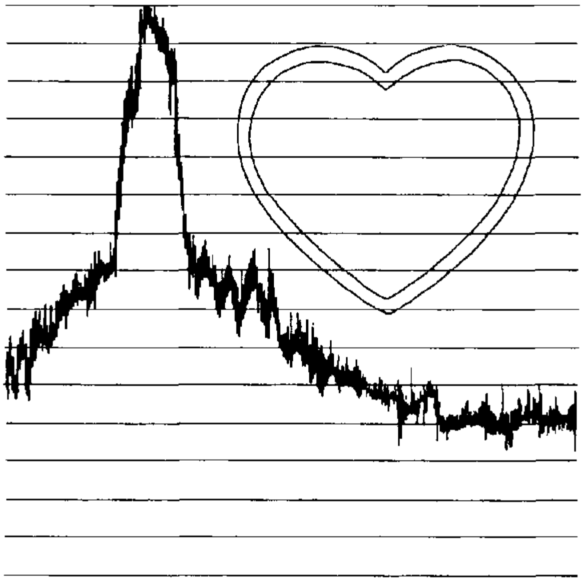
GA-DR-03-01

Directoraat-Generaal
Milieubeheer

Environmental noise
and health



**Onderzoekprogramma
geluidhinder**

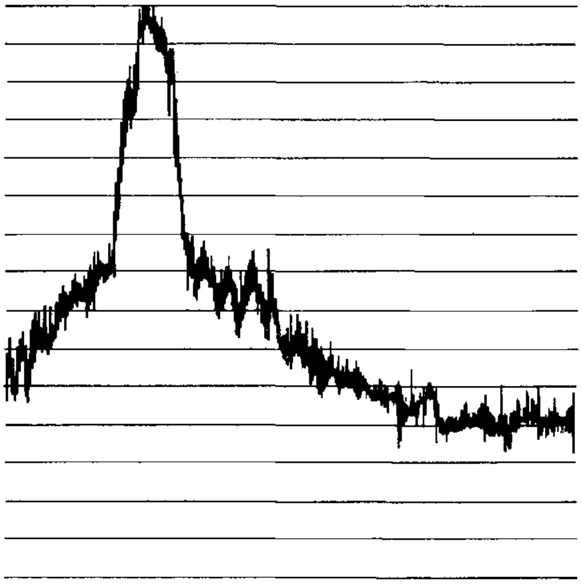
# Invloed van geluid op de gezondheid

**Ministerie van Volkshuisvesting,
Ruimtelijke Ordening en Milieubeheer**

-DR-03-01/002

GA-DR-03-01

# Environmental noise and health (description of data, models and methods used, and the results of the epidemiological surveys)



Ministerie van Volkshuisvesting,
Ruimtelijke Ordening en Milieubeheer

OG
Onderzoekprogramma
geluidhinder

# Documentbeschrijving

**1 Rapport nr.**
GA-DR-03-01

**2 Titel rapport**
Environmental noise and health
(description of data, models, methods and results)

**3 Schrijver(s)/redacteur(s)**
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**5 Opdrachtgever(s)**
Ministerie VROM

**6 ISBN nummer**
90 346 1835 8

**7 Distributienummer**
90017/2-89 5526/104

**8 Datum publicatie**
februari 1989

**9 Rapport type en periode**
deelrapport 1988

**10 Titel onderzoekproject**
Medische gevolgen van lawaai

**11 Samenvatting**

Dit rapport vormt een van de deelrapporten bij het hoofdrapport GA-HR-03-02 inzake een onderzoek naar de invloed van lawaai op de gezondheid. Het betreft een onderzoek, dat is verricht in de periode 1984-1988. In het onderzoek zijn circa 2.000 personen geïnterviewd. Bij circa 900 personen is een medisch onderzoek verricht, en bij een kleine groep (24) zijn tevens laboratoriummetingen gedaan. Uit de resultaten blijkt dat de wijze van omgaan met geluidbelasting ('coping') en de individuele beoordeling van de mogelijkheden om in te grijpen ('control') van groot belang zijn bij de verklaring van optredende hinder en klachten over de gezondheid.
In het onderhavige rapport wordt een beschrijving gegeven van de gegevens, modellen en methoden die zijn gebruikt, alsmede van de resultaten van de interviews en het medische onderzoek.
Dit deelrapport is geschreven in de Engelse taal, gezien het belang van internationale uitwisseling van dergelijke schaarse onderzoeksgegevens.

**12 Begeleidingscommissie**

| | |
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| Prof. Dr. F. de Waard | RIVM |

**13 Bijbehorende rapporten**

GA-HR-03-01
GA-HR-03-02
GA-DR-03-02
GA-DR-03-03
GA-DR-03-04

**14 Aantal blz.**
348

**15 Prijs**
*f* 55,00 *

Rapporten uit de reeksen van het Onderzoekprogramma Geluidhinder zijn schriftelijk te bestellen bij Staatsuitgeverij/DOP, postbus 20014, 2500 EA 's-Gravenhage, onder vermelding van bestelnummer of ISBN en een duidelijk afleveringsadres.

* prijswijziging voorbehouden

# ACKNOWLEDGEMENTS

This research was made possible by a grant from the Dutch Ministry of Housing, Physical Planning and Environment (VROM). This Ministry has supported the preliminary phase (started in 1983 with detailing the programme) and consequently the final research proposal of 1984.
The research described in this report has been carried out by a team of scientists from several disciplines:

| | |
|---|---|
| dr. K. Altena | psychologist, project leader |
| dr.ir. W. Biesiot | physicist, co-projectleader since May 1987 |
| drs. N.E. van Brederode | (medical) doctor |
| drs. I. van Kamp | psychologist |
| T.R. Knottnerus | medical sociologist |
| drs. J.V. Lako | social geographer (untill February 1987) |
| dr. M.P.J. Pulles | physicist |
| drs. R.E. Stewart | methodologist |
| drs. J.B.P. Veldman | psychologist |

The authors are much indebted to a number of other persons who have contributed in several phases of the study to the collection and processing of data: amongst them deserve special attention:

H. Amelsvoort
drs. E. Beneker
drs. C.J. van Dam
A. Heino
drs. B. Opheikens
drs. C. Schaffels
drs. T. Twisk
the IVEM secretariat: H.W. Vos, F. Epema, R. Koers, M.L.Q. Vintges.

During the research period (1984-1988) the work has been reviewed by an advisory board, consisting of:

| | |
|---|---|
| ir. A. Moerkerken,<br>ir. M. van de Berg and<br>ir. F.W.J. van Deventer | Ministery of Housing, Physicial Planning and Environment (VROM) |
| ir. J.A.M. Blok and<br>ir. M.A.P. Verwijmeren | Ministry of Social Affairs |
| drs. L.J.P. van Doornen | Free University of Amsterdam |
| dr. J.H. Ettema | University of Amsterdam |

| | |
|---|---|
| prof.dr. H.A.W. Hogerzeil | (until June 1984) State University of Groningen |
| drs. H. Miedema | TNO Research Institute for Environmental Hygiene |
| prof.dr. G. Mulder | Institute for Expertimental Psychology, State University of Groningen |
| prof.dr. F. de Waard | State Institute for Health and Environmental Hygiene (RIVM) |

A number of collegues and institutes has contributed to our work:

- Prof.dr. G. Mulder and ir. L.J.M. Mulder, Institute for Experimental Psychology of the State University of Groningen;
- Dr. H. Ising and co-workers, Institute for the Conservation of Water, Soil and Air, Ministery of Health, Berlin, FRG;
- R. Linschoten, director, Medisch Diagnostisch en Preventie-Centrum, Utrecht.

The process of documentation of noise levels and selection of adresses for the sampling procedure would not have been possible without the invaluable assistence of numerous authorities and officials of

- the provincies of Friesland, Groningen and Overijssel;
- the municipalities of Amsterdam, Groningen, Hengelo, Leeuwarden, Leeuwarderadeel, Menaldumadeel and Oldenzaal.

In this research project we used an approach in three successive stages: an epidemiological survey measuring psychosocial and (objective and subjective) health effects, an epidemiological survey on cardiovascular diseases, and a laboratory experiment measuring effects on a psychological, subjective and task performance level. In the final phase of the project it was decided that the team indicated on the front page should be held responsible for the major part of the report: description of data, models and methods used, and the results of the epidemiological surveys. The results of the laboratory experiments are reported elsewhere. The authors are much indebted to one of them, W. Biesiot, for his valued managerial support in the completion of this study.

This report describes the main results of the present investigation. The results of the laboratory experiments are published in another volume (Veldman, 1988). Details of the research programme are documented in a series of reports:

Knottnerus, T.R., Altena, K., Pulles, M.P.J. (1983). Onderzoeksvoorstel Geluidbelasting en Gezondheid (Research proposal environmental noise and health, Internal report). Groningen, The Netherlands: State University Groningen, IVEM.
Altena, K. (Ed.).(1987). Invloed van lawaai op de gezondheid: Beschrijving onderzoeksopzet (Theory and method of an interdisciplinary investigation into the effects of environmental noise on health; English preface and introduction; Report No. GA-HR-03-01). 's Gravenhage, The Netherlands: VROM.
Kamp, I. van (1986). Geluidbelasting en Gezondheid: Psychologische aspekten in de relatie geluidbelasting en gezondheid: keuze en meting van begrippen (Noise and health: Psychological aspects in the relationship between noise and health: choice and measurement of concepts; Report No. 18). Groningen, The Netherlands: State University Groningen, IVEM.
Kamp, I. van (forthcoming). Deelrapport over psychosociale survey, (Report No. 27). Groningen, The Netherlands: State University Groningen, IVEM.
Lako, J.V. (1987). Geluidbelasting en migratie: selectie-effecten bij onderzoek naar geluidbelasting en gezondheid (Environmental noise and migration: selection-effects in research into environmental noise and health; Report No. 25). Groningen, The Netherlands: State University Groningen, IVEM.
Brederode, N.E. van (forthcoming). Deelrapport over medisch onderzoek; Report No. 28. Groningen, The Netherlands: State University Groningen, IVEM.

Several reports describe research results related to the subject of this study.

1. Jong, R.G. de, Knottnerus, T.R., Altena, K. (1986). De gevolgen van lawaai veroorzaakt door nachtvluchten, op slaap, gezondheid en gedrag (The effects of environmental noise caused by night-time aircraft operations, on sleep, health, and human behaviour). 's Gravenhage: VROM (GA-HR-01-02). Leiden/Groningen: NIPG-TNO/IVEM (IVEM-report No. 16).

2. Dormolen, M. van, Kamp, I. van, Vries-Griever, A.H.G. de & Altena, K. (1988). Omgevingslawaai, slaap en gezondheid (Environmental noise, sleep, and health). 's Gravenhage: Vrom (GA-HR-01-03). Groningen: IVEM (Report No.26).

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# 1. INTRODUCTION

K. Altena and W. Biesiot

# 1. INTRODUCTION

## 1.1 Overview over the relationship of environmental noise and health

"It is generally believed that continued exposure to noise in real life can be a source of physiological stress possibly capable of causing health disorders beyond that of direct damage to the auditory receptor system (...). However, research on these questions is complicated and somewhat controversial (...)" (Kryter, 1985, p.390). These statements are part of the introduction to a review of research on nonauditory-system response to noise and effects on health, characterizing the state of the art in the starting phase of this project. Kryter concludes that many sounds can cause physiological stress reactions. Whether a person reacts with a stress respons to noise probably depends on conscious or unconscious cognitive processes. He also concludes that for example the level of exposure to aircraft noise is correlated with an increase in the number of people with subjective health problems requiring an increased use of certain drugs and visits to physicians.

In reviewing some eighty studies on the effects of noise on the cardio-vascular system, Thompson (1981) concludes that the evidence implicating noise as a risk indicator is strongest for changes in blood pressure; evidence on effects of noise on cardiovascular parameters other than blood pressure is weak and fragmentary.

The intensity of the exposure to noise seldomly explains more than about one-quarter of the variance in individual annoyance. Psychological factors (the respondents "attitudes and beliefs" about the noise and the noise source) are often explaining over half this variance (Cohen et al., 1986).

Kryter (1985) states regarding mental and psychomotor task performance zunder noisy conditions that these do not differ systematically from quiet conditions. "(...) Noise can have a positive effect, no effect, or a negative effect on performance of non-auditory mental and psychomotor tasks" (Kryter, 1985, p. 380). Furthermore, results of different investigations are inconsistent. In many of them methodological deficits are present. Although it cannot be ruled out that no significant adverse effects do exist, a lot of research is devoted to the hypothesis that the subjects' resources are used in order to maintain the level of task performance ("compensatory effort"). There is evidence of at least after-effects at a physiological level (see e.g. De Jong et al., 1986, and Van Dormolen et al., 1987).

In a review of the effects of noise on man Kryter (1985) places emphasis on psychological factors as playing a *mediating/moderating role* in the noise-effect relationship; see also Cohen et al. (1986) and Evans and Cohen (1987). This theory states that nonauditory-system stress response results from the cognition of the meanings of the sound or noise, or from on the interference effects of the noise with sleep, rest, and auditory communications. The degree of response is controlled by the attitudes and knowledge of the individual and by the activities being engaged in by the individual when the sound or noise occurs. Sufficient repetitions of these stress responses could have adverse effects on psychological and physiological health. Field studies reveal the occurrence of subjective health effects in relation to noise.

## 1.2 Methodological issues

Many methodological issues concerning environmental noise and health have arisen. Thompson (1981) reviewed and assessed literature on the effects of noise on the cardiovascular system. The author had a group of scientists assign numerical rating scores of adequacy with respect to noise exposure, health effects and epidemiologic methodology. Many aspects of methodology of a number of published research studies were judged as poor or insufficient. But it is also concluded that most investigations on which the conclusions are based are cross-sectional. This is one of the weaker designs for deriving data from which to infer causality. Furthermore, it is concluded that deficiencies in the study design exist with respect to exposure characterization, outcome specification, sample selection and data analysis. "Weaknesses in any one of these areas lead to substantial problems in interpretation of study findings, making it difficult, if not impossible, to derive valid conclusions from the data" (Thompson, 1981, pp. 4-20).

The subjective ratings of the group of scientists in Thompson's study, are challenged by Kryter. To illustrate his criticism, Kryter discusses a study of Cohen, Evans, Krantz, and Stokols (1980) and of Knipschild (1976). The ratings on health effects of these two studies, as given by Thompson, was 9 for Cohen at al. and 0 for Knipschild. Nevertheless, Kryter concludes: "These relative ratings are completely inconsistent with the relative merits of the two studies." (Kryter, 1985, p. 505).

In her review on effects of noise on the cardiovascular system, Thompson (1981) compares the distinct powers of experimental and epidemiologic studies. "Controlled experiments in animals and man serve to
(1) direct attention to health states, physiologic responses and health behavior that may be affected by noise;
(2) provide information on the mechanisms which produce the causal linkages between noise and these responses;
(3) rule out plausible alternative explanations and punt disparate findings in perspective.
Epidemiologic studies can best
(1) provide information on long-term effects of noise on human health in populations of diverse susceptibility;
(2) clarify the significance of varying levels of noise exposure on individuals living in uncontrolled environments by quantifying and comparing risks;
(3) place observed relationships in proper etiologic perspective by careful analytic control of other known risk factors of the health response under investigation" (pp. 1-2).

Evans and Cohen (1987) stress the need to pay much attention to the methodological issues, amongst which:

- measurement of the stressor (range of stressor analyzed),
- individual differences (especially vulnerability to stressor),
- measurement of stress (psychometric issues of calibration procedures, range adjustment),
- *temporal factors influencing* the effects of stressor (acute and chronic conditions; adaptation; temporal characteristics of different measures of stress).

With respect to the issue of laboratory experiments versus the field situation, Evans and Cohen (1987) conclude: "Probably the best methodological strategy is to examine the effects of environmental stressor in both field and laboratory situations. Reliable effects of stressors can be carefully charted in the laboratory and then validated under more natural conditions. Field research can suggest certain dimensions of the stressor that appear to be important, and laboratory work can rule out plausible rival hypotheses that exist in the field (Cohen et al., 1980, Evans and Cohen, 1987, p. 602).

## 1.3 Scope of this research programme

In order to increase the understanding of the relationship between environmental noise exposure and health it is necessary to try to achieve less ambiguity in theoretical and operational terms.
This had led us to carry out epidemiological studies (measuring psychosocial and subjective health effects, and cardiovascular and physiological effects) in conjunction with laboratory experiments (measuring effects on a physiological, subjective and task performance level). This is an attempt to overcome the limitations of separate epidemiological and laboratory studies as far as possible and also to combine the advantages of the two approaches. Conform the lessons learned from the deficits of other surveys (see par. 1.2), much attention has been devoted to the elimination of possible biases add confounding factors.

A review of the different theoretical approaches in the field has led us to several classes of structural models that are used in the analyses. In the most elaborated one we have integrated several theories (biological (Ursin 1978, 1985) and psychological (Lazarus 1966) stress approaches) regarding the inclusion of psychosocial constructs in order to enhance the understanding of the noise-health relationship. The results of this type of analysis have been compared to those of the other classes of structural models. Where possible, the results obtained have been compared with literature.

## 1.4 Phase of the study

This study is planned into three successive phases. In the first phase the problem has been defined in detail and the range of measuring instruments has been developed. Part of the instruments are also tested in a test location in this phase. This work has been reported in Altena (ed.) (1987). In the second phase, the link between the physiological, physical and psychosocial parameters is investigated in a wide-ranging epidemiological study. This work is documented in this report. In laboratory studies connected to this, the link between the same parameters is studied at several levels. The results are reported elsewhere (Veldman, 1988). In the third (and future) phase, on the basis of the earlier findings and under more controlled conditions, the relationship between the parameters could be analysed in greater depth. The first phase should be considered as a preliminary study. The second and third phase constitute the study proper: both phases are arranged so that they can be considered as relatively independent studies, although both build on the previous stage. In any event, the results of each independent stage provide starting points for policy making purposes.

## 1.5 Research contracts

The Dutch Ministry of Housing, Physical Planning and Environment (VROM) accepted in a letter dated August 26th 1983 the research proposal regarding the first phase of this study. The following tasks were agreed upon:

1. Selection of suitable locations from which samples of the required size could be drawn.
2. Detailling the relevant physical, physiological and psychosocial parameters, necessary to indicate health effects conform the integral definition of health as given by the WHO. Not only factors as blood pressure, heart beat frequency and physiological parameters should be measured. Also information on cardiovascular diseases, intake of drugs, subjective health monitoring and related aspects should be taken into account.

3. Validation the measuring instruments of the epidemiological survey in a test location.
4. Design and preparation of the laboratory experiments.
5. Detailling the consecutive phases of the research.
6. Consulting the advisory board, external to the contractor.

After the completion of the first phase the Ministry of VROM accepted in a letter dated July 10th 1984 the research proposal regarding the second phase of the study. The set-up comprised of the following elements:

1. An epidemiological enquiry into residential health effects:
   a. a questionnaire to be filled out by a sample of 2000 households consisting of groups exposed to military aircraft noise and to road traffic noise, and a control population;
   b. a medical survey on about 1200 subjects, selected from the sample mentioned above.
2. A laboratory experiment on 48 subjects selected from the sample indicated above. Effects of noise exposure were to be studied under task performance and under control conditions.
3. Documentation of the analyses to be performed and the results thereof, thereby consulting the advisory board.

The epidemiological surveys have been carried out in 1985, and the laboratory experiments have been performed in January 1986. As is documented in Chapters 4 and 7, a subsample for the medical survey has been selected from the sample of 2000 subjects. Due to several causes, 900 subjects attended the medical examination. Furthermore it was decided that the laboratory experiment should be conducted with a sample of 24 persons as a first stage. Based on the results thereof, the conditions for a second experiment and for a selection of a new sample of 24 persons were to be chosen. Due to the complexity of the data processing the available time has been consumed by the analysis of the first experiment. After consultation with the Ministery of VROM the second phase of the laboratory experiment has been postponed (to be part of phase 3 of the project).

## 1.6 Introduction to this report

This report describes the results of the research programme outlined above. Due to the differing background of the participating scientists and associated disciplines, it was felt necessary to develop common grounds regarding a formal language and the theoretical models to be used (termed structural models in this report). Therefore this report starts with

Chapter 2: FORMAL ASPECTS OF MODEL CONSTRUCTION that defines the common formal language.

Chapter 3: THE STRUCTURAL MODELS USED IN THE ANALYSES gives a description of three families of models to describe the relationship between environmental noise and adverse health effects. These three types of models increase in complexity. We start with the most simple type of models, the dose-effect models. In the second family of models, individual characteristics are taken into account. The third family of models enables the introduction of a number of phsychological and stresstheoretical constructs (by integrating biological and psychological stress approaches) into the relation between the noise exposure and the effects observed.

Chapter 4: MATERIALS AND METHODS outlines the research strategy chosen to evaluate the respective models. Two main topics are dealt with in this chapter. Firstly the population used in the field survey is described in terms of noise exposure and a number of demographic variables. Secondly the measuring instruments are described in general terms and in connection to the constructs of the models described in chapter 3.

Research conclusions may be invalid if the population from which the sample is drawn, is subject to noise-induced migration. In chapter 5: RESIDENTIAL SATISFACTION AND WISH TO MOVE RELATED TO ENVIRONMENTAL NOISE the relationship between environmental noise and wish to move is analysed in order to estimate noise-induced migration and possible contaminations of the populations which may result from such an effect.

The relationship between environmental noise and well-being is analysed in chapter 6: PHYCHOSOCIAL ASPECTS RELATED TO ENVIRONMENTAL NOISE.

In this chapter the underlying psychological mechanisms in the noise-health relationship are described. General well-being is measured by different aspects of annoyance and subjective health complaints. Specific attention is paid to the role of appraisal and coping in the noise-health relationship.

The relationship between environmental noise and cardiovascular risk factors and diseases is the subject of chapter 7: ENVIRONMENTAL NOISE AND CARDIOVASCULAR DISEASES.
This chapter outlines the methods used to measure two cardiovascular diseases, hypertension and ischaemic heart disease, and their risk factors. The relationship between noise and risk factors, between risk factors and cardiovascular disease and between noise and cardiovascular disease are analyzed. The influence of individual characteristics and of psychological variables (appraisal, control and coping) have also been evaluated.

