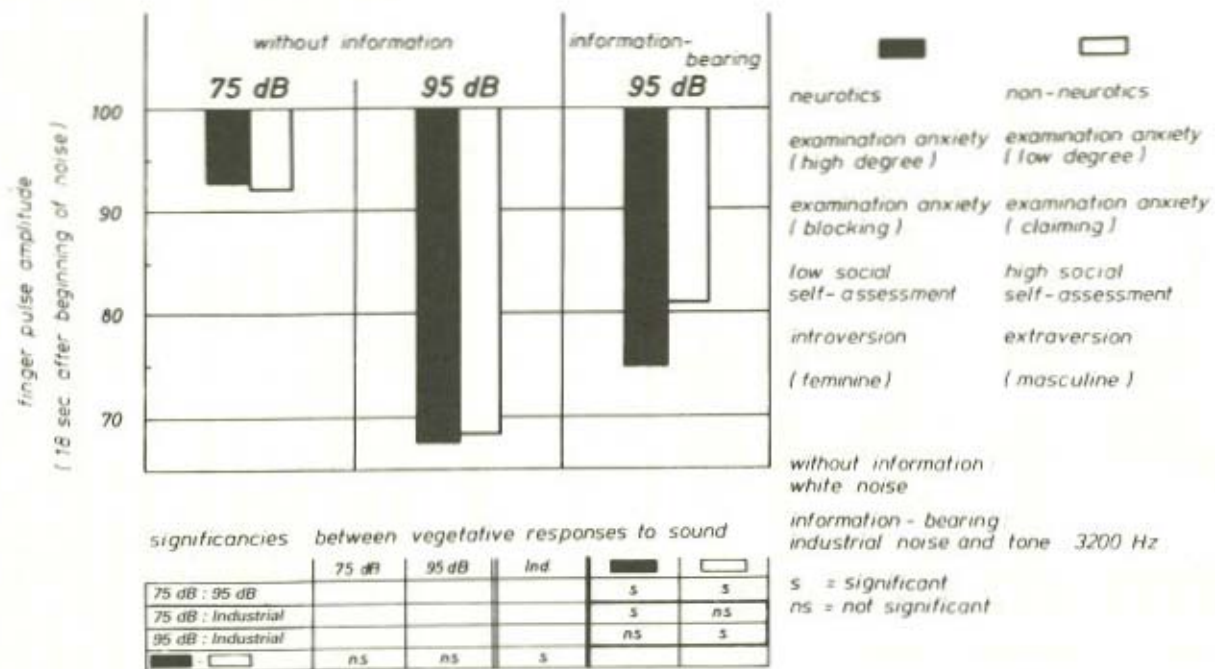


Figure 8.6 Personality traits and vegetative responses to noises without information and with information-bearing ones

showed the same reactions. The same music or information-bearing noises induced in the beginning different responses in stable and labile persons. But these differences disappeared in the course of time. Those, who showed in the beginning strong reactions to information-bearing noises have reacted less intensely after a certain time. Afterwards, both groups were similar in their responses. This behaviour emphasizes that the more the habituation to a certain noise the less the information taken from it, and the physiological responses become balanced for both groups (compare Figure 8.6, the respective pairs of columns). However this is only true for intensities above the level of noise-induced hearing loss.

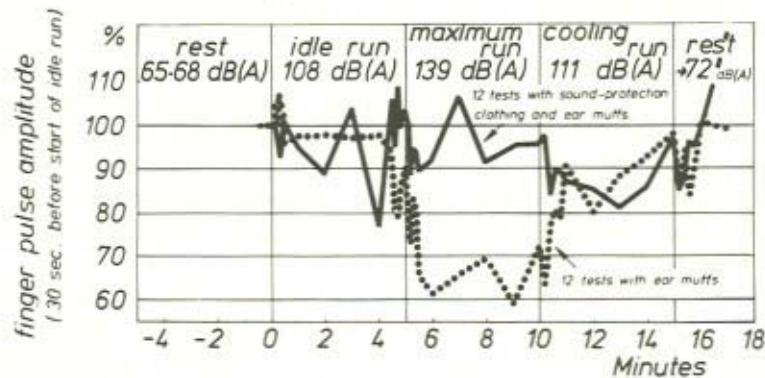


Figure 8.7 Finger pulse amplitude in jet-engine test-drive using noise protection

More distinct effects manifest themselves if the noise-induced hearing loss level is widely exceeded. Figure 8.7 relates to mechanics who had been engaged in maintaining jet-engines when test-drives took place. The typical working situation is depicted, after rest (65–68 dB(A)), the turbines are set in motion, the 'idle-run' results in a noise of 108 dB(A), this ascends to 139 dB(A) in the 'maximum-run', then lowers to 111 dB(A) in the 'cooling-run' and returns again to the rest situation. This procedure has to be carried out by the test-mechanics three to four times daily all the year round.