Recently the importance of electrolyte concentrations in the development of cardiovascular diseases is recognized in the field of noise and stress research. In chapter 8: ENVIRONMENTAL NOISE AND ELECTROLYTE CONCENTRATIONS IN BLOOD, the mechanisms postulated and the relevant research findings are summarized. Analyses of the erythrocyte and serum electrolyte concentrations (as measured from samples drawn from subjects examined in the medical survey described in chapter 7) are not yet completed. Only preliminary results are presented and possible explanations for the effects found are indicated.

In chapter 9: DISCUSSION AND EVALUATION the results of the preceding chapters are discussed at a more or less integrated level. The central claims of this project:

- improvement in methodology by combining different disciplinary research methods into one project;

- improvement of the understanding of the noise-health relationship by more complex models, incorporating psychological variables

are evaluated on the basis of the results obtained.

This report concludes with chapter 10: CONCLUSION AND RECOMMENDATIONS. The conclusions of earlier chapters are summarized and recommendations for further research and for policy making are derived.

Table 1.1 Methodological criteria for research on effects of noise on the cardiovascular system (Thompson 1981)

| | | |
|---|---|---|
| 1 | Noise exposure | |
| 1.1 | noise description | type of noise<br>frequency composition<br>levels<br>duration of exposure<br>source |
| 1.2 | instrumentation | type<br>make & model<br>compliance with standards |
| 1.3 | environment | type (sound field, room etc.)<br>controlled-uncontrolled |
| 1.4 | measurement procedure | type<br>compliance with standards |
| 1.5 | subjects | history of vocational noise exposure<br>history of avocational noise exposure<br>hearing thresholds<br>history of ear disease<br>otological examination |
| 2 | Cardiovascular health effects | |
| 2.1 | diagnostic criteria for clinical manifestations or diseases | |
| 2.2 | documentation of pre-existing cardiovascular disease | |
| 2.3 | time relationships of exposure events to clinical manifestations, disease development, clinical events | |
| 2.4 | the natural cause of disease states | |
| 2.5 | risk of specific clinical manifestations or pathological responses | |
| 2.6 | methodology for determining respons | |
| 3 | Epidemiologic methodology | |
| 3.1 | classification of study design | - strength of the design<br>- bias potential in design<br>- data sources and method of collection |
| 3.2 | sample | - type<br>- size adequate for testing<br>- follow-up<br>- potential bias and its control |
| 3.3 | specification of the exposure and respons variables | - noise exposure as an epidemiologic variable<br>- health outcomes as epidemiologic variables |
| 3.4 | treatment of the data | - strength of association<br>- statistical tests<br>- dose-response relationship evident?<br>- confounding |

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Veldman, J.B.P. (1988), to be published.

# 2. FORMAL ASPECTS OF MODEL CONSTRUCTION

M.P.J. Pulles

# 2. FORMAL ASPECTS OF MODEL CONSTRUCTION

## 2.1 Introduction

In the research project, described in this report, scientists from a broad range of disciplines cooperated intensively. Due to the differing backgrounds of the participating scientists, the need was felt to define very precisely the language used within the project.
Since the intended readers of this report will also have a variety of scientific backgrounds, we present the language chosen in this chapter. The chapter should be read as a kind of grammar used during the development of the project, thus lining up the reader's "frame of mind" with that of the writers.
It should be stressed that this chapter only deals with the formal concepts and formal aspects of the language used. In other chapters these formal concepts will be used to define the psychosocial, the medical, the physiological and the physical concepts in the relation between environmental noise and health.

We first describe some basic formal concepts necessary to create a language for our purpose (par. 2.2). In section 2.3 we define structural models and the components to build these models. Paragraph 2.4 deals with observations and measurements and describes the measuring level.
To this chapter a section 2.5 is added, presenting a summary of the formal conventions used throughout this report.

## 2.2 Some basic concepts

The mere fact that a group of scientists decides to study a certain problem implies that they believe in the existence of some kind of "reality". We will not go into the philosophical complications of the existance of reality, neither into the philosophical problems related to the (im)possibility to know this reality. We choose a pragmatical point of view and define reality as follows:

> Reality is (a part of) the environment of the scientist that can be observed and may be understood by observing it.

This reality is the everyday reality we all "know" intuitively. It should be noted, that this reality is not equal to the situation a subject is brought in when a scientist is observing or measuring. A subject in a laboratory or even in an interview session is not present in his or her real world.

An individual scientist or a group of cooperating scientists needs a (common) language for two reasons:

1. The language allows every individual scientist to develop his or her thinking about and understanding of the problem in a systematic and consistent way.
2. The language allows communication both within the group of cooperating scientists and with other interested persons outside this group.

This communicative function of the language makes this chapter necessary. An individual scientist can probably use his or her own language internally without explicitely defining it.
The concept "language" can be defined as follows:

> A language is a set of words and concepts together with the grammar and syntax necessary to use it properly.

The purpose of the language is to describe the part of reality under consideration in such a way that both functions given above can be fulfilled. The description is called a "model". We define the concept "model" as follows:

> A model is a consistent language that, according to an agreement between a group of researchers, will be used to describe (a part of) reality and to make statements about the reality.

A few words in the above definition need further clarification. First the word "consistent" indicates that use of the model in different ways is not allowed to lead to conflicting results. The word "agreement" is used to indicate that the model is not universal. Another group of scientists may use a different model to describe the same reality. Making "statements about reality" can only be meaningful when these statements are predictions or hypotheses that can be tested.

A model may be regarded as an abstraction from reality analogous to the relation of a map to the geographical reality.

Another concept, frequently used by scientists is the concept of "theory". In our opinion the concepts "model" and "theory" are closely related and almost interchangeable. "Model" is often associated with a more quantitative description, whereas "theory" is associated with a more qualitative description. We will use only the concept "model" in this report.
In the above definition two functions of the "model" were given: the descriptive and the predictive function. Both functions need some kind of observation of reality to be relevant. We can conclude from that, that a model must have two levels:

1. The "structural level": the part of the model that describes the reality under study in abstract terms.
2. The "measuring level": the part of the model that describes the way observations of reality can be made: the abstract entities of the structural model need to be "translated" in measurable quantities.

The measuring model therefore connects the structural model (= the rational knowledge) with the natural world. Both levels, the structural and the measuring level, are likewise distinguished in the statistical technique of LISREL (Linear Structural Relations) as described in Jöreskog (Jöreskog 1979).

## 2.3 Structural model

The structural model is that part of the model that enables the scientist to describe the part of reality one is interested in. This level is the most abstract one: the scientist formulates his or her ideas in abstract terms. To build this part of the model one needs the following types of components:

1. constructs and
2. relations between constructs.

Both types of components will be discussed below.

### 2.3.1 Constructs

The concept "construct" can be defined as follows:

> A construct is a description of a property present in reality.

This means that a construct is an abstraction of the property just like the model is an abstraction of reality. Another term frequently used in this respect is "attribute" (De Groot, 1961, page 68) or quantity. In this report we regard both terms as synonyms. The concept construct has two aspects:

- the value
- the dimension.

The "value" is a measure of the intensity of the construct: the construct can be high or low, more or less etc. The value can be a numerical value from a continuous range (e.g. blood pressure), one from a set of discrete values (e.g. stratum number) or even a logical value (privatly owned house: true or false) The "dimension" is the aspect of the construct that makes the construct different from other constructs, regardless its value.
In a mathematical representation the dimension may be regarded as an actual dimension in a multidimensional space. In this representation a construct may be expressed in the projections (the coordinates) of the construct on a complete series of "basisvectors" defining (spanning) the space. The basis and therefore the coordinates of a construct can be changed by a transformation of the basisvectors. This however does not change the construct itself. The construct as an abstraction of a property of reality should remain unchanged.

### 2.3.2 Relations between constructs

Once the constructs necessary for the description of part of the reality are defined one needs relations between these constructs to complete the model. We define a "relation" as follows:

> A relation uniquely connects two or more constructs to each other in such a way that the total number of independent constructs decreases with one.

An once defined relation can in principle be expressed in a mathematical function in an indefinite number of ways. The above given definition of a relation allows only one of these functions to be incorporated into the model. In constructing a structural model one should be very careful to avoid such relations that make the model inconsistent. This is the reason why the word "uniquely" is used in the above definition.

Relations can be expressed in mathematical functions of the form:

$$X = f(Y,Z,....) \tag{2.1}$$

with: X, Y, Z, ... : constructs of the model

This relation means, that the construct X is uniquely determined when the constructs Y, Z, ... are given. The = sign in equation (1) means that not only the value of X equals the value of the function f(X,Y,...) but also the dimension of X equals the dimension of f(X,Y,...).
In multidimensional space representation the constructs are vectors and vector and matrix calculus should be used in the relations.
An important property of a relation is its reversibility or irreversibility. A relation like the above one (2.1) is reversible when from it a unique relation

$$Y = g(X,Z,....) \tag{2.2}$$

can be derived. An example of a reversible relation is the lineair relation of equation (2.3).

$$X = a + b.Y + c.Z + ..... \tag{2.3}$$

Relations of this type are used in (multiple) linear regression analysis.

From this equation the following (reversed) relation can be obtained:

$$Y = -a/b + (1/b).X - (c/b).Z - \dots. \tag{2.4}$$

An example of an irreversible relation is given in the stepfunction of (2.5).

$$\begin{aligned} X &= a \text{ if } Y \quad b \\ X &= c \text{ if } Y \quad b \end{aligned} \tag{2.5}$$

A relation of this type implies the existence of a treshold in the model.
In the relations (2.3), (2.4) and (2.5) the a, b and c are the "<u>parameters</u>" of the relation. They are constants that determine the exact function. The parameters may be defined during model construction but they can also be determined from a fitting procedure following the measurements.

### 2.3.3 Constructing a structural model

When the components of the structural model are defined the model can be constructed. This requires first of all the definition of the relevant constructs, both with respect to the dimension involved and to the possible values. Next the relations of the model must be defined and the parameters be chosen.
As a result of this process a structural model will emerge with a set of constructs and relations between these constructs. Every construct should be part of at least one relation and all relations should be independent, which means that no relation can be derived from other relations in the model.
From the model the scientist will deduce a number of statements, predictions and hypotheses that should be tested in the experimental part of the research.

## 2.4 The measuring level

Once the structural model is constructed the researcher must turn to observations and measurements to test his model. The scientist will develop "measuring models" for each construct of the structural model to be observed.

> A measuring model is a consistent (subset of a) language that is meant to provide a construct of the structural model with an actual value by means of a measuring device.

This definition is equivalent to the implicit one, given by Nunnally, who states: "Although tomes have been written on the nature of measurement, in the end it boils down to something rather simple: measurement consists of rules for assigning numbers to objects to represent quantities of attributes." (Nunnally, 1967, page 12).

The "measuring device" in the definition may be a physical measuring apparatus but also a questionaire. In the research project reported here both types of measuring apparatus occur. A third variety of a "measuring device" may be a computer simulation model. We will not use this technique here.

Like it is the case for the structural model, measuring models are constructed from two types of components:

1. variables
2. relations between variables and constructs.

### 2.4.1 Variables

Since the construct is an abstract concept, the result of a concrete measurement can not be the actual value of the abstract construct itself but will be an image of that actual value, namely the actual value of a "variable". The statement the measuring model makes is that the observed value of the variable is a reliable estimate of the actual value of the construct". The concept "variable" can be defined as follows:

> A variable is an estimate of a property in reality described by a certain construct of the structural model that can be observed or measured by means of a certain measuring device.

Since the variable is defined as an estimate of a construct it should have also two aspects: a dimension and a numerical value. It should be noted that the measuring device is involved in the definition. The dimension of the variable stems from an application of the measuring device. Its value is the numerical result thereof.

As has been stated above the numerical value of a construct may be continuous or discrete. Likewise the numerical value of a variable may be continuous or discrete. However, it is not necessary for a discrete construct to be connected to a discrete variable and vice versa. For instance, the continuous construct "noise level" may be expressed both in the continuous variable noise pressure (dimension: dB(A)) or in a discrete variable like "noise level stratum" (dimension: noise stratum number).

### 2.4.2 Relations between variables and constructs

The measuring model is a special kind of model in the sense that only relations between a variable and one or more constructs of the structural model are involved. The relation in a measuring model can therefore be defined as follows:

> A relation in the measuring model uniquely connects a variable observed or measured with one or more constructs of the structural model.

Relations in the measuring model can again be represented by mathematical functions. Many of these are of the form:

$$\underline{x} = X \qquad (2.6)$$

with: $\underline{x}$ the variable as observed
$X$ the construct of the structural model

More complicated relations involving more than one construct are of course also possible. The relation given above states a one to one correspondence between the variable and the construct. Although such relations may be assumed, one should always keep in mind that they are in fact a model and should be tested.

### 2.4.3 Constructing measuring models

For each construct of the structural model that must be observed or measured, the researcher should construct at least one measuring model. It is of course possible to construct more than one measuring model for a certain construct. In that case more than one (independent) estimate will be made of this construct. In the research project reported here this has been done for a number of constructs of the structural model (for instance the construct "Residential Satisfaction" in chapter 5 is measured by two variables).

In constructing a measuring model for a construct several steps must be taken:

1. the measuring device must be chosen.
2. the chosen measuring device must be tested to meet the required consistency. Its reliability and its precision must be established.
3. the relation between the result of the measurement (the variable) and the construct or constructs must be chosen.

In other chapters of this report these steps are dealt with in more detail. Measuring devices have been chosen from existing techniques and questionaires and some are newly developed. In both cases much attention is paid to the technical aspects of the measuring devices and of the variables measured.

When neither the data nor the model is perfect, statistical analyses are necessary. The results of these analyses are always stated in terms of probabilities. Because of the imperfection of data and models uncertainty margins are presented wherever appropriate.

Table 2.1 Definitions of concepts and notation convention, used throughout this report

| concept | denoted by | definition |
|---|---|---|
| CONSTRUCT | CAPITALS | a description of a property present in reality. |
| language | - | a set of words and concepts together with the grammar and syntax necessary to use it properly. |
| measuring model | - | a consistent (subset of a) language that is meant to provide a construct of the structural model with an actual value by means of a measuring device. |
| model | - | a consistent (subset of a) language that, according to an agreement between a group of researchers, will be used to describe (a part of) reality and to make statements about the reality. |
| parameter | lower case | a constant, determining a quantitative relation |
| reality | - | (a part of) the environment of the scientist that can be observed and may be understood by observing it. |
| relation | f(...) | uniquely connects two or more constructs to each other in such a way that the total number of independant constructs decreases with one. |
| variable | underlining | an estimate of a property in reality described by a certain construct of the structural model that can be observed or measured by means of a certain measuring device. |

## 2.5 Summary of conventions used in this report

In table 2.1 the definitions given in the above paragraphs are summarized. We will throughout this report use a consistent notation to indicate the nature of the concepts used. CONSTRUCTS will be denoted by capitals, variables will be underlined and parameters will be denoted by lower case bprinting. The notation conventions used in the report are also indicated in tabel 2.1.

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# 3. STRUCTURAL MODELS USED IN THE ANALYSES *

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* An earlier version of this chapter was prepared by M.P.J. Pulles, I. van Kamp and J.B.P. Veldman.

## 3.1 Introduction

This report is concerned with the relations between ENVIRONMENTAL NOISE and HEALTH. To be more precise we use the term HEALTH EFFECTS, since we are interested in the effects of environmental noise on health. We use the conventions developed in the preceding chapter (see table 2.1). Both ENVIRONMENTAL NOISE and HEALTH EFFECTS are constructs in the structural model. In this chapter we present the structural models used troughout this research project. The next chapter deals in general terms with the development of the measuring models that connect constructs with variables.
This chapter is devoted to:

- a description of the families of (structural) models, used in research on the effects of environmental noise on health (par. 3.2 through 3.5);
- a description of the terminology used in this report (par. 3.6).

As has been indicated in chapter 1, we use the broad definition of HEALTH as given by the World Health Organization (WHO):

> HEALTH is the state of complete physical, mental and social well-being and not merely the absence of disease and infirmity (WHO, 1948).

Following this definition we discern a number of different classes of health effects:

a) direct effects on the auditory system: high intensities of noise may induce hearing losses, thereby decreasing the physical condition (see for a recent review (Kryter, 1985; Van Dijk, 1984);
b) nonauditory physiological effects: noise can induce an increase in blood pressure and the secretion of certain hormones. This class of effects also influences the physical well-being of individuals;
c) effects on mental and psychomotoric task performances (see for a recent review: Cohen and Weinstein, 1981);
d) subjective health effects: noise may induce annoyance and thus decrease the social well-being of individuals.

A closely related classification is given by Evans and Cohen (1987), who conceive of noise as an environmental stressor together with such potentially annoying situations like crowding, heat and air pollution (stench).
In chapters 5 through 8 the literature on these effects will be discussed in more detail.

The models used to study these different classes of effects have been evoluted from rather straightforward dose-effect models to more complicated models introducing a variety of psychological variables. In our analyses of the different surveys of this project, three classes of models are applied in order to gain insight into the scope of the models and in order to be able to compare the results with the literature. These classes of models are:

- Dose-effect models (par. 3.2);
- Individual differences models (par. 3.3), and
- Models introducing psychological variables into the relationship (par. 3.4).

Together with the surveys a laboratory experiment was conducted. The results of these experiments is reported seperately (Veldman, 1988). Paragraph 3.5 however is devoted to a brief description of short time responses, relevant for the experiments.

## 3.2 Dose-Effect Models

In the dose-effect or dose-response approach, the structural model is rather simple (Figure 3.1):

> A direct relation between the NOISE received (the dose) and the EFFECTS produced (the response) is assumed. Besides the dose and the effect constructs, no other constructs are incorporated into the structural model. The relation between the constructs may be linear or nonlinear.

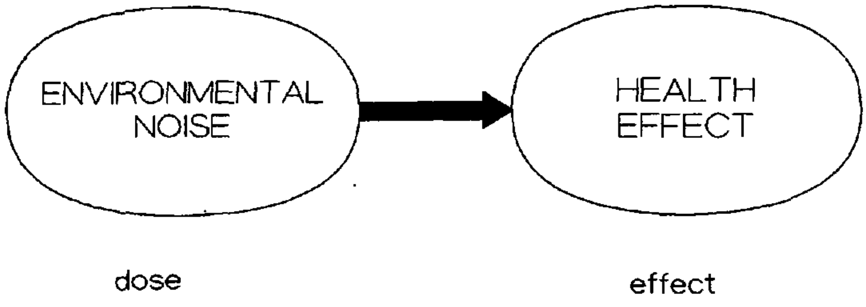

Figure 3.1 The-dose effect model applied to environmental noise

In most cases only a small part of the noise level axis is used and the researcher assumes a linear relation in the noise interval used. Earlier studies were focused on finding the perfect dose response line (see for reviews: Schultz, 1978; Kryter, 1970, 1985; Langdon, 1976; Weinstein, 1976). However only a small part of the variance of effect variables could be explained by the physical characteristics of noise: usually between 10 to 15% and maximum 25% of the variance was explained (McKennel, 1973; Schultz, 1978; Vallet et al., 1978; Langdon, 1968). Part of this can be accounted for by measurement errors both in determining the exact dose and in determining the effects.
In summary these family of models may be characterized by the relation:

HEALTH EFFECT = f(NOISE)

## 3.3 Individual differences models

A broad variety of effects has been studied using the simple dose-effect model. As we concluded above, this approach is able to explain only a small part of the variance in the effect. Empirically identified parameters of linear or nonlinear relations vary with the properties of the effect under consideration and the type of environmental noise used as the environmental disturbance. Part of these variations may be due to the different noise sources or different effects. Another part of these variations is explained by the assumption of individual differences giving rise to differences in noise sensitivity. These differences lead to a dependence of the relations upon the sample studied. In these models the poor results of dose-effect approach, in terms of explained variance, are improved to a limited extend by incorporating individual differences into these models.

When making the effects dependent upon individual characteristics, many constructs are or may be introduced that influence the dose-response relations, each of them influencing directly or indirectly the noise sensitivity.

Weinstein (1976) discerns three major reasons to study the relation between noise and health using individual differences models:

- identification of risk groups;
- identification of settings in which people need extra protection, and
- identification of attitudes that influence annoyance and might be altered.

Many recent studies have been aimed at the discovery of personal, situational and social factors that mediate the noise effect relationship. A great number of concepts has been introduced (Evans, 1986; Schultz, 1978; Cohen and Weinstein, 1981; Borsky, 1980). In this type of model the effect of noise is defined as a function of the noise level and of individual and situational characteristics. Some studies incorporated the relation between annoyance and health (Tarnopolsky, 1980; McKennel, 1973; Jonah Bradley and Dawson, 1981). This approach is hampered by the fact that a lot of variables may just measure the annoyance in a different way (Weinstein, 1976).

In summary the family of individual differences models may be characterized by the relation:

HEALTH EFFECT = f(NOISE, INDIVIDUAL CHARACTERISTICS)

In figure 3.2 this type of model is schematically represented. The effects are dependent upon the noise level and upon a number of individual characteristics, indicated by the $K_i$'s. In chapter 7 these individual characteristics are denoted as "risk factors". The $K_i$'s represent such variables as age, sex, education, dietary habits, personal circumstances and the like. They describe physiological and psychological properties of individuals that are supposed to influence the effect studied directly and independently.