The mechanics were furnished with ear-muffs as well as with sound-protective clothing, but they were not willing to wear the clothing. The sickness rate of the test-group was about 50%, resulting from diseases of the gastric-intestinal system (from gastritis to ulcers) as well as headaches associated with migraine. From this we can conclude that the physiological reactions to noises below the critical levels – i.e. 50, 60, 70 and 80 dB(A) – gradually develop to illness-causing responses at the moment when the level of 100 dB(A) is not only exceeded but reaches such extreme values as are reported here. It has to be mentioned that 50% of the mechanics who had been subjected to extremely high levels did not show any alteration in their physical condition.

The dotted line in Figure 8.7 demonstrates the peripheral circulation of the subjects when earmuffs with an effective attenuation of 30 to 35 dB(A) were used. This means, when the attenuation effect of the earmuffs of about 30–35 dB(A) has been deducted from 139 dB(A), 105 dB(A) still remain. If sound-protective clothing is worn, the noise effects, shown by the normal line in Figure 8.7, could be nearly eliminated.

We have carried out additional investigations which provided evidence that the internal organs can be affected directly by noise (cf. Döring *et al.*, 1980). Using an underwater loudspeaker to direct sound waves of 90, ascending to 150 dB(A), to isolated pieces of intestines it was found that no gastric-intestinal movements took place at the upper level. Returning to the example of the test-mechanics, assuming 105 dB(A) to be conducted by the ears but at the same time also directly absorbed by the organism (the mechanics do their job only dressed with loose shirts in summer which means that their whole organism is exposed to the noise). It is suggested that this might contribute to the aforesaid incidence of sickness. Consequently it can be stated that a risk to health only begins at very high noise levels, independent of the kind of noise. The noise effect is definitely of a physiological nature and depends exclusively on the noise level.

It may be added that we have tried to find out whether the predictors, shown in Figure 8.8, were really the factors which had caused the diseases in a group of sick people. The most important predictors were: outdoor noise level (people are exposed to high-noise levels in their recreation time), high-noise levels originating from jet engines at the workplace, age, physical stress, hearing threshold, psychosomatic symptoms and so on.

Three-fourths of all the health impairments could be attributed to the above mentioned predictors.

What matters now is whether, in cases where noise is a health hazard, other factors can also be held responsible for these physical impairments. The conclusion is justified: besides noise-induced hearing loss noise can never be the only cause of physical impairment! In connection with our test group it is undoubtedly correct to say that noise was the main factor in their physical impairment, since noise influences in their private life and noise-induced stress at their workplace had been the most considerable predictors out of the whole range of environmental stressors.

But in normal cases there exist other exogenous factors besides noise, namely vibration and dust, climate, toxic agents, etc. (Figure 8.9), which affect human beings and elicit reactions, additionally or in combination, moderated by individual constitution, disposition and motivation. There are also a number of other psychological factors which have played their part in the case of the jet-engine mechanics who felt the stress due to noise to be the main cause for their physical impairments namely, psychosomatic symptoms and stress in their private life.

**Criterion:** Class of medium finger pulse reaction 18, 24, 30s after starting the broad-band, 105 dB(A)

**Predictors:**

- Outdoor noise
- Sound-induced stress
- Age
- physical stress
- improved hearing threshold at 6000 Hz
- Psychosomatic symptoms (FPI 1)
- Nervous strain
- Neuro-vegetative indications
- Children's and infectious diseases
- Alcohol consumption
- (13 more)

	Class 1 Reaction 21,3%	(Class 2=healthy reaction)	Class 3 Reaction 63,9%	Correlation-coefficient	Beta-weight
<i>Determination</i>					
quiet		28,6%	(very) loud	.382*	.749**
none		23,8%	5 years	.566**	.420*
<41 years		21,8%	21 years	-.261	-.836***
slight		16,0%	high	.309	.517
> -6 dB		12,1%	30 dB	.224	.539**
no		7,8%	yes	.162	.481
		/		0	.692*
		/		0	-.505
none		-10,4%	4 to 9 diseases	.293	-.353
0 to 24 g/daily		-23,5%	75 to 125g/daily	.351	-.569**
		(negligible)			

$R^2 \times 100 = 76,2\% \bullet\bullet$

Significance Level  
 \*5%, \*\*1%, \*\*\*0,1%

Figure 8.8 Evaluated reaction of the finger pulse amplitude to sound as well as variables of stress and the general physical constitution

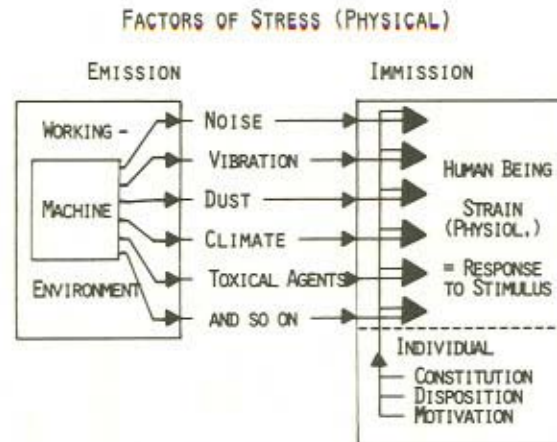


Figure 8.9 Stress due to environmental factors

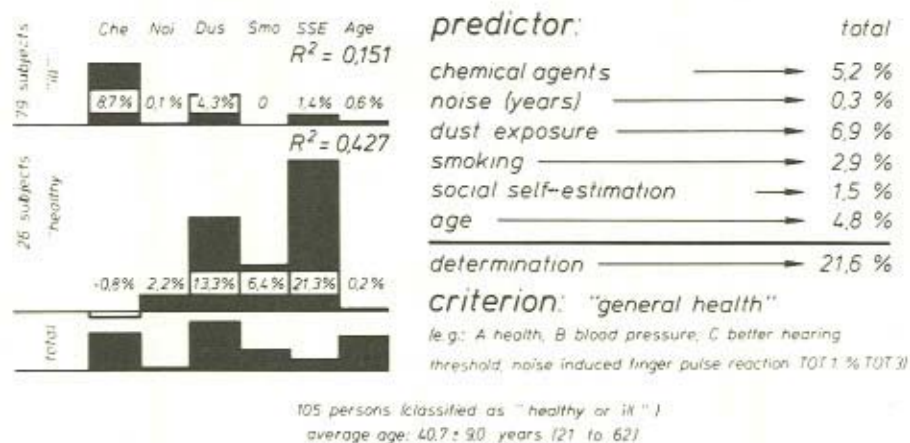


Figure 8.10 Different exposure factors and 'general health'

Figure 8.10 illustrates experimental-analytical and epidemiological investigations (Jansen *et al.*, 1981). A group of industrial workers was examined with regard to the toxic agents they have been exposed to, the years of their noise exposure, airborne dust at their workplaces; but, also, with regard to other factors of risk, namely smoking habits, social self-estimation and age. As Figure 8.10 shows, only 20% of the physical impairments in these workers (who had been exposed to an average noise-level at work of 90–115 dB(A)) were due to the afore-mentioned predictors. Airborne dust was most detrimental to their health and the noise exposure was of much less consequence.

From that it can be inferred that the question about noise effects and the valence of the different noise sources cannot be answered clearly and precisely. The individual noise sources can have a certain effect relevant to health or no effect to health at all. But we have to consider the large number of further predictors in human beings and their surroundings. Psychological and sociological factors have to be taken into account. This leads to the problem of the psychological effects of noise.

### 8.3 PSYCHOLOGICAL EFFECTS OF NOISE (Eckhard Gros)

Information theory uses the following three terms to describe the information-exchange process:

Emission — Transmission — Immission

A similar pattern is used by Psychology to explain human behaviour and sensations:

S(stimulus) — O(organism) — R(reaction)

To understand the psychological effects of noise the following three main factors have to be considered as a whole:

S(noise stress) — O(organism) — R(noise effects)

The factor 'organism' covers a complex system namely, processing of information, habits and attitudes as well as important personal and/or situational characteristics. Figure 8.11 shows the combined action of stress and strain with special regard to the so-called moderator variables. A moderator variable is operationally defined as a quantity of influence, at first unknown, between stress and strain. It can decisively determine the intensity of the reaction to strain without being directly connected with the occurrence of stress (cf. DFG, 1974). In the following, the psychological effects of noise are considered and the influence of moderator variables is taken into account.