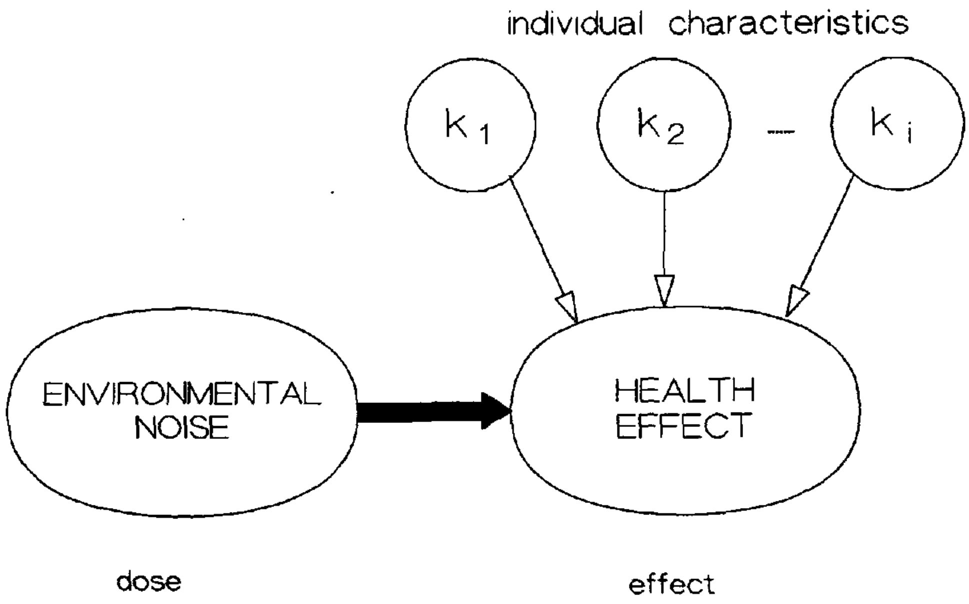

Figure 3.2 Schematical representation of individual differences models; the constructs $K_i$ denote the individual characteristics

The individual differences approach is used as a second model to analyse our data.

### 3.4 Introduction of psychological variables

In the paragraphs above only so called dose specific and effect specific variables are introduced into the model. A recent development in the field is the use of concepts from stress theories. In the models used by these authors, psychological constructs are introduced between the dose and the effect: some kind of appraisal of the stimulus is needed to explain the observed effects.

Noise has been shown to have general arousing properties in a physiological, emotional and behavioural sense and, as such can be defined as a stressor (Selye, 1976; Glass, 1977; Singer, 1972; Frankenhäuser and Lundberg, 1974; Baum, Singer and Baum, 1981).
The field of adaptation and stress research uses a number of constructs describing the processes within a person which lead to a stress reaction: an individual experiences a discrepancy between the demands he or she

has to meet and the response possibilities one has available. These response possibilities may be influenced by the noise present, thereby changing the discrepancy.

This discrepancy causes the individual to experience some kind of a load, resulting in an increase of the activation level: he or she does not have the response possibilities available to meet the demands sufficiently given the presence of noise. The individual will try to use coping strategies to either decrease his or her demands, to increase (the effectivity of) response possibilities or to decrease the disturbance by noise. Such strategies or the activation itself may influence the health of the individual, giving rise to health effects. In other words: in some cases the person will pay for the ability to meet the demands with his or her health.

Environmental demands, evaluation (appraisal) of the stressor, evaluation of coping resources and possibilities to control the stressor and health effects are the main categories that define the psychological perspective on stress. In chapter 6 these concepts are discussed in more detail.

The processes described in stress theories have a dynamical character. These dynamical aspects can only be studied in laboratory experiments. In the sociodemographic (chapter 5), the psychosocial (chapter 6) and the medical (chapter 7) surveys, described in this report, these aspects cannot be evaluated: the observed data have the character of point measurements in time.

Concepts of the stress theories in a model suitable to describe the relation between environmental noise and health in a field study like ours, can however be introduced as shown schematically in figure 3.3.

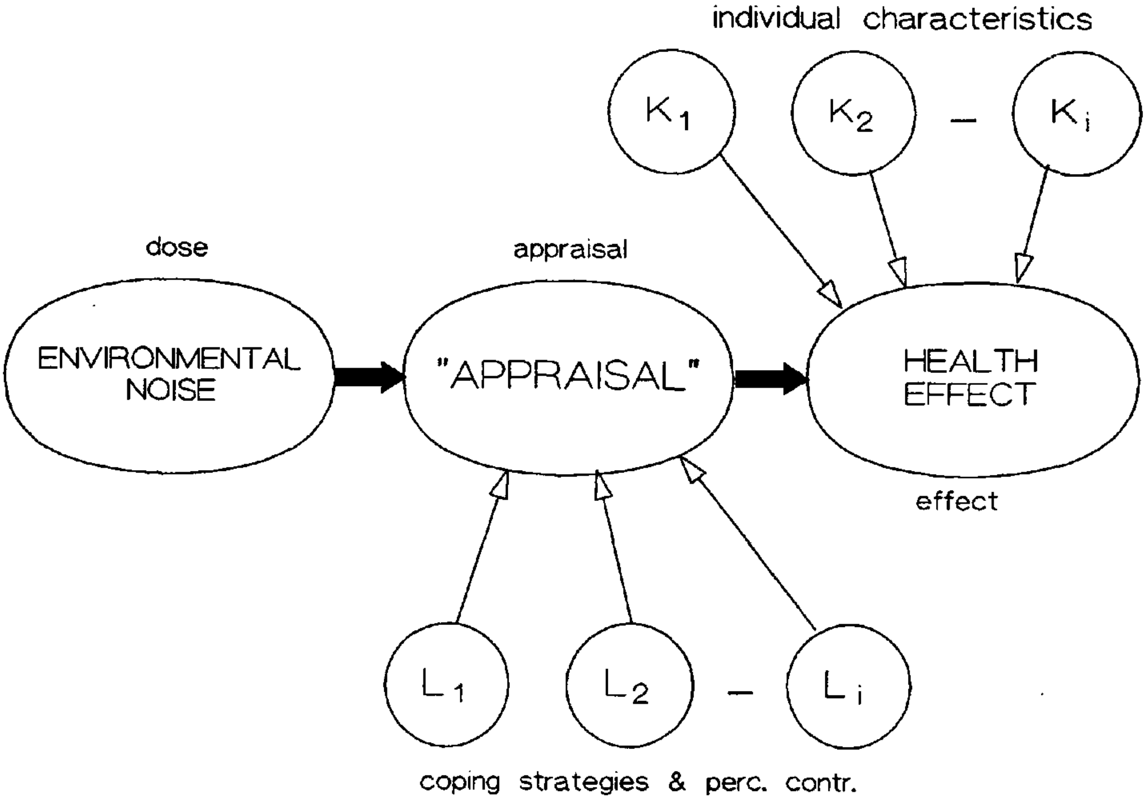

Figure 3.3 Schematical representation of a model incorporating stress theoretical concepts. Again the $K_i$'s indicate individual characteristics; the psychological construct now is dependent upon psychological characteristics of the individual, denoted by $L_j$

We introduce a psychological construct in between the environmental noise and the effects caused by this noise. We define this construct as follows:

> the evaluation of the external stimulus (i.e. the environmental noise) in terms of threat, loss or challenge and in terms of control possibilities (cf. Lazarus, 1966).

In this report we will denote this construct as "APPRAISAL". In the cognitive stress model of Lazarus (Lazarus, 1966) the appraisal process is described in a number of stages: primary appraisal, secondary appraisal and reappraisal (see chapter 6 for more detail). Since the surveys described in this report are in fact point measurements, these three stages cannot be discerned here. Hence, the "APPRAISAL" in our definition is a point measurement of the dynamical processes described by Lazarus.

Following the individual differences approach, we again introduce individual characteristics into the model. Several individual characteristics are of a psychological nature.
Personality traits may influence the way people appraise of an (unwanted) environmental stressor. Cognitive stress models (Lazarus, 1966) introduce the concept of COPING, which may be defined as:

> COPING is any attempt people make to conquer, minimize, tolerate or reduce the physiological and emotional activation, that follows when a situation is appraised as being threatening, cause of losses or challenging.

This coping again is a dynamical process and therefore can not be observed in our field surveys. It is, according to Lazarus, a state of the individual, which may be influenced by the intensity of the stressor. Ursin (1978) assumes available coping strategies to be a personality trait. We assume that the strategies a person has available to cope with a threatening or challenging situation are relatively persistent under the same stressor, although they may vary from individual to individual.

From the assumptions it follows, that the "APPRAISAL" may be dependent upon a second class of individual characteristics, denoted by $L_j$ in figure 3.3. These constructs characterize the individual in terms of the available coping strategies. As will be described in chapter 6, these strategies may vary from problem oriented strategies (try to change the environment, for instance), avoidance reactions (turn to something different, less threatening etc.) or a search for comforters ("compared to other people, it is not that bad after all"). See also Van Kamp (1986).

The position of these constructs in figure 3.3. indicates that the available coping strategies are interpreted as personality traits. In chapter 6 however, a few analyses are described, which interpret the coping variables to be states. A correct schematical representation of these analyses would incorporate these states within the construct of "APPRAISAL". The first of the coping strategies mentioned above is directed externally, the two others internally. Therefore one might argue that the first type of strategies influences the noise level ("closing the window") or the effects ("raising blood pressure to increase the efforts to perform a task").

Wherever appropriate we will indeed introduce such a relation into the analyses.

According to Lazarus (1966), the "APPRAISAL" may be dependent upon the perceived control. The more the individual, according to his or her own perception, is able to control the stimulus, the less negative he or she appraises it. The actual effectivity of the control is less important. This perceived control is also denoted by one of the $L_j$ in figure 3.3.

Formalizing this third type of model, it may be described as:

"APPRAISAL" = f(ENVIRONMENTAL-NOISE,
COPING-STRATEGIES,PERCEIVED-CONTROL)
HEALTH-EFFECT = f("APPRAISAL", INDIVIDUAL-CHARACTERISTICS)

In principle a feedback may be introduced in this type of model by making the available coping strategies dependent upon the effects already present. Such feedback models however are beyond the scope of this report.

Health effects of environmental noise may vary from adverse effects on well-being to pathological conditions, e.g., ischaemic heart diseases. Some remarks with respect to the relationship between appraisal and health effects are relevant here.
The first remark concerns the concept of "annoyance". The concept annoyance may express effects on well-being and therefore belong to the category of health effects. However, if annoyance is defined as interference with activities, it enters into the realm of primary appraisal. The wording of questionnaires with respect to annoyance in most cases involve an explicit link between sound heard and the unwanted effects perceived, estimated, or felt. This warrants the conclusion that annoyance may be catalogued under the heading of primary appraisal. The status of physiological processes also may introduce some ambivalence. A changing blood pressure, for example, related to changes in exposition to environmental noise, can be conceived of as an adaptational process that enters into the heading of coping processes. In laboratory research changing blood pressure levels within a subject may indicate a changing effort to cope

with a stressor. Evans and Cohen (1987, p. 587) state: "(...) there are emerging data suggesting that these psychophysiological indices are elevated when individuals expend effort to cope with a stressor during task performance conditions". The psychophysiological indices Evans and Cohen refer to are: level of catecholamines, level of blood pressure, heart rate and skin conductance. If however blood pressure is measured as an aspect of one's general physical condition, a high blood pressure might indicate hypertension or a risk factor for cardiovascular diseases. If measured in that context, increased blood pressure associated with increased level of environmental noise is an indication of adverse health effects and not an indication of enhanced effort to cope with the stressor noise.

## 3.5 Short term responses

In the laboratory experiment (Veldman, 1988), some dynamic processes are observed on a time scale up to about one hour. In these experiments however most of the dynamical processes mentioned so far have not been measured. In this section we mention a few aspects, relevant to interpret the results of the surveys described in this report together with the results of the laboratory experiments (see Altena, 1987).

Noise can have effects on three different levels of functioning: physiological functioning, performance, and subjective experience. The effects of noise on the physiological functioning depend on the performance required, the effort necessary to maintain, enhance or reduce the performance, and the mental processes involved. Depending on the interaction between these factors noise may contribute to stress.

If a person is exposed to noise a certain degree of effort is needed to meet the demands of the the situation. This results in psychophysiological costs: destabiliations of psychophysiological systems. If possibilities for recovery are insufficient, negative effects may occur which in the long run can become permanent. The effects of noise on physiological functioning depends on the performance required in the condition of exposure. This

leads us to the conclusion that mental processes and the effort required to reach a certain level of performance must be taken into consideration.
The mental processes that play an important role are changes in:

- visual and auditive selective attention
- speed and accuracy
- the capacity and availabilty of short-term memory
- motor behaviour
- alertness.

If a person is exposed to noise or another stressor, two different response strategies can be distinguished: firstly a trade-off between different components of the effort e.g. when speed is maintained at the cost of accurate performance; secondly, an increasing physiological effort to maintain the level of performance.

In his review of nonauditory effects of noise, Kryter (1985) gives a brief outline of major theories that have evolved around physiological responses to noise. Two theories are mentioned here. The first is a theory on the "startle-alerting-arousal" respons. The second theory is a orientation response theory . A brief discussion of these theoretical orientations will give an indication of functions possibly disturbed by exposition to environmental noise.

### 3.5.1 Startle-alerting-arousal response

The startle-alerting-arousal response indicates a response to sudden, intense sounds or noises, both unexpected and repeated or expected. The following responses are, amongst other things, involved (according to Kryter, 1985, p. 392):

- a circulatory response dominated by vasoconstriction of the peripheral bloodvessels with other adjustments of blood pressure throughout the body;
- a reduced rate of breathing;
- Galvanic Skin Response (GSR), a change in the electrical resistance of the skin, and
- a brief change in skeletal-muscle tension.

### 3.5.2 Orientation Response

The second type of theory mentioned by Kryter (1985) concerns reflex theory. Reflex theory assumes that nonauditory-system response to noise can be explained in terms of mechanistic, neural-learning models. The theory of Sokolov (1963) is mentioned specifically as a reflex theory. Two reflexive responses are mentioned by Kryter, the OR (orienting response) and the DR (defensive response). The orienting response of the organism alerts the organism and makes the organism ready for the purpose of receiving and responding. This OR is postulated to get stronger as the noise stimuli become weaker, but only so in the low intensity regio; on higher levels of intensity the OR gets stronger as the noise stimuli become stronger. The DR (defensive respons) prepares the organism for fight or flight. This DR becomes stronger as the strength of the noise is increased.

In the laboratory experiments primarily physiological variables representing the activation are measured (Veldman, 1988).

### 3.6 Summary of constructs used

Table 3.1 summarizes the constructs used in this study in the different analyses. The next chapter describes amongst other things the measurement of variables connected to these constructs.

Table 3.1 Summary of constructs and definitions

| CONSTRUCTS | models* | definition |
|---|---|---|
| ENVIRONMENTAL-NOISE | 1, 2, 3, 4 | This construct is the primary cause of their effects we are interested in. In the models 1 and 2 it is supposed to have a direct causal relation with the effects under study. In model 3 it increases the discrepancy between the demands and the response possibilities, leading to stress reactions |
| EFFECTS | 1, 2, 3, 4 | The effects of the environmental noise under study. The effects comprise of nonauditory physiological effects, effects on mental and psychomotoric task performances and sociopsychological effects |
| INDIVIDUAL-CHARACTERISTICS | 2, 3 | Properties of an individual which may influence the effect under study directly and independently |
| "APPRAISAL" | 3 | The evaluation of the external stimulus (i.e. the environmental noise) in terms of threat, loss or challenge and in terms of control possibilities |
| COPING-STRATEGIES | 3, 4 | Strategies and individual has available to conquer, minimize, tolerate or reduce the physiological and emotional activation, that follows when a situation is appraised as being threatening, cause of losses or challenging |
| PERCEIVED-CONTROL | 3, 4 | The perceived possibilities of the individual to decrease the intensity of the stimulus |

* 1: dose effect model; 2: individual differences model; 3: psychological model; 4: laboratory experiments

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# 4 MATERIALS AND METHODS

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# 4. MATERIALS AND METHODS

## 4.1 Introduction

The method to evaluate the models as presented in chapter 3 is outlined in this chapter. Several methods and procedures could be chosen to evaluate these models. The actual methods and procedures used in this investigation together form the research strategy.

The reasons for the choice of the research strategy for this investigation, are presented in section 4.2. The strategy chosen is stepwise and includes a questionnaire administred to about 2.000 subjects, a medical examination administred to a subsample of about 800 subjects, and a laboratory experiment conducted with a selection of 24 subjects.

The measurement of ENVIRONMENTAL NOISE is explained in section 4.3. Military aircraft and road traffic are chosen as two sources of ENVIRONMENTAL NOISE. The definitions of noise level for aircraft and road traffic, the criteria for selection of these sources, and the classification of exposition levels in six different classes are also presented in this section. Section 4.4 is about sampling. The theoretical and operational population are delineated, and a description of the sampling procedure and sampling results is given, including distributions of demographic variables over levels of noise, distributions of variables which are estimates of the theoretical constructs are presented here, and a concise description of the procedure used in selecting subjects from the survey sample for the medical examination and laboratory experiment. Section 4.5 presents an overview of all variables used in this project to measure the constructs of the model, and distribution of variables.

## 4.2 Research strategy

The research project is an effort to describe HEALTH EFFECTS due to chronic exposition to ENVIRONMENTAL NOISE and to analyze the relationship between ENVIRONMENTAL NOISE and HEALTH EFFECTS, assuming that factors from social and psychological origin are necessary to elucidate and explain that relationship. In order to realize this purpose a reseaerch stratgy was choosen. The elements in the decision to choose the research strategy as described below, are:

- the function of the investigation for decision-making
- the scope of the research problem, covering subjective experience, performance, and physiological processes, and
- inconsistency of results in the present state of knowledge on noise and health.

The objective of this analysis is in the first place to provide scientific information to be used in societal decision-making problem: the setting of norms with respect to environmental noise. This entails for research the requirement to describe the adverse effects of noise in real-life situations with the help of the survey technique. By partitioning subjects according to exposition to noise or noise dose, the relationship between noise dose and adverse effects can be described and analyzed.

Cause-effect relationships

The analysis of cause-effect relationships plays a role in the decision to choose not only the survey technique, but also the laboratory experiment as an element in the research strategy. A simple relationship between noise dose and response is not expected. To account more fully for the relationship between ENVIRONMENTAL NOISE and HEALTH EFFECTS, we assume that additional explanatory constructs are necessary e.g: APPRAISAL and COPING. The survey technique offers the opportunity for a description of real-life situations, dose-response relationships, and correlational analysis. The laboratory experiment is a more appropriate technique to analyze cause-effect relationships by creating create a behavioural setting within which the observed behaviour can be measured with a relatively great precision. Another difference concerns the time-scale. The survey technique if applied in one measurement cannot be used to analyse processes operating in a short time scale. A repeated measurement creates the possibility to analyse cause-effect relationships on a rather extensive time scale, e.g. years. Laboratory experiments offer opportunities to analyse processes occurring on a time scale of much shorter duration, e.g.

seconds, minutes or hours. (For a more extensive treatment on research strategies see McGrath (1968) and Runkel & McGrath (1972)). Thompson (1983) critizes the research on extra-auditory effect of noise for the abundance of cross-sectional studies which are inadequate for the establishment of cause-effect relationships. The inclusion of the laboratory experiment will meet the requirements to create the opportunity for analysis of cause-effect relationships.

### Efficiency, effectiveness, and comprehensiveness

Another group of strategic considerations with respect to the relative adequacy of data-collecting methods stems from McGrath (1968). These considerations derive from the efficiency, effectiveness, and comprehensiveness of data-collecting methods. One criterion to estimate the relative adequacy is the efficiency of the method. The efficiency of a method is defined as the ratio of accountable information to potential information. If for instance in a study many relevant variables are ignored and not measured, the yield of research information is relatively low and the investigator can account for less information than could have been possible. The laboratory experiment is appraised as more efficient than a field (or survey) study because the control of variables (keeping them at constant value) in the laboratory experiments excludes "noise". Uncontrolled and unmeasured variables which constitute noise, are part of the information potential of the study but do not contribute to the portion of accountable information. The second criterion mentioned by McGrath is the over-all effectiveness of a study. The over-all effectiveness of a study is its information yield compared to the total potential information of the referent situation. The highly controlled situation of the laboratory experiment reduces this over-all effectiveness compared to field studies.

The third criterion is the comprehensiveness of a study. The comprehensiveness of a study refers to its scope or generality, and is expressed as the relation between the information potential of the study and the information potential of the referent situation. The comprehensiveness of a laboratory study is generally low compared to a survey. This is due to the exclusion of variables by controlling them, i.e., keeping them at constant value, resulting in a loss of potential information in the study.

### Combination of methods

The models used in our analyses entail subjective evaluations, performance, and physiological variables. A questionnaire is one appropriate instrument to record subjective evaluations, aspects of the medical history, and medically relevant habits. This instrument, however, is not apt to record physiological variables. Therefore a medical survey was included in the research strategy.

A combination of a survey and a laboratory experiment in one research programme offers an additional advantage: the opportunity for testing of key hypotheses. APPRAISAL and COPING play a crucial role in the models. Selection of subjects, according to appraisal and coping activities as measured in the survey, for participation in the laboratory experiment offers the additional opportunity to test hypotheses about the role of these processes in a setting which is more apt to study cause-effect relationships.

### Methodological state of the art

Another consideration relevant to the choice of research strategy refers to the present state of the art in the field of noise and health. This state of knowledge and research is characterized by

- a variety of methods and measurements,
- scarce development of theory but an expansion of the number of variables included,
- diversity of results,
- source dependency of results.

The discussion on the methodological merits of epidemiologic studies on noise and health effects gives an illustration of the methodologocal state of the art. Research results of many studies may be challenged as to methodological quality. Thompson who seriously criticized the methodological merits of several studies on noise and cardiovascular diseases, gives a list of methodological criteria. This list is, in abbreviated form, given in Table 4.1.