#### 8.3.1 Interference with Human Performance and Behaviour

Performance alteration due to noise is the most controversial topic in the field of research on noise effects (cf. Broadbent, 1979; Burns, 1973; Gulian, 1973; Kryter, 1970; Miller, 1974; Poulton, 1979). The relevant scientific literature renders both, reports which prove that performance increases under the influence of noise and such which maintain just the contrary. Others, however, could not find any effect on performance at all (summarized by Loeb, 1980).

The two extremes on a two-point scale could be presented in a simple manner by discussing the positions of two eminent noise researchers. Kryter (1970) is of the opinion that noise has a rather positive effect on performance

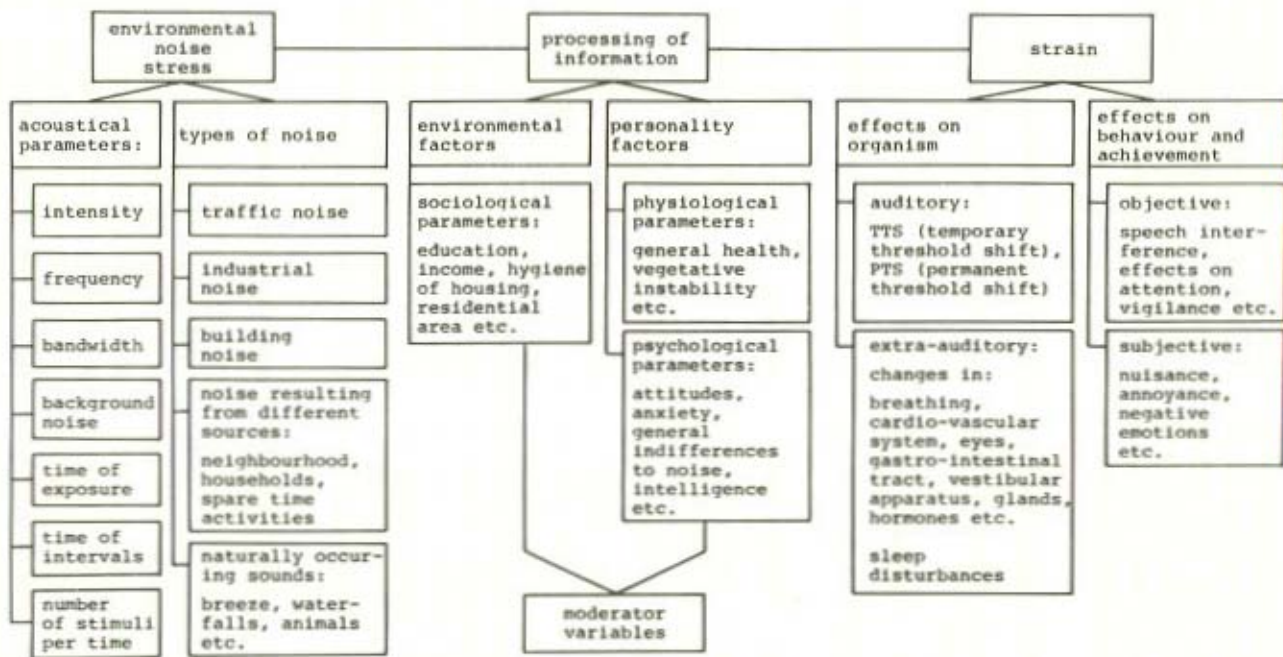


Figure 8.11 The relationship between stress and strain with special regard to moderator variables

whereas Broadbent (1971) thinks that performance is affected quite negatively by noise. A possible explanation of this problem seems to be the different use of the term 'performance': The most varied forms of reaction (e.g. control activity, opportunity to choose, rapidity of reaction, learning achievement, memory training) are all defined as 'performance' or 'achievement'.

A possible criterion for splitting up the comprehensive term 'performance' is, for example, to separate from it the part of intellectual activities. In the determination of sound-level threshold values, that ensure an undisturbed performance, the specific kind of activity should be taken in consideration, as was emphasized for example by Schönplugg and Schulz (1979):

- Sound levels higher than 90 dB(A) will, as a rule, lead to a drop in performance and a decrease in wellbeing *at activities of any kind*. Below this level, however, the reasonableness will largely depend on the kind of work to be done. Even very low noise levels (below 55 dB(A)) can produce disturbances
- Threshold values are to be set on particularly low in case that the task to perform
  - makes high demands on worker's intellect (e.g. planning activities),
  - makes high demands on worker's functions of memory,
  - if the worker lacks practise.