Table 4.1 Methodological criteria for research on effects of noise on the cardiovascular system (Thompson 1981)

| | | | |
|---|---|---|---|
| 1 | Noise exposure | | |
| | 1.1 | noise description | type of noise |
| | | | frequency composition |
| | | | levels |
| | | | duration of exposure |
| | | | source |
| | 1.2 | instrumentation | |
| | | | type |
| | | | make & model |
| | | | compliance with standards |
| | 1.3 | environment | |
| | | | type (sound field, room etc.) |
| | | | controlled-uncontrolled |
| | 1.4 | measurement procedure | |
| | | | type |
| | | | compliance with standards |
| | 1.5 | subjects | |
| | | | history of vocational noise exposure |
| | | | history of avocational noise exposure |
| | | | hearing thresholds |
| | | | history of ear disease |
| | | | otological examination |
| 2 | Cardiovascular health effects | | |
| | 2.1 | diagnostic criteria for clinical manifestations or diseases | |
| | 2.2 | documentation of pre-existing cardiovascular disease | |
| | 2.3 | time relationships of exposure events to clinical manifestations, disease development, clinical events | |
| | 2.4 | the natural cause of disease states | |
| | 2.5 | risk of specific clinical manifestations or pathological responses | |
| | 2.6 | methodology for determining respons | |
| 3 | Epidemiologic methodology | | |
| | 3.1 | classification of study design | |
| | | | - strength of the design |
| | | | - bias potential in design |
| | | | - data sources and method of collection |
| | 3.2 | sample | - type |
| | | | - size adequate for testing |
| | | | - follow-up |
| | | | - potential bias and its control |
| | 3.3 | specification of the exposure and respons variables | |
| | | | - noise exposure as an epidemiologic variable |
| | | | - health outcomes as epidemiologic variables |
| | 3.4 | treatment of the data | |
| | | | - strength of association |
| | | | - statistical tests |
| | | | - dose-response relationship evident? |
| | | | - confounding |

The research strategy outlined above, offers methodological advantages to cope with the problems encountered in this field. First, different methods (questionnaire, medical examination, laboratory experiment) combined in one research strategy offer an opportunity to reduce variability of research outcomes due to variation in method. By using a subsample of subjects from the survey, predictions can be made of subjects responses in the laboratory situation (and vice versa), using measurements made in the survey as classification variables. Instead of a simple addition of different methods accompanied with the danger of enhancing method variability, a situation is created in which the results of one method can be evaluated in another. Furthermore, in this design subjects serve as their own control over different methods. The theoretical model presented in chapter 3 is an effort to restrict the unlimited introduction of variables assumed to have explanatory power. The source dependency of dose-response relationships can be evaluated by introducing into the design two different sources of noise. This is treated in more detail in section 4.3.

The choice of the survey technique and the laboratory experiment should not imply the notion that field studies with a longitudinal character offer no advantages above a single survey. In evaluating studies on extra-auditory health effects of noise, Thompson (1983) mentions longitudinal designs to collect evidence about cause-effect relationships. In fact the study presented here can be conceived of as a first measurement point in a longitudinal research strategy. The "not-yet-realized-part" of this longitudinal study can have the character of a repeated measurement, but it is also possible to select from the survey a cohort for a follow-up study.

Overall strategy

The over all strategy of our project can be summarized as follows:
About 2,000 subjects are interviewed; they are more or less equally distributed over areas where one of two different noise sources are dominantly present, and are within each noise source more or less equally distributed over noise levels. The questionaire is about a number of psychosocial (van Kamp, 1987a; see also chapter 6 of this report) and medical issues (van Brederode, 1987; see also chapter 7 of this report). Using the first

results of this field survey, about 800 subjects are selected for medical examination. From these 800 subjects 24 women are selected to participate in laboratory experiments.

## 4.3 Sources and measurement of environmental noise

### 4.3.1 Sources

To estimate the influence of ENVIRONMENTAL NOISE on HEALTH, several sources of noise could be chosen, and within each source of noise, different levels of noise could be selected. In Dutch policy making concerning environmental noise, at least five distinct sources of noise are relevant: road traffic, railway traffic, military aircraft, civil aircraft, and industry. Since the effects of noise might be dependent upon a different physical characterization of the noise present, it was decided to use at least two physically different noise sources. In the first place, a noise source that produces a relatively smooth, continous level with no high intensity peaks present; traffic noise and certain kinds of industrial noise may be used as examples of this type of noise. Secondly, a noise source that produces high peak intensities, superimposed on a relatively low back ground level; both civil but especially military aircraft noise can be used. Within a certain source the noise patterns may be rather heterogeneous with respect to both characterizations. Industrial noise for example can have a relatively continuous character but also an impulse character. An optimal choice of intrasource homogenity and intersource differentiation is found in the combination of military aircraft and road traffic. Other combinations were possible, but the availability of noise data and the possibility to draw a sample large enough for our purpose were decisive practical arguments.

### 4.3.2 Measurement

The level of noise produced by road traffic can be expressed in units of dB(A). The sound pressure level $L_p$ is expressed in units dB. The basis of this pressure level is the ratio between the actual sound pressure level and a reference level. This reference level is 20 microPascals, indicating the minimum threshold or the quietest sound which can be heard by the average person. The ear processes acoustic information not linearly but logarithmically; for this reason the logarithm is taken of the ratio between the actual sound pressure P and the reference level $P_o$. The sound pressure level $L_p$ is proportional to the acoustic intensity, the power of sound passing through a unit area in space. The sound pressure level is:

$$L_p = \log (P/P_o)^2 = 2 \log(P/P_o) \text{ Bel} = 20 \log(P/P_o) \text{ deciBel}$$

where

$L_p$ = sound pressure level
P = instantaneous sound pressure
$P_o$ = reference sound pressure, usually 20 microPascals
DeciBel = one tenth of a Bel (after Alexander Graham Bell)

Sounds with the same intensity, but differing in frequency, are perceived as differing in loudness. To account for this perceptual mechanism, equal loudness curves are constructed. Starting with a frequency of 1,000 with an actual intensity level of 40 dB, a curve is constructed that denotes for each frequency the actual level of dB necessary to produce the same perceived loudness. This is an equal loudness curve. This process can be repeated for different levels of dB starting from the 1,000 Hz frequency, resulting in different equal loudness curves. A frequency spectre measured with a sound level meter can be filtered according to an equal loudness curve. The so-called A-weighted sound level, expressed in dB(A), using an approximation of one of these equal loudness curves, correlates fairly well with subjective response. The A-weighted sound level is frequently used in estimating road traffic noise. This A-weighted sound level can fluctuate considerably as a function of time. Therefore the $L_{Aeq}$ is taken as the continuous steady dB(A) level which produces an equal amount of acoustic energy as the fluctuating sound. The $L_{Aeq}$ is also expressed in dB(A). The use of this measure facilitates greatly the comparison between acoustically different situations. For the purpose of this investigation the estimates of $L_{Aeq}$ are taken from official reports and maps. The estimates are derived from traffic frequencies and calculated with an officially adopted computation programme (Berekeningsvoorschrift, 1980). Information on estimated or calculated levels lower than 50 dB(A) is not available; dwellings exposed to levels lower than 50 dB(A) are selected on the basis of knowledge of the local situation, the absence of railway traffic and main traffic routes. The traffic intensities date from 1984.

The level of noise produced by aircraft can be characterized by the Noise and Number Index, but in the Netherlands the Kosten Unit KE is used. From a practical point of view we will also use this unit. The noise level B is defined as:

$$B = 20\ {}^{10}\log \underset{N}{} (n_{ti} \, . \, 10^{Li/15}) - 157\ \text{KE}$$

where

$B$ = level of aircraft noise

$N$ = the number of flyovers in the period of one year

$Li$ = the maximum level of noise during a flyover measured in dB(A): the A-weighed sound level, measured outdoors

$n_{ti}$ = a weighting factor that accounts for the time of day of a single flyover. This factor varies between 1 and 10

KE = units of aircraft noise

This Kosten Unit was calibrated so as to maximally predict annoyance in the environment of Schiphol, the largest civil airport in the Netherlands. In the data we used, the level of KE is not measured but estimated, estimations being based on calculations by national authorities (Structuurschema, 1981). Equal KE-contours for the airforce base Leeuwarden are estimated according to the maximal number of flights expected in a year, acoustic characteristics of the airplane used (F-16), and expected flight plans. For the airforce base Twente, the same procedure is used. But in this case not the acoustic characteristics and flight plans of the F-16 but those of the NF-5 are used to estimate equal KE-contours. Due to the confidentiality of the military aircraft data, we only have to our disposal the KE-contours. It should be stressed that these contours are prognoses.

In this study we assume level of dB(A) and KE to be estimates of level of exposure to environmental noise. In this we follow the conventions in the field of noise and health. As a matter of fact, dB(A) and KE are estimators of noise level based on, amongst other things, the intensity of the acoustic stimulus. In KE the subjective aspects of the experience of sound pressure level is accounted for: the factor $n_{ti}$ is a weighting factor introduced as a penalty for time of day. We further have to be careful in the interpretation of KE because this measure is calibrated against noise annoyance. In both dB(A) and KE the sensitivity of the ear for different frequencies is accounted for. The introduction of the psychophysical relationship between acoustic intensity and perception of sound in estimators of noise levels gives however rise to doubts about the definition of noise as a purely physical phenomenon (Van Dormolen et al., 1988; Altena, 1987b). Apart from the possibility to define noise in purely psychological terms as unwanted sound (Kryter, 1985), other physical aspects of sound e.g. number of events (as in the KE measurement), rise time and peak level ($L_{Amax}$), can have an influence on health. Nevertheless we primarily try to establish a relationship between noise as estimated by level of dB(A) or KE and health and to elaborate the perspective that psychosocial constructs are necessary elements. In order to make the relationship between noise and health understandable, it is our opinion that this approach is a necessary SRP before proceeding with alternative estimators of noise.

### 4.3.3 Levels of noise

Six different noise levels are chosen. The highest level for both military aircraft and road traffic were the highest levels of noise in this study where sampling made sense, i.e. where a statistically suffucient number of dwelling could be found. For both military aircraft and road traffic noise each level encompasses 5 KE or 5 dB(A) respectively. It is supposed that a reliable discrimination can be made between subjects sampled from adjacent regions with respect to the noise exposition outdoors. For exposition to aircraft noise this is realized by excluding subjects living near the calculated KE-contours. No fixed upper limits for the highest noise levels, and no fixed lower limits for the lowest levels of noise could be applied. The dwellings in aircraft stratum number six are exposed to levels higher: than 55 KE; the upper limit is not 60 KE, values of about 65 KE may also be included. The lower limit of aircraft stratum 1 is not 30 KE, values of about 20 KE may also be included. For road traffic noise the upper and lower strata are also more than five units: in stratum number six the upper limit is not 75 dB(A); values of about 80 dB(A) may also be included. The lower limit of traffic stratum 1 is not 45 dB(A); values of about 40 dB(A) may also be included. The classification of noise sources, and noise level, is presented in Table 4.2.

Table 4.2 Source and level of environmental noise

| stratum | aircraft noise KE | traffic noise dB(A) |
|---|---|---|
| 1 | 35 | 50 |
| 2 | 35-40 | 50-55 |
| 3 | 41-45 | 56-60 |
| 4 | 46-50 | 61-65 |
| 5 | 51-55 | 66-70 |
| 6 | 55 | 70 |

A word of caution should be made with respect to the ordering of these strata. Strata one through six are ordinally related, that is: 5 indicates a lower noise level than than 6; 4 indicates a lower level than 5 etc. But notwithstanding the algebraic equality of the intervals of the strata 2, 3, 4 and 5, the strata are not representing physically equal intervals, e.g. 41-45 is not equal to 46-50. This is mainly due to the logarithmic transformation of the acoustic energy. But additional factors make the difference between units KE or dB(A) disproportionate with differences between acoustic energy. For the estimation of aircraft noise the maximum level of noise measured in dB(A) is chosen, not the acoustic intensity of the overflight as a whole. The introduction of the weighting factor that accounts for the time of the day adds to the disproportionateness. For the estimation of road traffic noise the disproportionateness between different levels of road traffic noise and different levels of acoustic energy is caused by the logarithmic transformation, the A-weighting and the addition of penalties. If for the estimation of KE and dB(A) level no real measurements are made but calibration procedures are applied the correspondence with differences in acoustic energy is still less certain.

## 4.4 Sampling

### 4.4.1 Concepts

To explain the sampling procedure we first introduce and define the relevant concepts. The theoretical population is the population the theory refers to and which is not restricted to a certain time and place. The operational or statistical population however is the same population, but restricted to a certain time and place. From this operational population an aselect sample can be drawn. For sampling, one often uses a sample frame: a registration of all elements in the operational population. The sample frame is the administrative reflection of the operational population; all elements in the sample space have equal chance to be drawn in random sampling. (Moors & Muylwijk, 1975; Bethlehem & Karsten, 1986). Population elements selected for research are the sample elements. All selected sample elements form together the sample.

A representative sample is any sample which is an accurate reflection of the operational population from which is was drawn. If each element of the sample frame has equal chance to be drawn, sampling is aselect. Following from the definition, an aselect sampling not necessarily results in a representative sample. Aselectness is required for generalization from the sample outcome to the population. Systematic sampling bias occurs if, due to a systematically operating factor, some elements in the population have a greater or smaller chance of being selected than they should, given their frequency in the operational population. If no information is available on elements drawn from the operational population, the term non-response is applied. If only partial information is gained, the response is a partial non-response. Three sampling procedures are relevant:

- Simple random sample: Sampling in which each selected element is not replaced back in the sample set and is thus not available for future sampling.
- Stratified sample: Sampling in which the population as a whole is separated into distinct parts or strata and each is drawn from aselect and separately. This helps to ensure that the whole population is properly represented.
- Purposive sample: Sampling is random; the sample consists of elements considered characteristic for the population

Another relevant concept is homogeneity. A population is homogeneous with respect to a certain variable if all elements have the same measured value on that variable. Most populations are heterogeneous with respect to the variables studied. Reliability of estimates is related to heterogeneity: the more heterogeneous the population is, the larger the sample should be.

### 4.4.2 Theoretical and operational population

The theoretical population as chosen for this research project is the population exposed to ENVIRONMENTAL NOISE. This implies that generalizations from the analyses of the research data are directed at those who are exposed to aircraft or road traffic noise. The results may be valid for exposition to other sources of environmental noise. But the sampling procedure is not designed to make this generalizations.

Restrictions were made with respect to the population from which ultimately a sample was drawn. These restrictions are
- exposition to road traffic or military aircraft noise only; other sources of environmental noise (industry and railway traffic) should not be present
- residents of a restricted number of locations for both sources. For aircraft the locations are the airforce bases Leeuwarden and Twenthe, for road traffic the cities Groningen and Amsterdam
- exposition to one source of environmental noise
- age between 20 and 55

### 4.4.3 Determination of sample size and sample frame

Sample size

Thompson (1983) recommends for the planning of epidemiological studies to estimate on the basis of statistical principles, required sample sizes necessary to reach a required power of the statistical tests. A statistical design has a relatively high power if the probability of a statistical test to detect significant differences in the sample while these are true differences in the population, is high. Cohen (1977) has presented a method to estimate the required sample size. This method requires the specification of three elements: error type I, error type II and effect size. Error type 1 is the well-know statistical level of significance: alpha. This alpha specifies the probability that an effect (difference between samples, the size of a correlation coefficient, etc.) is accepted as being true or real in the population, while in fact this is false. Error type II refers to the statistical power of a test, to detect effects that are true. A low power, implying a high error of type II, results in a high probability of not detecting effects that are in fact true. The effect size is the size of the difference between samples, of a correlation coefficient or another measure.

To determine sample size, given a desired level of type I and type II error, and certain effect size, we choose as a point of departure the basic design of Table 4.3. The choice of type I and II error, and the choice of effect size, is explicited as follows:

Table 4.3 Basic structure of the research design

| | Level of environmental noise | | |
|---|---|---|---|
| Source | High | Low | Sample size |
| Aircraft | $n_{11}$ | $n_{12}$ | $n_1$ |
| Road traffic | $n_{21}$ | $n_{22}$ | $n_2$ |
| Sample size | $n_1$ | $n_2$ | N |

If aircraft noise and road traffic noise are analysed separately, then the sample sizes for aircraft noise, $n_{11}$ and $n_{12}$ respectively, and the sample size for road traffic noise, $n_{21}$ and $n_{22}$ respectively are determined as follows: We first establish type I and type II error as 5%. Especially for differences in bloodpressure we do not expect large differences between $n_{11}$ and $n_{12}$, or between $n_{21}$ and $n_{22}$. Blood pressure is subject to a multitude of influences, so we cannot expect to detect more than a small difference between high and low levels of environmental noise. We can express the size of the difference as:

$$d = \frac{M_h - M_l}{o}$$

where d = difference

$M_h$ = Mean population value at high level of noise

$M_l$ = Mean population value at low level of noise

o = the standard deviation of either population (assumed to be equal)

Following the convention proposed by Cohen (1977) we identify a small effect size for values of d about 0.2. "In new areas of research inquiry, effect sizes are likely to be small (when they are not zero!). This is because the phenomena under study are typically not under good experimental or measurement control or both. When phenomena are studied which cannot be brought into the laboratory, the influence of uncontrollable extraneous variables ("noise") makes the size of the effect small relative to these (makes the "signal" difficult to detect)" (Cohen, 1977, p. 25). This line of reasoning fits in with the expectation of "effects" we can expect from high levels of environmental noise compared with low levels. For error type I= 5%, error type II= 5% and effect size d =.2, we identify a sample size n= 542 (Cohen, 1977, p. 54, Table 2.4.1). For aircraft noise the sample size $n_{11}$= 542 and $n_{12}$ is equally 542. The same applies to $n_{21}$ and $n_{22}$. The numbers are presented in Table 4.4. In designing the research strategy, we accepted this as reasonable for the survey. Subsequent selections for the medical examination and laboratory

Table 4.4 Determination of sample size for d= 0.2

| Source | Level of noise |  | Sample size |
|---|---|---|---|
|  | High | Low |  |
| Aircraft | 542 | 542 | 1,084 |
| Road traffic | 542 | 542 | 1,084 |
| Sample size | 1,084 | 1,084 | 2,168 |

type I error = 5%, type II error = 5%

experiment will reduce the sample sizes. But it is expected that the reduction of sample size and resulting loss of power, will be partly balanced by a reduction of "noise" or increase of "noise-to-signal ratio" because of the greater control of extraneous variables (see chapters 6, 7 and 8).

In the analyses, reported in the subsequent chapters of this report, several differing subdivisions are made of the same total number of subjects involved in this study. Often, the simple classification in high-low level of noise, is replaced by a distribution of subjects over six levels of noise; sometimes other classifications are made. This changes, given the already established total number of subjects, type I eror and effect size, the power of the resulting test. If, for instance a comparison is made between but two levels of aircraft noise from an array of six levels then, still expecting a small effect size and maintaining type I error as 5% the priori determined power will drop to 0.60, which corresponds to a type II error of 40%! This determination of power is based upon a subgrouping of $n_{.1}$ or $n_{.2}$ in Table 4.3 of 1,084 in six groups of equal size $n_{ij}$ = 180. If an analyses of variance is applied with six levels (groups) of noise exposition each level containing 180 subjects, the power of the F-test will be 0.72 which implies an error of type II = 28% (Cohen, 1977, p. 320, Table 8.3.16, u = 5, effect size f is small: 0.10). If the definition of effect size f for an analysis of variance as 0.10 is changed in 0.20 then the power increases beyond 0.98 and error type II is smaller than 5%.

Subgroupings and analyses (univariate, multivariate; and so on) differ in power of analysis. The determination of sample size is therefore not exact but as a method to specify the sample size a good heuristic.

Sample frame

The determination of the required sample size sets the limits to the minimum size of the sample frame. As defined a sample frame is the administrative reflection of the operational population. From this frame the *final* sample is drawn. Four separate samples were constructed:

- military aircraft, Leeuwarden
- military aircraft, Twenthe
- road traffic, Groningen
- road traffic, Amsterdam

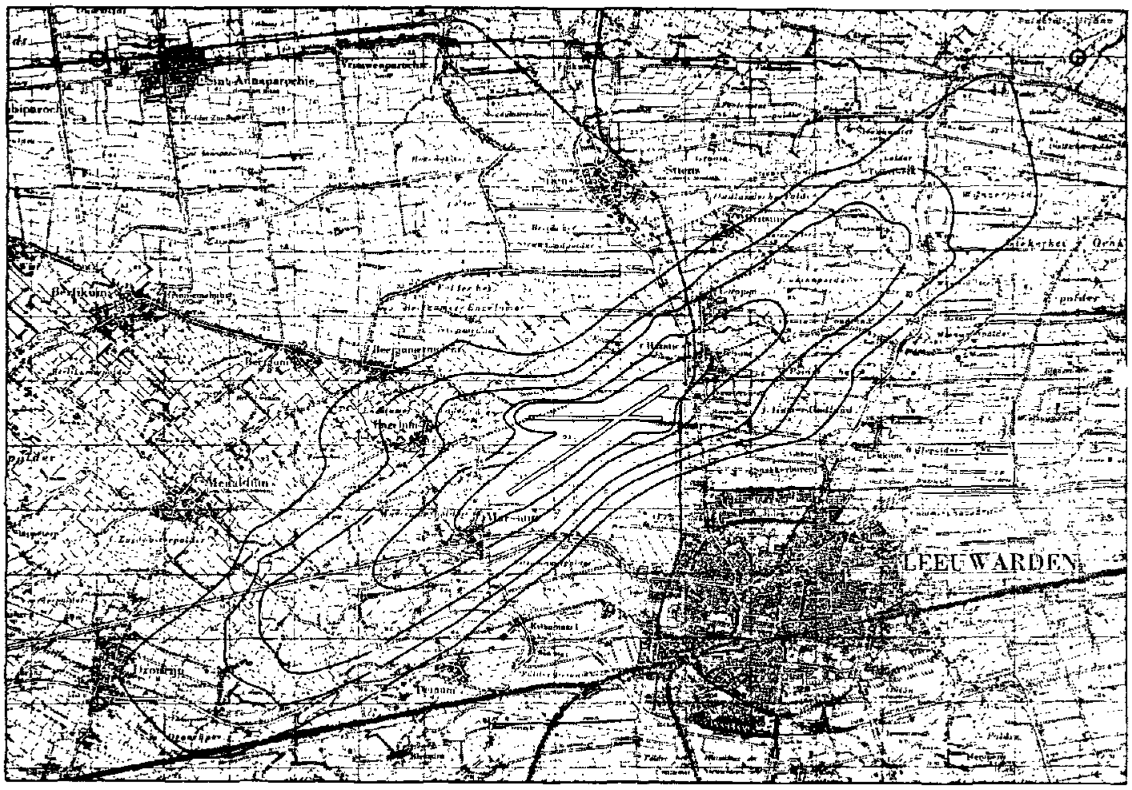
Selection of locations for military aircraft and road traffic take into account: number of dwellings within a location and the presence of dwellings exposed to high levels of noise. Both selection criteria are applied to create a sufficiently broad spectre of exposition levels in our study and also a sufficient base for statistical analysis. To avoid a contamination of noise source with unique aspects of a specific location, two locations within each noise source are selected.

The city of Groningen in the north and the city of Amsterdam in the west of the country are chosen as locations were residents exposed to different levels of road traffic noise could be selected. Dwellings are selected according to estimated exposition levels in dB(A).
Two airforce bases are chosen, one located near the city of Leeuwarden in the northern part of the country and one near the cities of Hengelo and Oldenzaal (airforce base Twenthe), in the mid-east part of the country. Dwellings are selected according to level of exposition estimated in units KE (See Figure 1 for an illustration of KE strata). In the course of our study, the actual level of exposure to military aircraft noise has been measured. The results from measurement of the noise exposure in the vincinity of one of the airport bases (Leeuwarden) same available only recently. Preliminary results from the measurements do indicate deviations from the calculated equal noise contours. These deviations occur especially

in the noise strata 4 to 6 (i.e., larger than 45 KE). An extensive inquiry into the consequences of the differences found is not possible within the timelimits available for this study. On first sight, for a great number of dwellings in the higher noise strata, a new assignment to the correct noise stratum should be made. (Part of the dwellings should probably be assigned to an adjacent higher noise stratum, part to an adjacent lower noise stratum.) Definite results of assignment for both airports will become available later.

The specific locations were chosen for the following reasons: for aircraft as well as for road traffic the locations are situated in different parts of the country to avoid the capitalization on regional peculiarities. The airforce bases Leeuwarden and Twente are surrounded by enough dwellings near the bases to draw a sample of the required size. Other aircraft bases did not have a substantial number of dwellings in the vicinity. The locations Amsterdam and Groningen were also chosen because of practical consideration (e.g. availability of noise data).

Leeuwarden



Twenthe

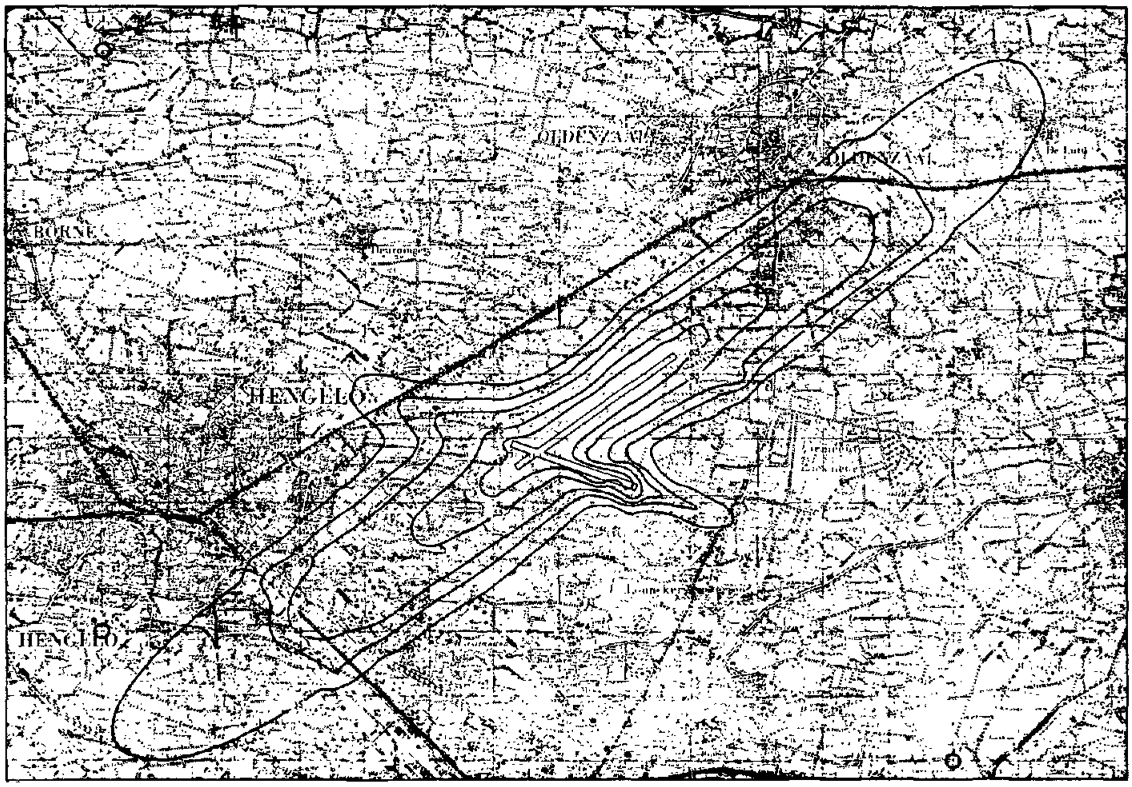


Figure 4.1 Equal KE contours

The general procedure for the construction of the sample frame consisted of selection of addresses pertaining to the area exposed to the defined levels of aircraft or road traffic noise. With the help of local municipalities and administrative agencies the selection was carried out. Only adresses of private houses were selected. An additional criterion was that no dwellings were included in which all the inhabitants were younger than 20 or older than 55. The resulting sample frame for aircraft noise is the administrative reflection of the whole operational population. For road traffic the sample frame is itself a random sample of the (much larger) operational population.

The two sample frames for aircraft and road traffic are not constructed independently with respect to numbers of elements. The general purpose is to arrive at equal numbers of respondents in the final sample for each level of noise. Due to an expected shortage of elements in one noise location, the number of elements for the corresponding level in the other location exposed to the same type of noise has been raised. This compensation will be especially necessary because of the lack of elements in the higher levels of noise exposure in the locations Twenthe and Groningen. The availability of elements in the four locations however, put a restriction on the possibility to achieve an equal distribution. This procedure implies that there is no question of stratified sampling with respect to location and level. The sample frames for military aircraft are given in Table 4.5, the sample frame for road traffic in Table 4.6.

Table 4.5 Sample frame for military aircraft

| | Leeuwarden | | Twente | | Total | |
|---|---|---|---|---|---|---|
| KE | n | % | n | % | n | % |
| 35 | 539 | 34.8 | 166 | 15.2 | 705 | 26.6 |
| 35-40 | 397 | 25.6 | 212 | 19.4 | 609 | 23.0 |
| 41-45 | 167 | 10.8 | 300 | 27.4 | 467 | 17.6 |
| 46-50 | 92 | 05.9 | 376 | 34.3 | 468 | 17.7 |
| 51-55 | 245 | 15.8 | 30 | 02.7 | 275 | 10.4 |
| 55 | 111 | 07.2 | 11 | 01.0 | 122 | 4.6 |
| Totaal | 1,551 | 100% | 1,095 | 100% | 2,646 | 100% |

Note: For 153 elements in the sample frame of Twente, no a priori selection according to age could be applied

Table 4.6 Sample frame for road traffic

| | Groningen | | Amsterdam | | Total | |
|---|---|---|---|---|---|---|
| dB(A) | n | % | n | % | n | % |
| 50 | 665 | 33.1 | 2,425 | 20.3 | 3,090 | 22.2 |
| 50-55 | 247 | 12.3 | 1,779 | 14.9 | 2,026 | 14.5 |
| 56-60 | 374 | 18.6 | 1,152 | 9.7 | 1,526 | 10.9 |
| 61-65 | 370 | 18.4 | 1,196 | 10.0 | 1,566 | 11.2 |
| 66-70 | 354 | 17.6 | 2,472 | 20.7 | 2,826 | 20.3 |
| 70 | 0 | 00.0 | 2,912 | 24.4 | 2,912 | 20.9 |
| Total | 2,010 | 100 | 11,936 | 100 | 13,946 | 100% |

Note: No a priori selection according to age was applied

### 4.4.4 Sampling and interview procedure

The final sample was the result of the sampling procedure. This procedure consisted of the following elements

- sampling
- approach of the respondent: by mail or directly
- response: yes or no

The procedure for selection and instruction of interviewers was as follows: fourty interviewers were selected, mostly recruted from the student population. Selection criteria were: education, motivation, time available, prior interview training and experience. Interview training consisted of an elaborate explanation about the research goal, rationale behind the questionnaire, detailed information about codes and a video taped instruction of general interview techniques.

The interviewers were instructed to interview only at selected addresses, not to mention the issue of environmental noise and to avoid elaborate discussion about noise and health related issues before the interview. They were also instructed to try and contact someone at different times in the day and only after 3 times 'not home' skip the address. In the course of the interview period skillfull interviewers were sent to areas with the highest percentage of non-response.

The reasons for non-response were tabelled as follows. Subjects invited for participation in the investigation could reply by mail and react positively or negatively. If they declined the request to participate one or more reasons could be mentioned. This is the first source of information on non-response and reasons for non-response. The second source of information came from the interviewers, who visited potential participants and made a short note on the reasons for non-response. Table 4.7 presents reasons for non-response.

Table 4.7 Reasons for non-response

| Response by mail | Aircraft<br>n | Road traffic<br>n |
|---|---|---|
| 1. Not the required age | 28 | 286 |
| 2. Not regularly at home | 30 | 46 |
| 3. No time for interviews, ill, etc. | 44 | 45 |
| 4. No interest | 32 | 30 |
| 5. Preparing to move | 3 | 2 |
| 6. No reason known | 32 | 45 |
| Total | 169 | 454 |
| **Response at the door** | | |
| 1. Not the required age | 106 | 151 |
| 2. Not regularly at home no time | 185 | 357 |
| 3. Not found in | 216 | 1181 |
| 4. No interest | 448 | 561 |
| 5. Preparing to move | 5 | 11 |
| 6. Bad experience with interviews | 27 | 11 |
| 7. Does not master Dutch | 18 | 63 |
| 8. No reason known | 37 | 95 |
| Total | 1042 | 2430 |

As can be concluded from Table 4.7 many subjects declined an invitation to participate in the survey, giving as a reason that they were too old or too young. The same applies for not being regularly at home. Both reasons for non-response conform to the requirements for the construction of the sample: the subjects should be between 20 and 55 years of age and exposed to the noise level as estimated (see section 4.3.3), by being regularly at home. Because in the sample frame for road traffic (Table 4.6) no a priori selection acording to age was applied, many subjects declined the invitation to to participate because of age.

Table 4.8 presents the figures for the sample size for each noise level, resulting from the selection procedure and the non-response.

Table 4.8 Type and level of environmental noise and number of subjects

| aircraft noise KE | n | % | traffic noise dB(A) | n | % |
|---|---|---|---|---|---|
| 35 | 220 | 23.9 | 50 | 204 | 18.5 |
| 35-40 | 200 | 22.7 | 50-55 | 170 | 15.5 |
| 41-45 | 185 | 20.0 | 56-60 | 160 | 14.6 |
| 46-50 | 148 | 16.1 | 61-65 | 187 | 17.0 |
| 51-55 | 129 | 14.0 | 66-70 | 226 | 20.6 |
| 55 | 39 | 4.2 | 70 | 150 | 13.7 |
| N | 921 | 100% | | 1097 | 100% |

Three subjects, exposed to road traffic noise, could not be classified according to level of noise. These are not included in Table 4.8; 35 interviews were judged to be unreliable by the interviewers, due to language problems and/or lack of understanding of the questions. These subjects are included in Table 4.8, but not in the analyses. Some 28 subjects did not satisfy the required age limits. These are included in the analysis of the data, except for the analyses pertaining to the medical survey.

Table 4.9 presents response percentages. These percentages were calculated by putting the number of subjects who completed an interview in the numerator and the number mailed invitations to participate in the denominator. Thes percentages should be corrected for the number of subjects not invited by mail but by the interviewer. For aircraft traffic this number is about 250, reducing the response percentage of 49.4% to 43.6%. Unfortunately we do not have available an accurate number of subjects invited by the interviewer but not by mail, for road traffic.
If we should subtract from the number of invited subjects all those who were too old or too young, or not regularly at home, the response percentage should increase: for aircraft to 55.3%, for road traffic to 29.8%. A large portion of the non-response for road traffic is due to "not found in" (Table 4.7). If we consider this group as not-being-invited, the response percentage for road traffic increases to 43,8%.

Table 4.9 Response ratio's

| aircraft noise KE | n sampled | response % | traffic noise dB(A) | n sampled | response % |
|---|---|---|---|---|---|
| 35 | 387 | 56.8 | 50 | 795 | 25.7 |
| 35-40 | 402 | 49.8 | 50-55 | 764 | 22.3 |
| 41-45 | 385 | 48.1 | 56-60 | 720 | 22.2 |
| 46-50 | 413 | 35.8 | 61-65 | 833 | 22.5 |
| 51-55 | 194 | 66.5 | 66-70 | 700 | 32.3 |
| 55 | 83 | 47.0 | 70 | 713 | 21.0 |
| Total | 1864 | 49.4 | | 4524 | 24.2 |

Possible reasons for the difference in response percentages for aircraft and road traffic noise are: degree of urbanization (the sample for road traffic being drawn from large cities and for aircraft from small country cities and villages), number of invited subjects not satisfying the requirements (not regularly at home, not having the required age; see Table 4.27), and not found in (Table 4.7). The last two reasons apply most frequently to the road traffic sample.

### 4.4.5 Selections for the medical survey

From the subjects interviewed in the survey a group has been selected for medical examination. The selection is intended to exclude subjects having a high value on variables which influence hypertension and ischaemic heart diseases not being a result of exposure to noise. These variables include: renal disease, congenital heart condition, cardiac valve condition and diabetes. Details of this selection procedure are given in chapter 8. The resulting sample is given in Table 4.10.

Table 4.10 Sample subjected to medical examination

| aircraft noise KE | n | % | traffic noise dB(A) | n | % |
|---|---|---|---|---|---|
| 35 | 101 | 22.7 | 50 | 76 | 18.2 |
| 35-40 | 108 | 24.3 | 50-55 | 77 | 18.4 |
| 41-45 | 88 | 19.8 | 56-60 | 56 | 13.4 |
| 46-50 | 72 | 16.2 | 61-65 | 76 | 18.2 |
| 51-55 | 60 | 13.5 | 66-70 | 90 | 21.5 |
| 55 | 16 | 3.6 | 70 | 43 | 10.3 |
| Total | 445 | 100% | | 418 | 100% |

It might be possible that subjects participating in medical examination differ from those who did not (wish to) participate. This would add to possible selection biases in selecting subjects for partipation in the interview part of the study. In order to examine this possibility, differences between interviewed subjects who did and who did not participate were calculated on a number of theoretically relevant variables (chapter 3); see Table 4.11. From this table it can be concluded that only the difference on the coping variable for the aircraft sample has a probability of 4%.

Table 4.11 Differences between interviewed subjects who did or did not participate in the medical examination

| | Aircraft n yes/no 445/476 | | Road traffic n yes/no 419/680 | |
|---|---|---|---|---|
| | t-stat. | p | t-stat. | p |
| Noise level | -0.59 | 0.55 | -1.39 | 0.16 |
| Coping general: problem solving | -1.58 | 0.11 | 0.12 | 0.90 |
| Coping general: avoidance | -0.09 | 0.93 | -1.29 | 0.20 |
| Coping general: comforting | -0.61 | 0.54 | -0.65 | 0.52 |
| Coping specific: problem solving | 1.65 | 0.10 | 1.14 | 0.25 |
| Coping specific: avoidance | 1.65 | 0.10 | 0.76 | 0.45 |
| Coping specific: comforting | 2.11 | 0.04 | -0.35 | 0.73 |
| Disturbance of activities | -1.15 | 0.25 | -1.17 | 0.24 |
| HSCL Somatic complaints | 1.65 | 0.10 | -0.36 | 0.72 |
| HSCL Social anxiety | 1.21 | 0.23 | 0.67 | 0.50 |
| HSCL Depression | 0.34 | 0.73 | -0.48 | 0.63 |
| Sleep quality | -0.88 | 0.38 | 0.19 | 0.85 |

See Table 4.13a for list of constructs and variables

From this table it is concluded that no selection bias was present in selecting subjects for the medical examination with respect to theoretical relevant variables.

### 4.4.6 Selection for the laboratory experiments

The selection for the laboratory experiments is based on information from the field survey and the medical examination. Two classes of selection variables are used: variables used to satisfy methodological requirements by excluding subjects (exclusion) and variables wich were used to classify experimental subjects on theoretically relevant constructs (inclusion). In Table 4.12 both classes of variables are listed. Variables for which the distribution is controlled are listed in colum number three. Details of the selection procedure are given in Van Kamp (1986).

Table 4.12 Selection for the laboratory experiments

| | |
|---|---|
| Included | subjects participating in the medical survey<br>women younger than 40 years |
| Excluded from this group | subjects who smoke more than 40 sigarettes a day<br>subjects who drink more than 10 glasses a day<br>subjects who suffer from diabetes mellitus<br>subjects who suffer from renal failures<br>subjects who suffer from congenital heart diseases<br>subjects who are treated for hypertension |
| Controlled range of values | inclusion of subjects with values on residential satisfaction mean ± 1 s.d.<br>inclusion of subjects with values on daily hassless: mean ± 1 s.d.<br>primary appraisal (perception of road traffic/aircraft noise) values higher than a fixed threshold |
| Classification | subjects classified according to:<br>coping (problem oriented and avoidance behaviour) and perceived noise control |

* For specific information on the selection procedure see Van Kamp and Veldman, in: Van Kamp, 1986.

## 4.5 Constructs, variables and distributions

### 4.5.1 Variables measuring constructs

Table 4.13a gives the list of theoretical constructs and variables as used in this study. Table 4.13b and 4.13c give means and standarddeviations for aircraft and road traffic noise respectively.

Table 4.13a List of variables

| Variables | Question (items) | |
|---|---|---|
| Daily hassless | 17 | (1,2,3,4,5,6,7,8,9) |
| Coping with stressors, general | | |
| Problem oriented behaviour | 18 | (1,4,8,10,13) |
| Avoidance behaviour (palliatives) | 18 | (2,3,5,14,15) |
| Comforting cognitions | 18 | (6,7,9,11,12) |
| Admission psychiatric hospital | 76 | |
| Psychotherapy | 79 | |
| Respiratory insufficiency | | |
| asthma | 81 | |
| hoarseness | 85 | |
| Gastrointestinal disorder, ulcer | 83 | |
| Number of days ill | 87 | |
| Number of visits to General Practitioner | 89 | |
| Birth | | |
| miscarriage yes/no; number of | 92 | |
| Sleep disturbance | 106* | (1,2,3,4,5,6,7,8,9,14) |
| Sleeping pills, frequency of use | 107* | |
| Earplugs, use during night | 108 | |
| Perception of road traffic noise | 119 | (1,2,3,5,6) |
| Perception of military aircraft noise | 125 | (1,2,3,5,6) |
| Stress | 126/120 | (2,3,4,5,6) |
| Annoyance, general | 127/121 | |
| Perceived noise control | 130/123 | (1,2,3*) |
| Disturbance of activities, intensity | 131C/131B | (1,2,3,4,5,6,7,8,9) |
| Coping with environmental noise | | |
| Problem oriented behaviour | 134 | (1,5,8,9,17,20,23) |
| Avoidance behaviour (palliatives) | 134 | (6,7,11,13,21,22,24) |
| Comforting cognitions | 134 | (2,3,10,12,14,19) |
| General health, Hopkins Symptoms Checklist | GHRS | |
| Social Anxiety | HSCL | (11,21,34,35,36,37,38,41) |
| Depression | HSCL | (15,19,22,30,32,50) |
| Somatic complaints | HSCL | (4,12,27,39,40,42,47,51) |
| Blood pressure | SBP1, DBP1, SBP2, DBP2 | |

* recoded
For multi-item lists, simple unweighted sumscores are used
Bitterscale

Table 4.13b Summary information aircraft noise

| | Question | Mean** | Standard** deviation | Number of subjects |
|---|---|---|---|---|
| Daily hassless | 17 | 20.3 | 5.2 | 914 |
| Coping with stressors, general | | | | |
| Problem oriented behaviour | 18 | 12.9 | 2.5 | 885 |
| Avoidance behaviour (palliatives) | 18 | 9.7 | 2.3 | 884 |
| Comforting cognitions | 18 | 12.7 | 2.3 | 886 |
| Admission psychiatric hospital yes/no | 76 | yes = 19 | | 889 |
| Psychotherapy yes/no | 79 | yes = 21 | | 888 |
| Respiratory insufficiency | | | | |
| asthma yes/no | 81 | yes = 30 | | 888 |
| hoarseness | 85 | yes = 69 | | 880 |
| Gastrointestinal disorder, ulcer | 83 | yes = 22 | | 888 |
| Number of days ill | 87 | 10.2 | 22.7 | 889 |
| Number of visits to General Practitioner | 89 | 2.5 | 4.6 | 889 |
| Birth | | | | |
| miscarriage yes/no; number of | 92 | yes = 66 | | 658 |
| length of pregnancy, normal, late early | 94 | | | |
| birth weight,normal, high, low | 95 | | | |
| Sleep disturbance | 106* | 21.8 | 2.0 | 884 |
| Sleeping pills, frequency of use | 107* | 1.1 | 0.4 | 885 |
| Earplugs, use during night | 108 | 1.1 | 0.3 | 885 |
| Perception of military aircraft noise | 125 | 10.7 | 4.3 | 834 |
| Stress | 126 | 13.1 | 4.7 | 837 |
| Annoyance, general | 127 | 3.1 | 1.3 | 838 |
| Perceived noise control | 130 | 4.8 | 1.0 | 836 |
| Disturbance of activities, intensity | 131C | 20.4 | 9.6 | 742 |
| Coping with environmental noise | | | | |
| Problem oriented behaviour | 134 | 15.8 | 8.5 | 880 |
| Avoidance behaviour (palliatives) | 134 | 11.4 | 4.2 | 882 |
| Comforting cognitions | 134 | 18.8 | 5.2 | 881 |
| General health, Hopkins Symptoms Checklist | GHRS | 36.4 | 25.0 | 955 |
| Social Anxiety | HSCL | 11.3 | 3.2 | 860 |
| Depression | HSCL | 7.2 | 1.8 | 859 |
| Somatic complaints | HSCL | 10.4 | 2.7 | 842 |
| Blood pressure | SBP1 | 130.6 | 17.0 | 443 |
| | DBP1 | 78.1 | 10.9 | 443 |
| | SBP2 | 125.1 | 15.3 | 442 |
| | DBP2 | 77.2 | 9.9 | 442 |