The kind of work to be done under the influence of noise was also taken into consideration when a guideline was established in the Federal Republic of Germany: 'Assessment of Noise in the Working Area with Regard to Specific Operations (VDI-Guideline No. 2058, Part 3, 1981)'.

There are three sound-level classes depending on specific activities: the highest permitted noise levels at the work-place, including the disturbing outdoor noise that pours in, are (see VDI 2058, Part 3, 1981):

- 55 dB(A) if the intellectual part of work predominates (e.g. if activities demand intense concentration, creative thinking, or if decisions of consequences are to be made),
- 70 dB(A) if uncomplicated or partly mechanized office work is to be done (or similar activities),
- 85 dB(A) at all other activities.

Jansen & Klosterkötter (1980) contributed — in cooperation with some other renowned scientists of different faculties — to the clarification of the varied explanations of noise and its effects. They found the most frequently explanations in case of alterations in performance to be the following:

1. Distraction and/or reduction in attention.
2. Prolonged reaction time, simultaneously resulting in a slow-down of physical and mental processes.

3. Changes in aspiration level.
4. Increase in readiness of risk-taking behaviour (in connection with speeding up of mental processes).
5. Increase in the general activity of the organism (psychophysiological activation) connected with a decrease in discrimination ability and increase in interference.

Summing up, the authors stated that, generally, all the physical and mental performances can be affected by noise with regard to their quantity (e.g. volume, speed) as well as their quality (e.g. grade, frequency of errors). Impairment of performance will be the more likely, the more complex, difficult and timeconsuming the activity necessary is to achieve the result.

Figure 8.12 shows a rough pattern based on the sound level. In the individual case, there can result shifts from specific characteristics of personality and situation. A coincidence of some of these characteristics can lead to effects that exceed the sum of the single effects.

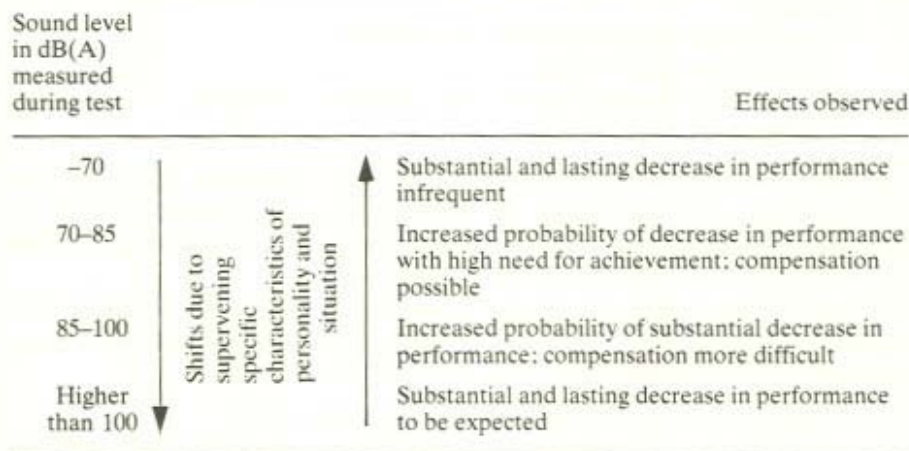


Figure 8.12 Sound levels and effects on performance

With regard to the pattern shown in Figure 8.12, Jansen and Klosterkötter (1980) especially drew the attention to the fact, that allowances have to be made for both, the differences between the individuals (inter-individual differences) and the varying responses in one and the same person depending on the time (intra-individual variability).

According to Jansen and Klosterkötter (1980), the individual differences are to be attributed to the following factors:

- individual excitableness and sensitivity,
- individual proneness to being disturbed, distracted, as well as lability,

- individual performance capability (as determinant of the task-inherent difficulty),
- individual attitude towards the noise and the noise source,
- degree of achievement motivation.

The compensation of noise effects, also mentioned (see Figure 8.12) (by increasing motivation, for example) can in itself produce adverse effects (psychic costs).