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* recoded

** All figures are recorded

Bitterscale

Table 4.13c Summary information road traffic noise

| | Question | Mean | Standard deviation | Number of subjects |
|---|---|---|---|---|
| Daily hassless | 17 | 21.5 | 5.7 | 1091 |
| Coping with stressors, general | | | | |
| Problem oriented behaviour | 18 | 13.1 | 2.5 | 1035 |
| Avoidance behaviour (palliatives) | 18 | 10.0 | 2.3 | 1034 |
| Comforting cognitions | 18 | 12.6 | 2.3 | 1036 |
| Admission psychiatric hospital yes/no | 76 | yes = 36 | | 1039 |
| Psychotherapy yes/no | 79 | yes = 39 | | 1037 |
| Respiratory insufficiency | | | | |
| asthma yes/no | 81 | yes = 43 | | 1034 |
| hoarseness yes/no | 85 | yes = 125 | | 1040 |
| Gastrointestinal disorder, ulcer yes/no | 83 | yes = 32 | | 1038 |
| Number of days ill (0 to 99 or more) | 87 | 15.1 | 26.8 | 1040 |
| Number of visits to General Practitioner | 89 | 2.6 | 4.2 | 1040 |
| Birth | | | | |
| miscarriage yes/no; number of | 92 | yes = 34 | | 708 |
| Sleep disturbance | 106* | 21.3 | 2.3 | 1034 |
| Sleeping pills, frequency of use | 107* | 1.1 | 0.5 | 1040 |
| Earplugs, use during night | 108 | 1.1 | 0.4 | 1040 |
| Perception of road traffic noise | 119 | 14.5 | 4.7 | 813 |
| Perception of military aircraft noise | 125 | | | |
| Stress | 120 | 11.1 | 4.4 | 813 |
| Annoyance, general | 121 | 2.4 | 1.2 | 816 |
| Perceived noise control | 123 | 4.4 | 0.8 | 808 |
| Disturbance of activities, intensity | 131B | 13.6 | 5.9 | 579 |
| Coping with environmental noise | | | | |
| Problem oriented behaviour | 134 | 17.2 | 8.5 | 1033 |
| Avoidance behaviour (palliatives) | 134 | 12.2 | 4.8 | 1034 |
| Comforting cognitions | 134 | 18.1 | 5.1 | 1033 |
| General health, Hopkins Symptoms Checklist | GHRS | 36.4 | 25.0 | 955 |
| Social Anxiety | HSCL | 11.5 | 3.5 | 1015 |
| Depression | HSCL | 7.7 | 2.3 | 1010 |
| Somatic complaints | HSCL | 10.6 | 3.0 | 971 |
| Blood pressure | SBP1 | 124.7 | 15.6 | 413 |
| | DBP1 | 75.9 | 10.9 | 413 |
| | SBP2 | 119.5 | 13.8 | 410 |
| | DBP2 | 74.4 | 10.6 | 410 |

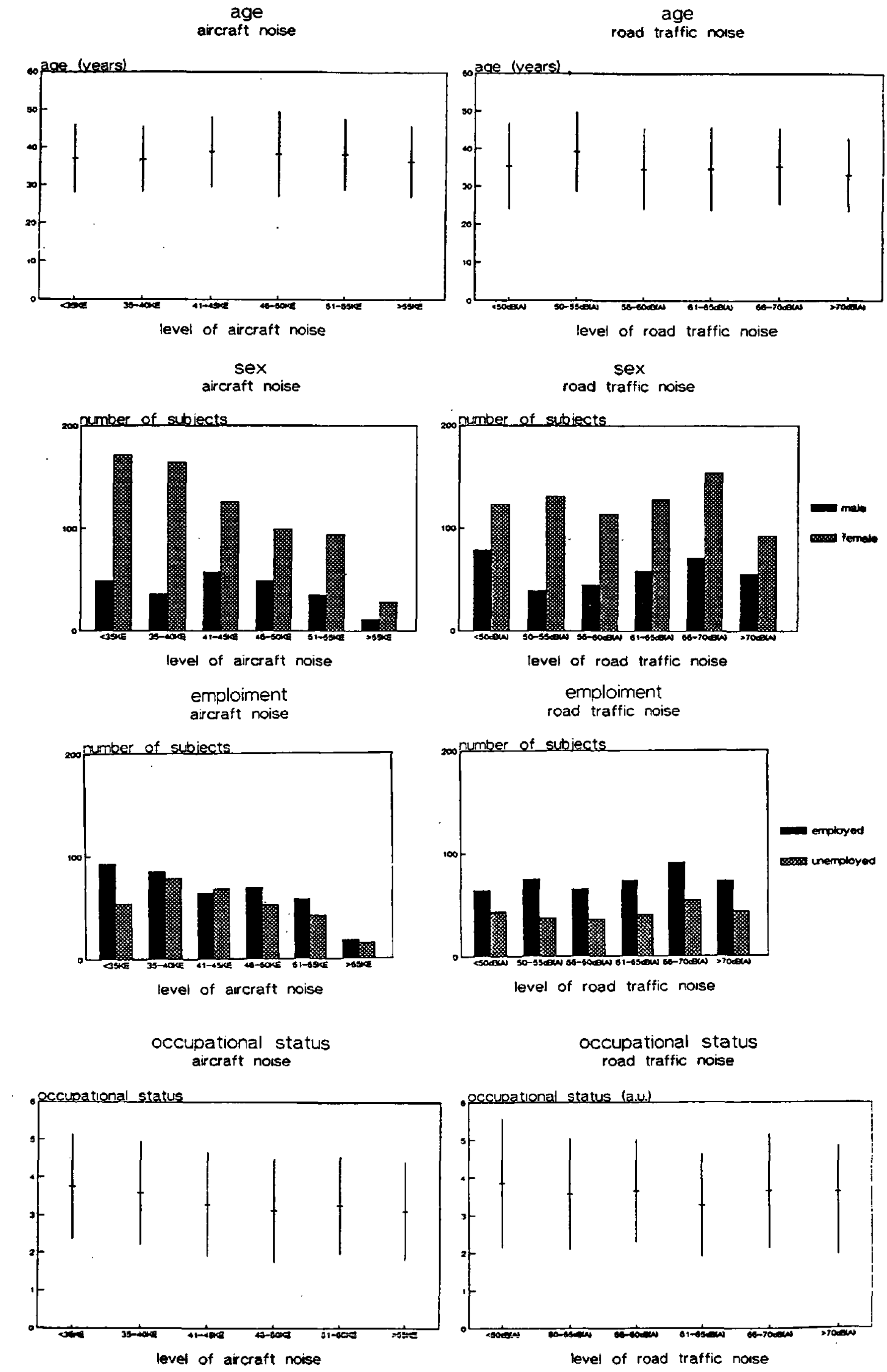
* recoded

Bitterscale

### 4.5.2 Distributions of demographic variables

Age, sex, (un)employment and occupational status should be distributed equally over levels of environmental noise (see Figure 4.2).
In order to test this assumption an analysis of variance was conducted using level of noise as the independent variable and age and occupational status as dependent variables. In case of the dichotomous variables sex and unemployment, the chiquare test was used.
Statistical tests reveal significant relationships between level of aircraft noise and sex (chi-square = 15.27, df = 5, p = .0093), and occupational status (F = 3.88, df = 5, p = .002, explained variance .030); no significant relationships are found between level of aircraft noise, (un)employment, and age. Level of road traffic noise is significantly related with age (F = 6.14, df = 5, p = .000, explained variance .027) and sex (chi-square = 14.25, df = 5, p = 0.141); no significant relationships are found with (un)employment and occupational status. Inspection of the chi-square tables does not reveal a systematic relationship between level of noise and demographic variables. Inspection of the F-tables suggests negative linear correlation between level of aircraft noise and occupational status (r = -.16, n = 632, p = .001). The correlation between level of road traffic noise and age is - .09 (n = 1096, p = .001).

It can be concluded that some contaminations occur between level of environmental noise and demographic variables.



Figuur 4.2 Distributions of age, sex, employment and occupational status over levels of aircraft and road traffic noise

Age is a variable relevant to the definition of the theoretical population. The distribution of age groups for aircraft and road traffic is presented in Table 4.14.

Table 4.14 Source of noise and distribution of age groups

| | Aircraft | | Road traffic | |
|---|---|---|---|---|
| Age | n | % | n | % |
| ± 20 | 21 | 2 | 49 | 05 |
| 21 - 25 | 78 | 9 | 191 | 18 |
| 25 - 30 | 126 | 14 | 198 | 18 |
| 30 - 35 | 161 | 18 | 157 | 15 |
| 36 - 40 | 187 | 21 | 151 | 14 |
| 41 - 45 | 133 | 15 | 112 | 10 |
| 46 - 50 | 95 | 10 | 101 | 9 |
| 51 - 55 | 110 | 12 | 122 | 11 |
| Total | 911 | 100% | 1,081 | 100% |

The theoretical population is not restricted to man or woman, but the selection resulted in a skewed distribution. Considerably more women than men are interviewed. See Table 4.15. In the road traffic sample the ratio male/ female is .47; in the aircraft sample the ratio is .35. The national ratio lies between .48 and .52 (CBS, 1986). This is primarily the result of the purpose to select only those subjects who are regularly at home (i.e. exposed to the environmental noise).

Table 4.15 Source of noise and distribution of sexe

| | Aircraft | | Road traffic | |
|---|---|---|---|---|
| | n | % | n | % |
| Man | 238 | | 351 | |
| Woman | | 682 | | 745 |
| N | 920 | | 1096 | |

Due to the fact that interviews were primarily held in the day time it is possible, that an a-typical group has been included, such as shift workers, chronically ill, and unemployed people especially in the male part of the sample. When these people live in the higher exposed areas this might lead to an overestimation of the effect on noise on health. In order to rule out this possibility some features were studies for men and women separate.

Table 4.16 Specific features of the male sample

| | Airtraffic | | Road Traffic | |
|---|---|---|---|---|
| employment | | | | |
| 1. Yes | 139 | 59% | 152 | 45% |
| 2. No | 95 | 41% | 187 | 55% |
| no because of: | | | | |
| 1. illnes | 35 | 15% | 41 | 12% |
| 2. unemployed | 32 | 14% | 37 | 11% |
| 3. stopped | 4 | 2% | 9 | 3% |
| 4. other | 7 | 3% | 6 | 2% |
| 5. studies | 17 | 7% | 94 | 28% |
| shiftwork: | | | | |
| 1. Yes | 68 | 30% | 82 | 24% |
| 2. No | 145 | 62% | 152 | 45% |
| Total | 234 | | 339 | |

* the % are given of the total sample

Of the women in the total sample 38% is employed and 62% is unemployed due to family (51%), illness (4%), unemployed (4%) and other reasons (3%). When we compare these findings with those of the men, we see a considerably higher number of men who are unemployed or ill (see Table 4.16). Also the percentage of shiftworkers is rather high. Concluding we can state that the male part of the sample is a-typical for a normal male population. However we can also state, that the group is representative for people who are at home in the day time. Still we are dealing with a selection effect, which puts limits to the generalization of our findings. Fortunately these work situation features are not confounded with noise class.

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# 5. ENVIRONMENTAL NOISE AND MIGRATION *

M.P.J. Pulles, J.V. Lako and K. Altena

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* This chapter is primarily based upon the results described by Lako (1987). Some additional analyses have been performed.

## 5.1 Introduction

In the previous chapters the theoretical framework of the research project and the methods used were described, including documentation regarding factors which may contaminate the sample data. This chapter deals with the problem of migration: is the wish to migrate out of the area under study related to the level of exposure to environmental noise? Which factors are important in this regard?
The analyses will provide information on the possible existence of a bias in our sample: people who react to noise exposure or noise annoyance by out migration may be less present in the sample at higher noise levels than at lower noise levels.

Migration is the change in usual place of residence. Migration rate refers to a rate which reflects the relative frequency of migration within a population (Multilingual Demographic Dictionary, 1982). In the area of research on noise and health, not much is known about the possible influence of noise induced migration. If exposition to noise changes the structure of the population, in other words, when in areas exposed to high levels of noise more people move in or out, then the assumption that the level of noise and the duration of the exposition to this noise are independent upon each other is invalid. This has two related consequences:

a. apart from annoyance and health effects, noise will have sociogeographic effects, and
b. the population from which the samples are drawn, is a 'survivor population'.

The goal of the analyses therefore is twofold:

a. to establish a relation between environmental noise exposure and (wish to) migrate out of the area;
b. to detect possible contaminations in the sample by the effect of selective migration.

The migration model of Speare (1974) serves as a guide to the analyses.
Section 5.2 will summarize the relevant literature. In section 5.3 the research problem of this chapter is formulated. In section 5.4 migration specific data and methods are described in further detail. Section 5.5

entails the body of the chapter presenting the results obtained. Section 5.6 finally will summarize the conclusions and discuss the results.
The present chapter is based upon a study performed by Lako and reported earlier (Lako, 1987).

## 5.2 Environmental stressors and migration. Survey of the literature

In summarizing evidence concerning the relationship between noise and migration, we distinguish between push factors, driving the person away from a city, neighbourhood, or dwelling, and pull factors, attracting the person towards a location. Residential (dis)satisfaction is generally considered as a push factor. Clark and Cadwallader (1973) even use the term "locational stress". Speare (1974) sees migration as a response to stress. He prefers however to speak of dissatisfaction, rather than stress, to avoid the notion of mental tension. In his model of migration the decision to migrate is the result of a decision-making process and relative satisfaction with residential location plays a central role. Once the threshold for dissatisfaction has been passed, a person considers moving and will search for alternatives. Residential satisfaction is assumed to depend on characteristics and aspirations of the household, characteristics of the location, and "social bonds" between household members and other people. Only those who are dissatisfied carry out a cost-benefit analysis and decide whether or not to become movers. Empirical data of Speare (1974) and Bach and Smith (1977) support Speare's model. Bach and Smith also report an interaction between residential satisfaction and wish to move.

### 5.2.1 Environmental stress and migration

Clark and Cadwallader (1973) report relationships between air pollution and quality of residence, social structure of the neighbourhood and proximity to friends. In this study the relationship between annoyance with air pollution and considering the possibility to move is relatively weak but nevertheless significant.

Openbaar Lichaam Rijnmond (1976) reports a correlation between air pollution and wish to move. It is suggested that the appraisal of the neighbourhood is independent from the appraisal of air pollution.

Bozzo and coworkers (1979) studied the effects of air pollution and income on human mortality in the context of a demographic model (Population Dynamic Model). All counties in the U.S. were aggregated into 192 groups based on 17 levels of income and 21 levels of pollution emissions/sq. miles. The results (only analyzed for the white population) indicate that income correlates positively with in-migration and negatively with out-migration. Air pollution correlates negatively with in-migration and positively with out-migration. The results apply to both white males and white females. The authors conclude that "... pollution has a positive effect on out-migration which is twice as strong as the income effect. These results are consistent with the recent pattern of nonmetropolitan growth produced by net out-migration from center cities" (p. 98). This last observation implies that factors other than pollution but associated with nonmetropolitan area's might explain the data.

Bronner, Schreurs and Slootman (1981) report a positive correlation between physical measures of and annoyance with air pollution; they report also a positive correlation between annoyance with air pollution and dissatisfaction with the neighbourhood.

Openbaar Lichaam Rijnmond (1976) reports a negative correlation between annoyance with road traffic noise and residential satisfaction. A research project of the "Laboratorium voor Akoestiek en Warmtegeleiding" (1977) reports a relationship between $LA_{eq}$ and residential satisfaction. But the wording of the questions in the questionnaire with respect to satisfaction is not independent from the suggested cause: road traffic. Lansing (1980) reports a negative correlation between level of noise (neighbourhood characteristics being characterized by the subjects themselves as varying between noisy and quiet) and satisfaction with neighbourhood. The characterization of noise however is not unequivocal as to the source: noise may include residential noise.

### 5.2.2 Noise and intentions to move

Openbaar Lichaam Rijnmond (1976) reports a positive correlation between noise annoyance and wish to move.

Hitchcock and Waterhouse (1979) analyze the relationship between disturbance by noise and plans to move. Moving plans of the apartment tenants in the study ("Do you have any plans to move when your lease is up?", p. 257) are considered as a rough indicator of relative satisfaction with the residential environment. The results of the study demonstrate a consistent relationship between disturbance by noise and moving intentions. But for "screened faces" (residences, located on the blind side of the apartment buildings, not facing the road), no consistent relationship between noise disturbance and moving intentions was found. There is no indication that the level of rents charged provides compensation for adverse environmental influences. However, Hitchcock and Waterhouse find a stronger relationship between noise disturbance and moving intentions in low-rent buildings than in high-rent ones for those tenants living alongside unscreened building faces. For tenants living on the screened side of the buildings the relationship between noise disturbance and moving intentions is less clear. Use of the expressway also plays a role in noise disturbance. Those who do use the expressway are less likely to report disturbance from noise than those who do not use it. The authors conclude that there has been a self-selection process whereby expressway users have located themselves close to the expressway, but Hitchcock and Waterhouse also conclude: "... apparently some expressway users have made apartment decisions without considering the noise hazard or the real accessibility which their choice of location provides" (p. 261).

Baldassare, Knight, and Swan (1979) asked the question: "...will people prefer to live close to (...) an urban service for the sake of travel convenience, or will people voluntarily relocate in order to avoid its adverse environmental impacts ?" (p. 435). The authors refer to the Bay Area Rapid Transit System in the San Francisco metropolitan area. They examine the impact of three separate environmental conditions: stations, aerial lines (i.e., elevated tracks), and at-grade lines (i.e., ground-level tracks). For each type of site the cost-benefit pattern differs with respect to factors as accessibility to the transit system, emission of noise, level of background noise, daytime parking, and facing the aerial structure. Reported reasons for out-migration are negatively related to accessibility to the transit system, and positively related to environmental costs. Reported reasons for in-migration are positively related to accessibility.

Lambert et al. (1983) conclude that above the level of 66-68 dB(A) noise can be an impetus to move.

Schollaart (1986) reports that noise annoyance seldomly is mentioned as a motive to move. On the other hand, of those who wanted to move more were annoyed as compared to those who planned to stay.

### 5.2.3 Noise and actual migration

With respect to noise and actual migration, not much empirical research is carried out. Arvidson et al. (1965) surveyed residents in an Swedish city. Compared to a quiet district, traffic noise was twice as often cited as annoying. Traffic density and noise, however,did not seem important enough to justify moving. Finsterbusch (1980) concludes: "... noise is not an important cause of moving in the general population. The reason is twofold. First, only a small percentage of the population lives in environments with noise levels high enough to induce moving. Second, even residents of noisy neighbourhoods will not move only because of the noise" (p. 216).

Brinton and Bloom (1969) find high turnover rates and rent concessions made to tenants living in units next to the highway.

Clary (1974) analyzes the relationship between demographic structure and aircraft noise in the Los Angeles International Airport area. High noise areas are characterized by relatively lower incomes, higher unemployment and vacancy rates, a larger percentage of minority residents (except Blacks) and great residential turnover.

In reviewing research on community attitudes and action in response to airport noise, Goodman and Clary (1976) suggest that depreciation of the market value of residential property (resulting in reduction of the level of public pressure, and increase of flight patterns over poorer neighbourhoods) can intensify or reinforce a pattern of demographic transition already evident.

Evans and Tafalla (1986) conclude: "Areas of high noise impact or high air pollution tend to be occupied by low socioeconomic groups. Fidell (1984) for example, postulated that a doubling of income is associated with a reduction of 15 decibels in noise. Moreover, individuals exposed to one negative environmental condition such as noise tend to also be exposed to other problems, including air pollution, crime, poor schools, and substandard housing..." (pp. 17,18).

Lengkeek (1975) concludes that in areas with a considerable amount of aircraft noise (45-55 KE) but a few or no real indications at all are found of a relationship between noise annoyance and migration. In one area (Amstelveen) he finds in the high noise exposure area for single-family houses a higher turnover rate compared to the low noise exposure area. But Lengkeek concludes that the relationship between annoyance and turnover rate remains unclear until more knowledge is available on characteristics of residents and dwellings. In another area (Zwanenburg) outmigration increases after an increase in aircraft noise. But this trend could also be explained by a reduction in the number of newly built houses.

Lako (1987) analyses the relationship between road traffic noise and migration in a sample of 3.000 dwelling units; the sample was divided in a high exposure area (exposure levels higher than 65 dB(A)) and a low exposure area (noise levels below 55dB(A)). Dwellings exposed to a high level of noise are about 20% larger in size compared to dwellings exposed to lower levels. The size of the family is also greater but the households have nevertheless more space available in the high noise area. Vacancy in high noise areas is more frequent and of longer duration. No general relationship is found between exposure to noise and out-migration. A subdivision according to socieconomic status of the dwelling units revealed a higher out-migration in high noise areas for dwellings with a higher status (as indicated by real estate tax classes). The reverse was true for dwellings with a lower status; these classes are characterized by a lower out-migration especially in the case of larger families. This suggests a stagnation for low socioeconomic groups under adverse environmental conditions. The author concludes that a selection process may operate in the population, due to environmental noise. A change in population might be expected in the direction of a lower socioeconomic position. The effect may be compensated by an opposite effect due to the larger averaged size of the noise exposed homes compared to the quiet ones in this sample.