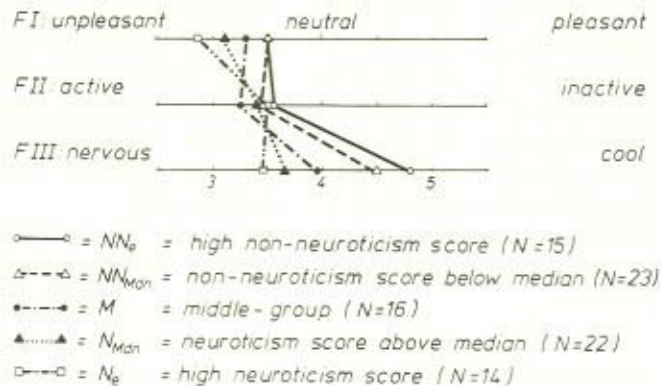


Figure 8.13 Noise-ratings, judged by various subgroups

Besides the influence quantities, with regard to sound level and kind of activity, individual's characteristics play an important part. Jansen and Hoffmann (1965, 1973) studied, for example, the subjective mood as well as changes of handwriting-pressure under different noise situations in dependence on the personality factor neuroticism. The noise situations contained: white noise 75 and 95 dB, octave-band noise 95 dB (mid-frequency 3,200 Hz), third-octave-band noise 95 dB (mid-frequency 3,200 Hz), and pure tone 95 dB (3,200 Hz). Judging noise situations by means of adjective scales it was proved that increasing loudness caused increasing annoyance. The concept of annoyance consisted of three dimensions; emotional factor (pleasant-unpleasant), activity (active-inactive), and tension (nervous-cool). The negative judging of noise was intensified by the personality factor neuroticism (see Figure 8.13). Handwriting-pressure tests showed a noise-induced drop in handwriting pressure. The effects of narrow-band noise exceeded those of broad-band noise. Thus neuroticism was found to be a factor that increases noise-induced effects.

Basow (1974) was able to prove the effects of white noise on the performance of attention as a function of the tendency to become anxious. Discipio (1971) likewise found the psychomotoric performance depended on white noise as well as on personality variables. Guski (1975) investigated in an empirical

study the approach of Glass and Singer (1972) according to which a person's reaction to noise depends in a higher degree on his cognitive evaluation of the noise event than on the noise itself or one of his own personality characteristics. Based on his studies, Guski (1975) concluded that the observed drop in performance under noise exposure is mainly due to the subject's evaluation of the noise situation and therefore the alteration in performance is only to be seen as a secondary, by cognition elicited sound effect. In a field-experiment dealing with noise, sleep and performance, similar results were found by Gros (1985). Methodical aspects of researching noise and performance effects are discussed by Gros and Mehnert (1986).

Summing up it may be said, the present stage of knowledge regarding the psychological effects of noise on human performance can best be described by the theoretical concept of the 'moderator variables'. It is assumed that noise elicits cognitive and emotional evaluation processes which are modifiable by characteristics of the situation as well as of the individual.

Figure 8.14 (based on DFG, 1974) demonstrates the possible different effects of noise on performance by means of the moderator variable 'sensitivity to noise'.

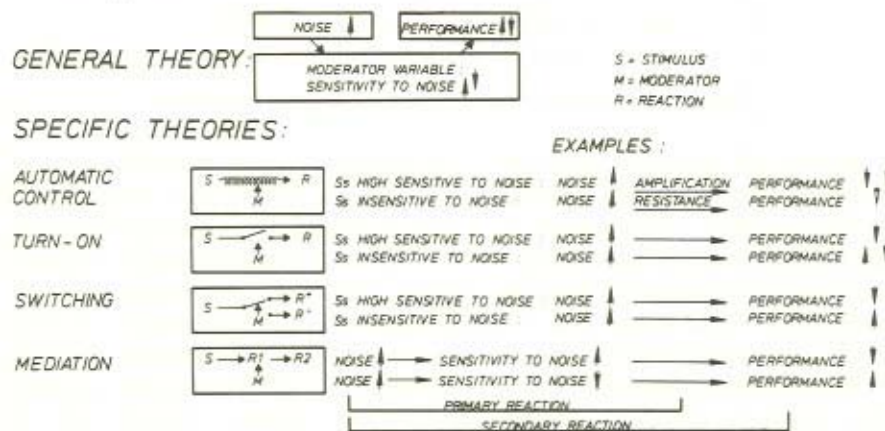


Figure 8.14 Examples for different effects of a moderator variable

### 8.3.2 Psychological Well-Being and Annoyance

Sound events that elicit annoyance detract from people's wellbeing (UBA, 1978). Noise has, because of its acoustical characteristics (e.g. intensity, bandwidth or impulse content), *directly* adverse effects on man, startle response or defensive blocking, for example. Other direct effects can be due to the information-bearing characteristics of the noise source (e.g. moped, lorry). But annoyance mainly results from people's knowledge not to be able to escape that as unnecessary felt noise.

The *indirect* adverse effects of noise can be impairment of people's psychic wellbeing due to disturbances during recreation and relaxation. Annoyance results also from being compelled to close the windows or to raise one's voice in order to reduce or to drown the noise coming from outdoors (cf. Rohrmann, 1976, 1977, 1978; Rohrmann *et al.*, 1978, 1980; Finke *et al.*, 1980). From this lasting alteration in behaviour — e.g. increased drug consumption — can ensue (Meier and Müller, 1975). Further noise-induced alterations in behaviour are, turning up of radio or television, reducing speech communication or refraining from it, changing one's dwelling or moving to another area.

The extent of continual annoyance due to sound emission is only reflected in people's reaction. It was ascertained that the connection between the degree of annoyance and the physical sound pressure, above all in the mid-intensities (45 to 70 dB(A)), is not especially close. The acoustically characteristic values of noise represent in this connection only *one* determinant of the annoyance reaction besides the sociological, physiological and psychological characteristics of the aggrieved individuals. Thus, the concept of the moderator variables can also be applied to the effects of annoyance due to noise.

The DFG study on aircraft noise (DFG, 1974) comprises an empirical examination of the moderator concept. The accuracy of prediction regarding noise effects could be doubled by inclusion of moderator variables.

World-wide demoscopical surveys have been carried out in order to ascertain the extent of annoyance elicited by environmental noise (Bradley, 1980; Brown and Law, 1978; DFG, 1974; Fidell, 1977, 1978; Finke *et al.*, 1980; Rohrmann *et al.*, 1978; Suzuki, 1978). According to this as well as to other studies, about 80% of the Western German population, for example, feel disturbed — depending on the noise source. Looking in this connection at traffic noise, the most annoyance-causing effects are ascribed to lorry noise, followed by aircraft noise, industrial and construction noise, as well as noise originating from the neighbourhood (UBA, 1978).

The most commonly used social-scientific measuring instruments are interviews, questionnaires and psychological tests which are executed in connection with an identification of respective acoustical data. Common to all social-scientific procedures is the collection of substantially very different aspects of annoyance-effects which are finally reflected in global values which have to be obtained by statistical procedures (Guski *et al.*, 1978). It is to be taken into account that global values only represent average annoyance effects. Therefore, they are suitable at most for the interpretation of average reactions in general. Figure 8.15 gives an example (cf. Shaw, 1975).

Social-scientific inquiries within communities that are exposed to noise will fail to register the direct noise effects but rather establish the indirect and long-term ones. Nevertheless, these investigations are — under simultaneous measurement of the noise level in the respective area — of great importance for the research on noise effects. The connection between the degree of acoustical

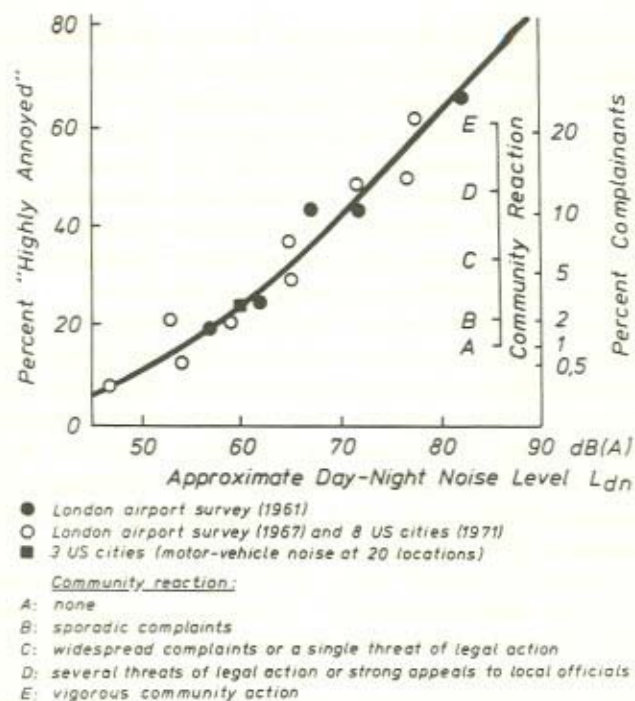


Figure 8.15 Community reaction to average noise levels

environmental pollution and the social-scientific registerable noise effects is, as a rule, more markedly reflected in such surveys than in other studies on noise effects. The inquiry results of independent research teams harmonize to a high degree (e.g. Relster, 1975; Tracor, 1970; Vallet *et al.*, 1978).