## 5.3 Research problem

As has been stated in the previous paragraph, the model of Speare describes migration as taking place after a wish to move has been developed. This wish to move is a result of a low residential satisfaction, a taxation process. In this model residential satisfaction is determined by a number of individual and socio-economic characteristics.

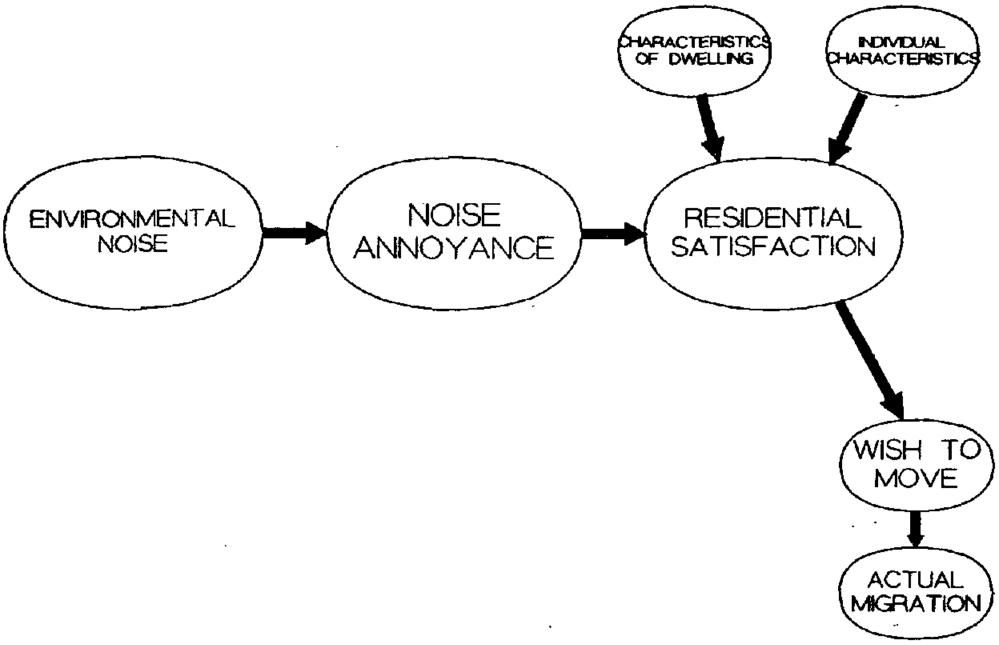


Figure 5.1 Schematic representation of the model of Speare to which environmental noise is added as a factor influencing *residential satisfaction*

We added to these predictors the concept of noise, which either directly or indirectly via noise annoyance influences the residential satisfaction. In the first case we have a model of the individual differences type (cf. figure 3.2). In the second case we have a model incorporating psychosocial constructs (cf. figure 3.3). The latter model applied to the migration problem is depicted in figure 5.1.

So, in accordance with chapter 3, several classes of structural models will be used in the analyses: a simple dose effect model (section 5.5.1), individual differences model (section 5.5.2) and a model incorporating psychosocial constructs (section 5.5.3). The related measuring instruments are described in section 5.4.

## 5.4 Materials and methods

### 5.4.1 Specific characteristics of the sample

*In addition to the description of the sample, as given in chapter 4,* some additional data are relevant in this chapter. A detailed description can be found in Lako (1987). Here we present these data in figure 5.2.

The following observations are made:

a. In the aircraft noise sample a larger part of the dwellings is owned by the respondent, whereas in the road traffic noise sample a large majority of the dwellings is rented by the respondent.
b. In both samples a large majority of the dwellings is not insulated against noise.

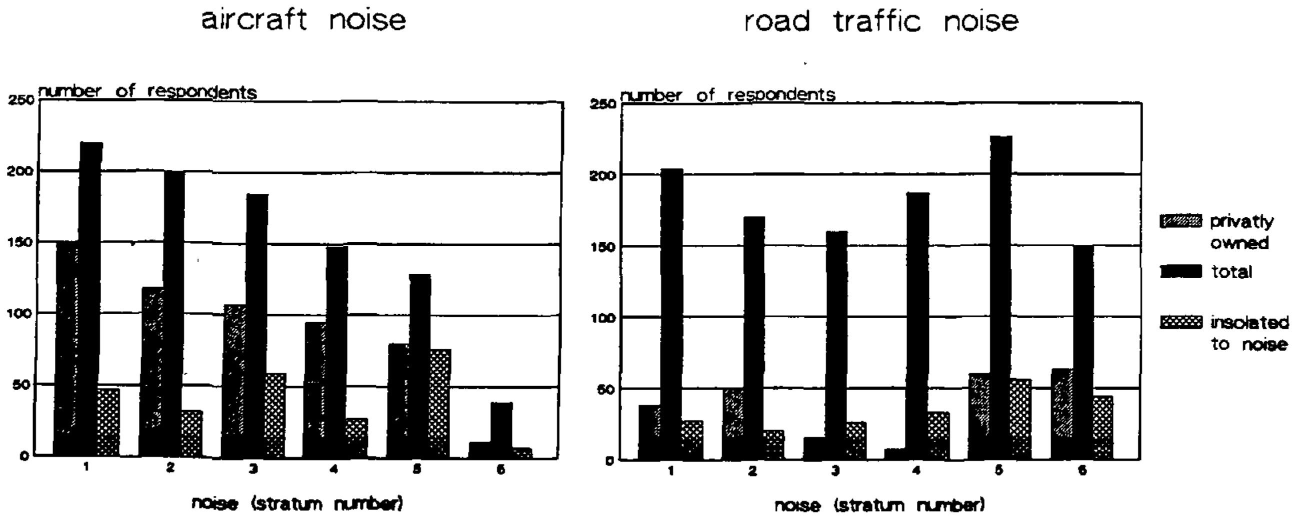


Figure 5.2 Bar diagrams of privatly owened vs. rented houses and number of noise insulated dwellings in the sample of aircraft noise (left) and road traffic noise (right), both as a function of noise stratum number

### 5.4.2 Measurings instruments

As we have seen in chapter 2, a structural model as presented in figure 5.1 has to be supplemented with a number of measuring models to enable its use in interpreting the results. In other words: we have to select variables meant to estimate actual values of the constructs involved. In this section we describe these variables. An overview is given in Table 5.1. *A detailed description is presented in Lako (1987).*

Calculated noise levels in dB(A) (road traffic noise) and KE (aircraft noise) were used as described in chapter 4. This noise level will be called stratum number. As was indicated in section 2.4.3, constructs can be measured by more than one variable. As a second (more subjective) measure of noise level a 8-item scale (Van Kamp, 1986) was used. This level is denoted as perceived loudness.

Noise annoyance is measured in two ways:

a. A 1-item, five point scale is used, ranging from 'no annoyance at all' to 'very much annoyance'. The questionnaire used this scale 3 times for road traffic noise, aircraft noise and noise caused by neighbours respectively. This scale is called annoyance(1). It should be noted that this scale is different for the different noise sources.
b. A second scale is constructed using 6 out of 7 items of a disturbance scale developped by Bitter and Schwager (1964); see Van Kamp (1986) for details. We denote this scale by annoyance(6).

Residential satisfaction is also measured using two scales:

a. A satisfaction(1): a five point scale ranging from 'not satisfied at all with my dwelling' to 'very much satisfied with my dwelling'.
b. A satisfaction(9) in which a number of components of the (residential) environment are evaluated (Flowerdew, 1973). This scale is adapted from De Jong and Beurs (1978) and validated by Van Kamp (1986). Each item consists of a statement on which the respondent indicates his or her agreement on a five point scale, varying from 'totally agree' to 'totally disagree'.

Table 5.1 Scale properties of migration relevant variables (see chapter 4 and also Van Kamp, 1986, and Lako, 1987)

| Variable | Number of items | Scale quality (Cronbach's) | N (aircraft/ road traffic) |
|---|---|---|---|
| NOISE LEVEL | | | |
| . stratum number | 1 | n.a.* | |
| . perceived loudness | 8 | 0.80 | ./. ** |
| NOISE ANNOYANCE | | | |
| . annoyance(6) | 6 | 0.75 | 877/994 |
| . annoyance(1) | 1 | n.a. | |
| RESIDENTIAL SATISFACTION | | | |
| . satisfaction(9) | 9 | 0.75 | 1972 |
| . satisfaction(1) | 1 | n.a. | |
| WISH TO MOVE | | | |
| . wish to move | 1 | n.a. | |

* n.a.: not applicable

** The perceived loudness scale yields higher values at lower perceived loudness levels

The wish to move is measured by asking the question (translated): 'Do you want to stay living here for the time being or do you seriously consider moving, whenever the possibility is present?'. Three answers were possible: "I wish to stay here", "I wish to move" or "I wish to move but I do not see a possibility".

In the analyses the scale is made dichotomous by combining the last two answers to "I wish to move". Subjects expressing their wish to move were asked to mention the most important reason.

In this study we were not able to measure the actual migration.

Frequency distributions of some of the variables used in this part of the study are presented in figure 5.3. Frequency distributions of the other background variables and of the noise annoyance scales are presented in chapter 4.

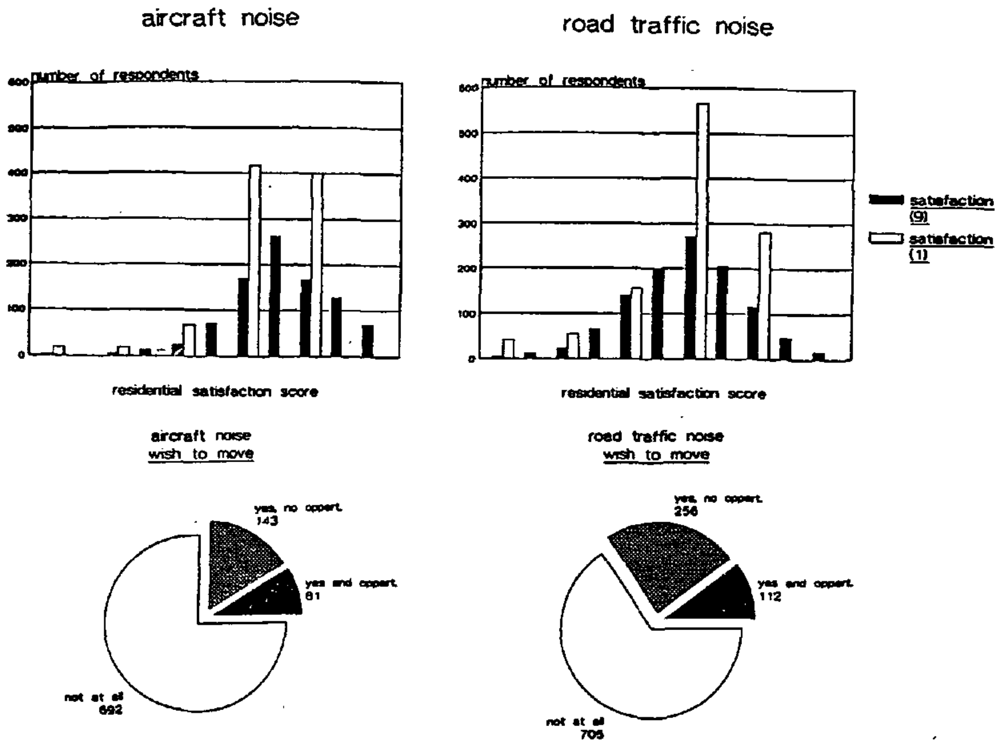


Figure 5.3 Frequency distributions of <u>residential satisfaction</u> (both scales, above) and <u>wish to move</u> (below) within the sample of aircraft noise (left) and road traffic noise (right)

Table 5.2 T-tests on differences in migration variables between the road traffic and aircraft noise sample (program BMDP3D)

| Variable | road traffic mean | N | aircraft noise mean | N | T-stat. separated | p-value 2-sided |
|---|---|---|---|---|---|---|
| Noise level | | | | | | |
| . *stratum number* | 3.47 | 1097 | 2.87 | 921 | n.a.* | |
| . perceived loudness | 14.5 | 853 | 10.8 | 864 | n.a.* | |
| Noise annoyance | | | | | | |
| . annoyance(6) | 9.3 | 995 | 7.7 | 881 | 17.62 | 0.0000 |
| . annoyance(1) | | | | | n.a. | |
| Residential satisfaction | | | | | | |
| . satisfaction(9) | 10.8 | 1099 | 12.1 | 921 | -17.38 | 0.0000 |
| . satisfaction(1) | 3.9 | 1099 | 4.3 | 921 | -8.94 | 0.0000 |
| Wish to move | ** | 1093 | | 916 | 4.27 | 0.0000 |

* Not applicable since questions were different in both samples
** Dichotomous variable

In Table 5.2 T-tests on the differences of the relevant variables in both samples are presented. We conclude that differences between both samples are present in every variable relevant in this chapter. This of course hampers comparison of the results obtained in both samples seperately.

### 5.4.3 Summary of the migration model used

In figure 5.4 a summary of the complete model, consisting of the (most complicated) structural model of figure 5.1 and the measuring models, is given. Environmental noise, residential satisfaction and noise annoyance are measured by two variables (cf. section 2.4.3).

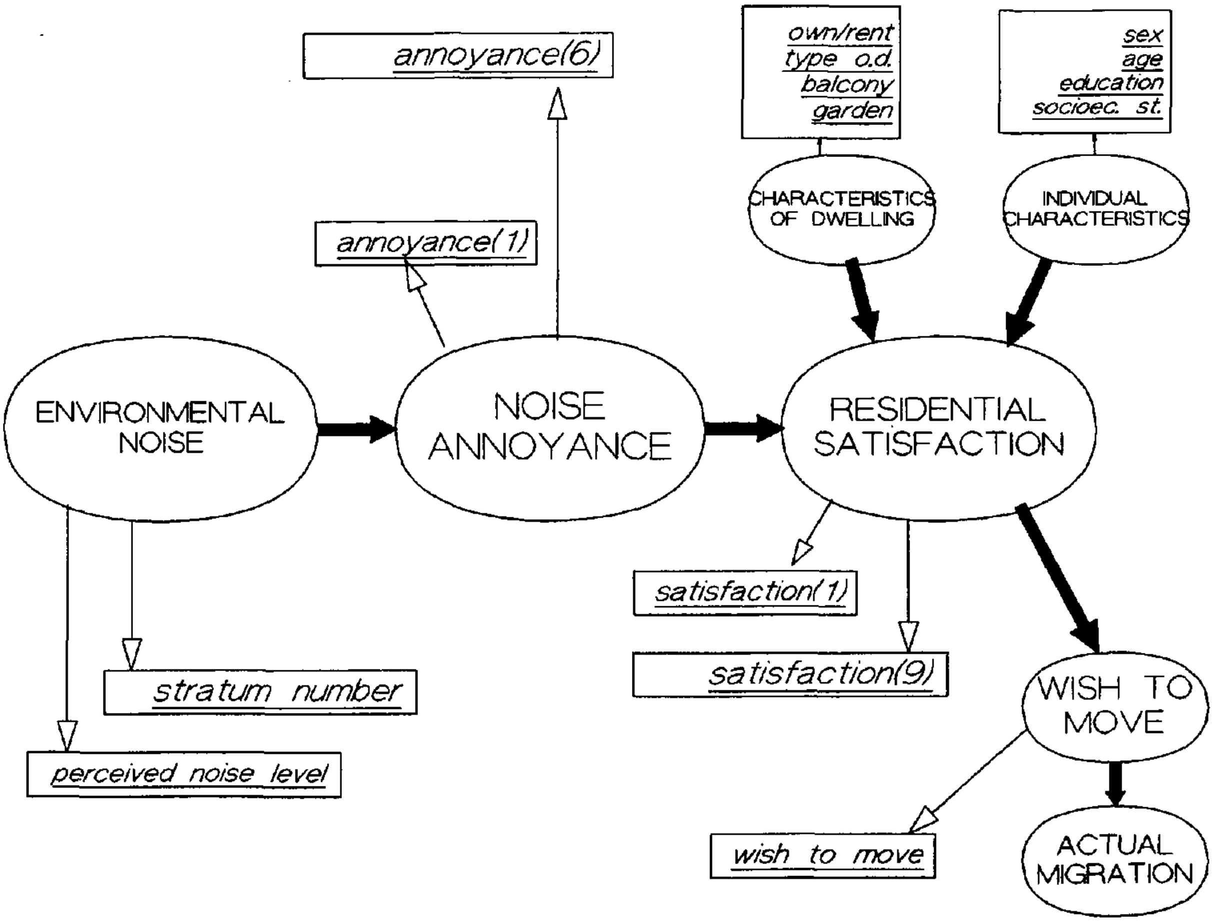


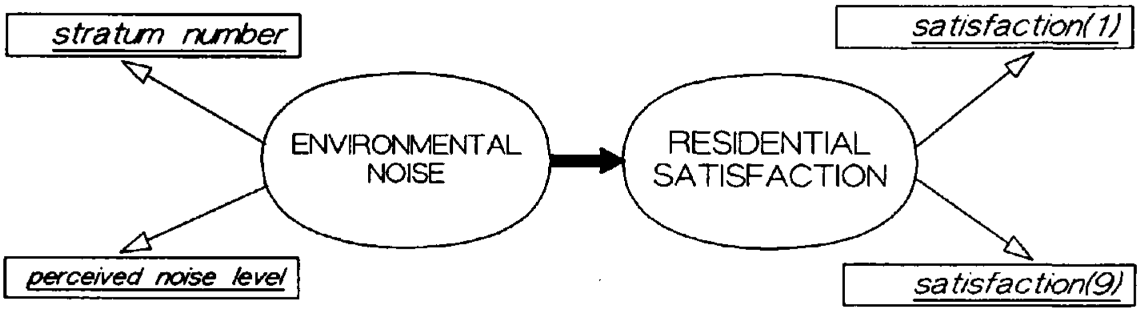
Figure 5.4 Complete model used to analyse the migration data. The LISREL convention is used. Constructs are indicated by ovals, measured variables by boxes

Table 5.3 Linear regresssions between both variables measuring environmental noise, noise annoyance and residential satisfaction respectively; calculations were performed using BMDP1R

| Construct | aircraft noise | | road traffic noise | |
|---|---|---|---|---|
| | $r^2$ | N | $r^2$ | N |
| ENVIRONMENTAL NOISE | 0.025 | 1000 | 0.064 | 1100 |
| NOISE ANNOYANCE | 0.407 | 881 | 0.421 | 995 |
| RESIDENTAL SATISFACTION | 0.326 | 919 | 0.238 | 1099 |

Correlations between the three pairs of variables, measuring the same constructs, are given in table 5.3. We conclude that, apart from the environmental noise variables, there is a reasonable covariance between each pair of variables. Weak correlations between objective and subjective noise levels are frequently observed.

Table 5.4 Linear regressions between noise level as independent and residential satisfaction as dependent variables. All correlations are significant at the 0.05 level. The analysis model used in this table is schematically indicated; calculations are performed using BMDP1R



| | aircraft noise | | | | road traffic noise | | | |
|---|---|---|---|---|---|---|---|---|
| | RESIDENTIAL SATISFACTION | | | | RESIDENTIAL SATISFACTION | | | |
| | satisf.(1) | | satisf.(9) | | satisf.(1) | | satisf.(9) | |
| | $r^2$ | N | $r^2$ | N | $r^2$ | N | $r^2$ | N |
| NOISE LEVEL | | | | | | | | |
| stratum number | 0.009 | 919 | 0.006 | 919 | 0.013 | 1099 | 0.011 | 1099 |
| perc. loudness | 0.012 | 864 | 0.019 | 863 | 0.034 | 852 | 0.063 | 853 |

## 5.5 Results

### 5.5.1 Dose-effect approach

We first present results on the direct relationship between the NOISE LEVEL and RESIDENTIAL SATISFACTION and WISH TO MOVE respectively. It should be noted, that the wish to move is a dichotomous variable. We therefore use different analysis techniques for this variable.

Table 5.4 shows the results of the analyses, using the simple dose effect approach. We conclude that no more than about 1% of the variance of the residential satisfaction can be explained by the level of environmental noise.

As can be seen from table 5.4, the level of noise as measured in this study, can not explain more than a few percent of the variance in both the residential satisfaction as measured by the 9-item scale and the 1-item residential satisfaction scale. We conclude that, although the effects of environmental noise on the residential satisfaction are significant, these effects are very small. The effects are somewhat larger in the road traffic sample. The largest effect is observed when perceived loudness is used as the predictor and annoyance (9) is used to measure the effect. Possibly this is partly a statistical artefact, induced by the specific interpretation of the loudness scale.

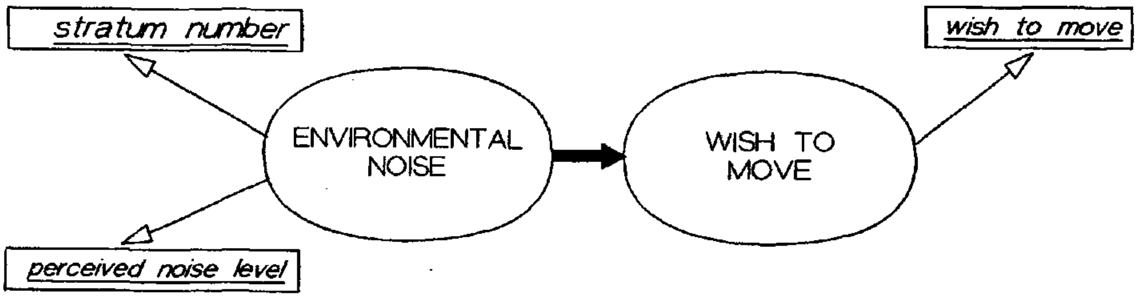
Table 5.5 presents the direct relation between RESIDENTIAL SATISFACTION and WISH TO MOVE, which are, according to Speare (1974), directly dependent upon each other.
Also presented are the results of T-tests on the difference in noise exposure level between people who indicated that they wish to move and people who indicated that they did not wish to move. In this analysis, the wish to move is assumed to be the direct effect of the environmental noise, either measured as the noise stratum number or as the perceived noise level.