#### 8.4 NOISE AND CRITICAL GROUPS (Eckhard Gros and Gerd Jansen)

Measures of noise abatement are, in general, based on acoustical threshold or limit-values, identified as protective to the average person within the community. But there exist critical groups within the population who have a right of being protected against noise by specific measures. Although no model of a generally acceptable classification of the critical groups has been available until now, it can be stated that the elderly, children, sick people (especially those living in acute conditions as, for example, hypertonics or reconvalescents), pregnant women, as well as the lower social classes need particular attention (Jansen and Gros, 1976; Gros and Jansen, 1978; Rehm and Gros, 1980; McLean and Tarnopolsky, 1977; WHO, 1980).

Using physiological criteria, those critical groups may be defined as people

who are in more vulnerable condition, permanently or temporarily. The aim of a study carried out by Rehm and Gros (1980) was to show whether the physiological reaction of ill people to noise was different from the reaction of healthy people. They found that in comparison to healthy subjects, patients suffering from cerebro-vascular disease showed a reaction to noise which could be judged as abnormal. It seems to be most important that the capacity of increasing the peripheral blood flow after having had a vaso-constriction due to noise is very much reduced (Rehm and Gros, 1980). This appears to suggest that a normal adequate physiological response to sound stimuli is not warranted in these sick people — a condition which could thus make them more susceptible to the detrimental effects of noise.

If, for example, a *medically defined* health-protective threshold value were taken as a basis, all those would have to be protected who are especially sensitive to noise; since they are already at risk at noise levels that are far below the *acoustically defined* threshold values, covered by administrative regulations (see Figure 8.16, based on Rohrmann, 1977).

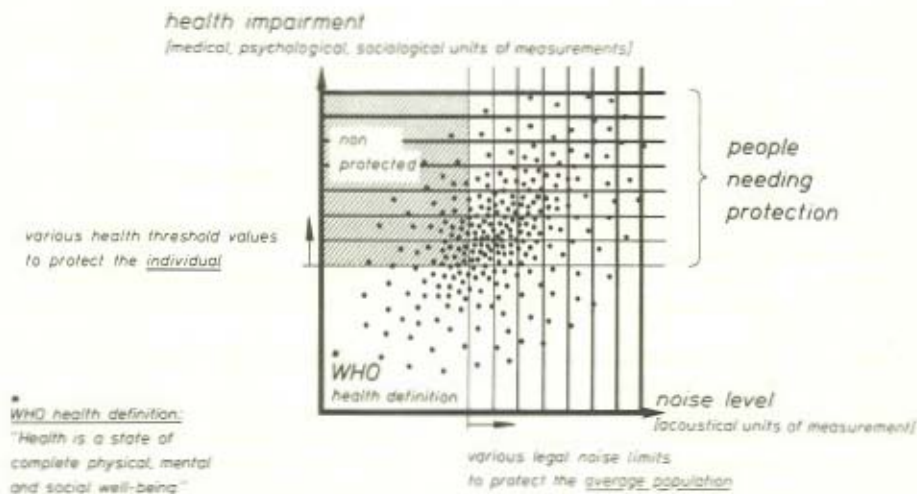


Figure 8.16 The localization of people needing protection based on acoustical and social-scientific values

It should be borne in mind, additionally, that the mentioned groups not only suffer particularly from noise pollution but can scarcely participate in the advantages of e.g. modern transportation techniques, one of the main originators of environmental noise.

Another noise-related effect can be seen in a shift in the social-structure of especially noise-exposed areas (cf. Herridge and Low-Beer, 1973). First, the population fluctuates, then a change in its structure takes place since only those

people stay who are not in a position to move to quiet living areas due to financial or other reasons (e.g. the elderly, foreigners, socially underprivileged). Then, gradually, the quality of the infra-structure deteriorates, recreation grounds, medical, cultural and material care centres become reduced.

Hence, it follows, shall those population groups, who are particularly sensitive to environmental noise, be subsumed under the protection of acoustically defined threshold values either noise protection has to be made more individual or the noise level must be so low that it ensures adequate protection as far-reaching as possible.

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