From this table we may conclude that:

a) People who indicate that they wish to move from their present dwelling have indeed a significantly lower residential satisfaction, measured by both variables. This is in agreement with the model of Speare.

b) People who indicate that they wish to move from their present dwelling live at significantly higher noise levels measured as perceived loudness. The differences however are very small. The differences in noise stratum number are not significant.

Table 5.5 T-statistics of difference between people who wish and people who wish no to move. The analysis model used in this table is schematically indicated. Calculations are performed using BMDP3D



| | aircraft noise<br>WISH TO MOVE<br>means yes | <br><br>means no | <br><br>T | <br><br>p* | road traffic noise<br>WISH TO MOVE<br>means yes | <br><br>means no | <br><br>T | <br><br>p* |
|---|---|---|---|---|---|---|---|---|
| RESIDENTIAL SATISFACTION | | | | | | | | |
| satisfaction(1) | 3.732 | 4.434 | 9.81 | 0.000 | 3.407 | 4.179 | 12.52 | 0.000 |
| satisfaction(9) | 11.16 | 12.47 | 9.51 | 0.000 | 9.95 | 11.29 | 12.28 | 0.000 |
| NOISE LEVEL | | | | | | | | |
| noise stratum | 2.920 | 2.867 | -0.48 | 0.633 | 3.607 | 3.397 | -1.94 | 0.052 |
| peceived loudness** | 9.77 | 11.09 | 4.20 | 0.000 | 13.67 | 15.01 | 3.98 | 0.000 |

* T: T-statistic (separated); p: 2-sided p-value

** The perceived loudness scale yields higher values at lower perceived loudness levels

### 5.5.2 Individual differences approach

In table 5.6 analyses are shown using the individual differences approach. The used model is schematically drawn in figure 5.5. Besides the environmental noise variables also relevant individual differences (Speare, 1974) are introduced. In subsequent steps the calculating algorithm introduces those variable into the multivariate linear equation that adds the most to the square of the multiple correlation coefficient. This coefficient is a measure of the portion of the variance of the dependent variable, which can be explained by the variances of the independent variables introduced into the equation up to the current step.

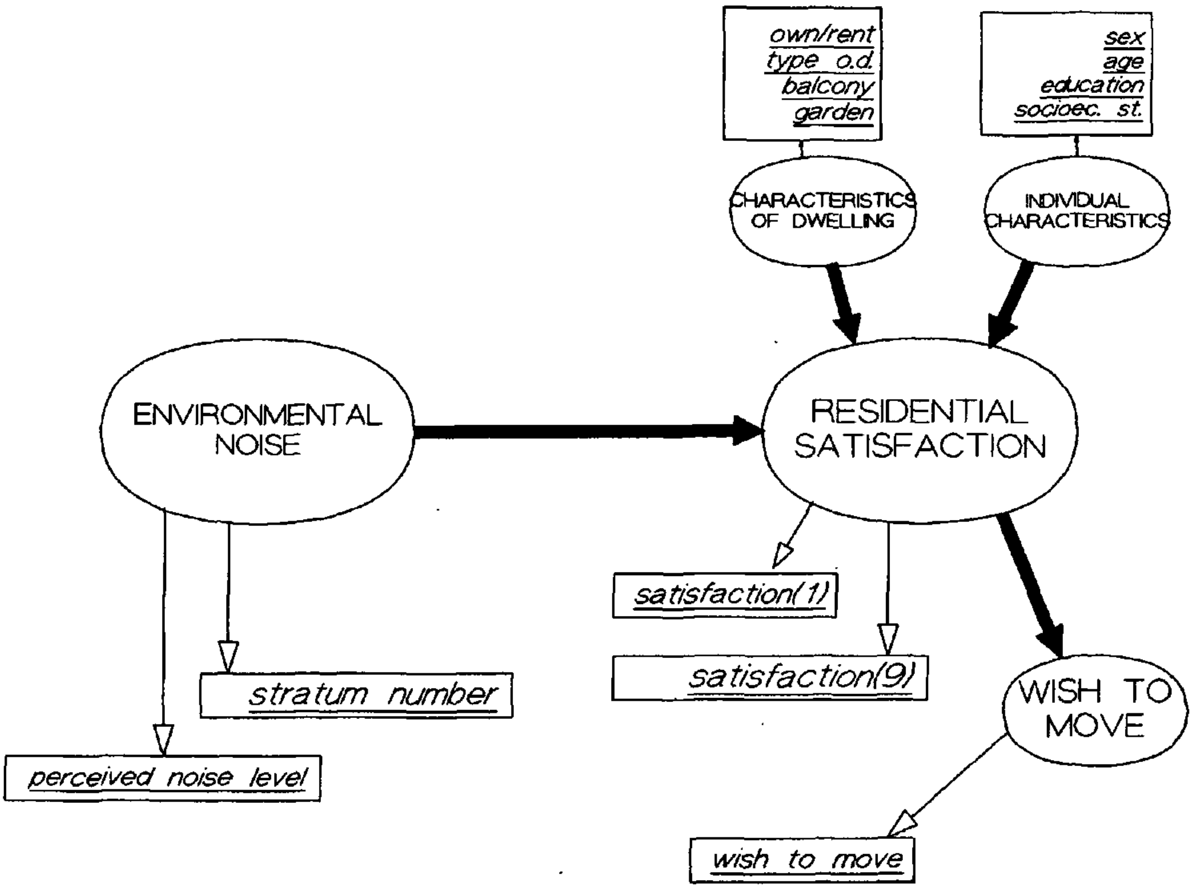


Figure 5.5 Model used in the individual differences approach; the resulting analyses are given in table 5.6

Table 5.6 Stepwise multivariate regression analyses using the individual differences approach. Dependent variable is residential satisfaction, independent variables are noise level, characteristics of the dwelling and individual characterisitics; calculations are performed using BMDP2R

Table 5.6 A: Aircraft noise:

variable analysed

| step no. | variable entered | r | multiple $r^2$ | change in $r^2$ | F to enter |
|---|---|---|---|---|---|
| NOISE LEVEL variable: stratum number | | | | | |
| RESIDENTIAL SATISFACTION variable: satisfaction(9) | | | | | |
| 1 | type of dwelling | 0.362 | 0.131 | 0.131 | 135.4 |
| 2 | presence of garden | 0.394 | 0.155 | 0.024 | 25.9 |
| 3 | ownership of dwelling | 0.416 | 0.173 | 0.018 | 19.2 |
| 4 | age of respondent | 0.437 | 0.191 | 0.018 | 19.7 |
| 5 | stratum number | 0.442 | 0.196 | 0.005 | 5.1 |
| RESIDENTIAL SATISFACTION variable: satisfaction(1) | | | | | |
| 1 | presence of garden | 0.381 | 0.145 | 0.145 | 152.9 |
| 2 | ownership of dwelling | 0.430 | 0.185 | 0.040 | 44.0 |
| 3 | age of respondent | 0.444 | 0.197 | 0.012 | 13.6 |
| 4 | type of dwelling | 0.455 | 0.207 | 0.010 | 10.8 |
| NOISE LEVEL variable: perceived loudness | | | | | |
| RESIDENTIAL SATISFACTION variable: satisfaction(9) | | | | | |
| 1 | type of dwelling | 0.363 | 0.132 | 0.132 | 127.7 |
| 2 | presence of garden | 0.396 | 0.157 | 0.025 | 24.8 |
| 3 | ownership of dwelling | 0.417 | 0.174 | 0.017 | 17.7 |
| 4 | age of respondent | 0.437 | 0.191 | 0.017 | 17.9 |
| 5 | perceived loudness | 0.446 | 0.199 | 0.008 | 8.19 |
| RESIDENTIAL SATISFACTION variable: satisfaction(1) | | | | | |
| 1 | presence of garden | 0.393 | 0.154 | 0.154 | 153.7 |
| 2 | ownership of dwelling | 0.446 | 0.199 | 0.045 | 47.7 |
| 3 | age of respondent | 0.462 | 0.213 | 0.014 | 14.9 |
| 4 | type of dwelling | 0.470 | 0.221 | 0.007 | 7.9 |

Table 5.6 B: road traffic noise:

variable analysed

| step no. | variable entered | r | multiple $r^2$ | change in $r^2$ | F to enter |
|---|---|---|---|---|---|
| NOISE LEVEL variable: stratum number | | | | | |
| RESIDENTIAL SATISFACTION variable: satisfaction(9) | | | | | |
| 1 | presence of garden | 0.258 | 0.067 | 0.067 | 75.6 |
| 2 | ownership of dwelling | 0.327 | 0.107 | 0.041 | 48.3 |
| 3 | education | 0.341 | 0.116 | 0.009 | 10.3 |
| 4 | stratum number | 0.349 | 0.122 | 0.006 | 6.9 |
| RESIDENTIAL SATISFACTION variable: satisfaction(1) | | | | | |
| 1 | presence of garden | 0.164 | 0.027 | 0.027 | 29.3 |
| 2 | stratum number | 0.185 | 0.034 | 0.007 | 8.1 |
| 3 | ownership of dwelling | 0.203 | 0.041 | 0.007 | 7.7 |
| NOISE LEVEL variable: perceived loudness | | | | | |
| RESIDENTIAL SATISFACTION variable: satisfaction(9) | | | | | |
| 1 | perceived loudness | 0.250 | 0.063 | 0.063 | 55.0 |
| 2 | age of respondent | 0.332 | 0.110 | 0.048 | 44.0 |
| 3 | ownership of dwelling | 0.369 | 0.136 | 0.026 | 25.2 |
| 4 | presence of balcony | 0.377 | 0.142 | 0.006 | 5.6 |
| 5 | education | 0.383 | 0.147 | 0.005 | 4.6 |
| RESIDENTIAL SATISFACTION variable: satisfaction(1) | | | | | |
| 1 | perceived loudness | 0.177 | 0.031 | 0.031 | 26.7 |
| 2 | presence of garden | 0.224 | 0.050 | 0.019 | 16.2 |
| 3 | presence of balcony | 0.236 | 0.056 | 0.006 | 5.0 |

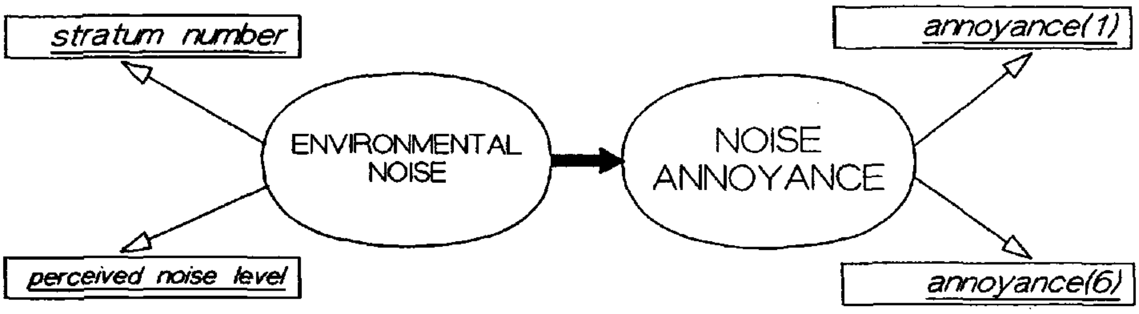
From these analyses we make the following observations:

a) In the aircraft noise sample about 20% of the variance of RESIDENTIAL SATISFACTION, measured by means of both scales, can be explained by the presence of a garden, the type of dwelling, ownership of the dwelling and age of the respondent. The NOISE LEVEL explains less than 1% of the variance of satisfaction(9) and no variance at all in satisfaction(1).

b) In the road traffic sample about 12 to 14% of the variance in satisfaction(9) can be explained by variances of the independent variables. Perceived loudness explains about half of this amount, while the other half is due to age of the respondent and ownership of the dwelling.

The results for satisfaction(1) are comparable, except that the amounts of explained variance are about half as high.

Table 5.7 Linear regressions between noise level and noise annoyance. For details see chapter 7. All correlation are significant at the 0.01 level. The analysis model used in this table is schematically indicated; calculations are performed using BMDP1R



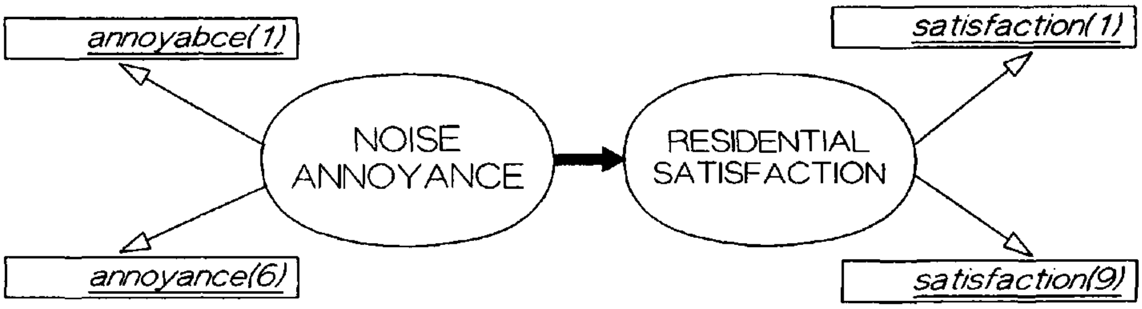
| | aircraft noise | | | | road traffic noise | | | |
|---|---|---|---|---|---|---|---|---|
| | NOISE ANNOYANCE | | | | NOISE ANNOYANCE | | | |
| | annoyance(1) | | annoyance(9) | | annoyance(1) | | annoyance(9) | |
| | $r^2$ | N | $r^2$ | N | $r^2$ | N | $r^2$ | N |
| NOISE LEVEL | | | | | | | | |
| noise stratum | 0.037 | 921 | 0.100 | 881 | 0.076 | 1097 | 0.082 | 992 |
| perc. loudness | 0.357 | 864 | 0.266 | 832 | 0.260 | 853 | 0.278 | 799 |

### 5.5.3 Psychosocial constructs

In the model, as presented in figure 5.1 it is assumed, that RESIDENTAL SATISFACTION, and hence the WISH TO MOVE, is dependent upon amongst other things NOISE ANNOYANCE, which in its turn is dependent upon the NOISE LEVEL. Table 5.7 gives the direct relation between the noise level variables and both noise annoyance variables. More details are presented in chapter 7. We conclude that about 5 to 10% of the variance in noise annoyance can be explained by the variance in noise stratum number. The amount of explained variance increases to 25 to 35% when perceived loudness is used as an estimator of NOISE LEVEL.

In table 5.8 we present monovariate linear regressions of residential satisfaction and noise annoyance. The following conclusion can be drawn: Only a few percent of the variance of RESIDENTIAL SATISFACTION can be explained by NOISE ANNOYANCE. the largest effect (±7.5%) is observed in residential satisfaction, measured by the satisfaction(9) in the road traffic sample.
These results confirm the results described by Lako (1987), who used a slightly different analysis.

Table 5.8 Linear regressions between noise annoyance and residential satisfaction. All correlation are significant at the 0.01 level. The analysis model used in this table is schematically indicated; calculations are performed using BMDP1R



| | aircraft noise | | | | road traffic noise | | | |
|---|---|---|---|---|---|---|---|---|
| | RESIDENTIAL SATISFACTION | | | | RESIDENTIAL SATISFACTION | | | |
| | satisf.(1) | | satisf.(9) | | satisf.(1) | | satisf.(9) | |
| | $r^2$ | N | $r^2$ | N | $r^2$ | N | $r^2$ | N |
| NOISE ANNOYANCE | | | | | | | | |
| annoyance(1) | 0.016 | 921 | 0.017 | 919 | 0.030 | 1099 | 0.075 | 1099 |
| annoyance(6) | 0.011 | 881 | 0.022 | 881 | 0.023 | 994 | 0.074 | 995 |

Stepwise multivariate linear regressions, incorporating psychosocial constructs, are presented in table 5.8. This table presents results of the analysis of the model of figure 5.4. The analysis is similar to the one of the table 5.6, except that both NOISE ANNOYANCE variables are introduced as possible independent variables. As can be seen from table 5.9, the program leaves the NOISE LEVEL variables out of the equations, because they have a non significant contribution to the explained variance as estimated by the multiple regression coefficient. This is in agreement with the model of figure 5.4: no direct relation between NOISE LEVEL and RESIDENTIAL SATISFACTION is detected, when the "APPRAISAL" variables have already been introduced into the linear regression equation.

Table 5.9 Stepwise multivariate regression analyses using psychological constructs. Dependent variable is residential satisfaction, independent variables are noise annoyance scales, characteristics of the dwelling and individual characteristics; calculations are performed using BMDP2R.

Table 5.9 A: Aircraft noise:

| variable analysed | | | | | |
|---|---|---|---|---|---|
| step | variable | multiple | | change | F to |
| no. | entered | r | $r^2$ | in $r^2$ | enter |
| RESIDENTIAL SATISFACTION variable: satisfaction(9) | | | | | |
| 1 | type of dwelling | 0.348 | 0.121 | 0.121 | 118.6 |
| 2 | age of respondent | 0.380 | 0.145 | 0.024 | 23.8 |
| 3 | ownership of dwelling | 0.406 | 0.165 | 0.020 | 20.7 |
| 4 | presence of garden | 0.428 | 0.180 | 0.016 | 16.3 |
| 5 | annoyance(6) | 0.440 | 0.194 | 0.013 | 14.0 |
| RESIDENTIAL SATISFACTION variable: satisfaction(1) | | | | | |
| 1 | presence of garden | 0.348 | 0.121 | 0.121 | 118.7 |
| 2 | ownership of dwelling | 0.400 | 0.160 | 0.039 | 40.1 |
| 3 | age of respondent | 0.420 | 0.176 | 0.016 | 16.8 |
| 5 | annoyance(1) | 0.431 | 0.186 | 0.009 | 9.7 |
| 4 | type of dwelling | 0.439 | 0.192 | 0.007 | 7.0 |

Table 5.9 (continued) B: road traffic noise:

| variable analysed | | | | | |
|---|---|---|---|---|---|
| step | variable | multiple | | change | F to |
| no. | entered | r | $r^2$ | in $r^2$ | enter |
| RESIDENTIAL SATISFACTION variable: satisfaction(9) | | | | | |
| 1 | annoyance(1) | 0.294 | 0.086 | 0.086 | 90.7 |
| 2 | age of respondent | 0.382 | 0.146 | 0.060 | 67.0 |
| 3 | ownership of dwelling | 0.424 | 0.180 | 0.034 | 39.2 |
| 4 | annoyance (6) | 0.433 | 0.188 | 0.008 | 9.4 |
| RESIDENTIAL SATISFACTION variable: satisfaction(1) | | | | | |
| 1 | annoyance(1) | 0.183 | 0.033 | 0.033 | 33.2 |
| 2 | presence of garden | 0.240 | 0.058 | 0.024 | 24.8 |
| 3 | ownership of dwelling | 0.251 | 0.063 | 0.005 | 5.3 |

From these analyses we observe the following:

a) About 20% of the variance of residential satisfaction, measured by means of the 9-item scale, can be explained by the age of the respondent, ownership of the dwelling and noise annoyance. The latter explains about 10% of the variance in the road traffic sample and only 1.5% of the variance in the aircraft sample.

b) About 20% (aircraft noise) respectively 7.5% (road traffic noise) of the variance of residential satisfaction, measured by means of the 1-item scale, can be explained by the presence of a garden and noise annoyance. Age of the respondent, ownership and education play less important roles. Again noise annoyance can be associated with half of this explained variance in the road traffic sample and only about 1% in the aircraft sample.

We may conclude, that in the road traffic sample a significant part of the variance in residential satisfaction can be attributed to annoyance by environmental noise. A direct relation with noise level was not observed. In the aircraft sample we observed only a very small contribution of noise annoyance to residential satisfaction.

Type of dwelling and ownership of the home are relatively good predictors of RESIDENTIAL SATISFACTION. Since both samples differ on the prevalence of these variables in such a way, that in the aircraft sample much more dwellings are owned by the inhabitant, we conclude that the differences between the samples exposed to aircraft noise and road traffic noise, observed above, are due to confounding by these dwelling characteristics.

## 5.6 Conclusions and discussion

### 5.6.1 Noise induced migration

In this chapter the following conclusions were obtained regarding the influence of environmental noise upon residential satisfaction and wish to move:

a) People, who indicate that they wish to move out of their present home have, as expected, a lower residential satisfaction and perceive significantly higher noise levels. No significant difference is observed in noise level expressed in more or less physical dimension (dB(A) or KE).

b) In our population around *military airfields* (about 1000 subjects) almost no effect of environmental noise on the residential satisfaction, and hence the wish to move, could be detected. Only a very weak effect of perceived loudness upon residential satisfaction was observed (explaining about 1% or less of the variance of residential satisfaction).

c) In our population around noisy roads (also about 1000 subjects), the perceived loudness could be shown to affect the residential satisfaction to some extend. The importance of the perceived loudness was about equal to the total importance of all other explaining variables together. Depending upon the variables used the total amount of explained variance is 10 to 20%. It should be reiterated that this possibly is due to a statistical artefact as "perceived loudness" can be interpreted as containing elements of "annoyance". The noise levels as measured in more or less physical dimensions (dB(A) or KE) did not show an effect.

d) The difference between road traffic noise and aircraft noise samples may be due to the fact that in the latter a much higher part of the houses is owned by the inhabitant. Also the distribution of homes over different types is different in both samples. Ownership of the home and type of dwelling were amongst the most important explaining variables in residential satisfaction.

### 5.6.2 Selection effects by noise induced migration

On the basis of this conclusions the following may be stated about possible selection effects within the population, used in this study:

a) There are no indications that selective migration has induced a bias in the population exposed to aircraft noise used in this study.

b) A relatively small selection effect in the sample exposed to road traffic noise can not be excluded. This means that some people (most sensitive to environmental noise?) may move out of the noisiest areas, yielding a "survivor" population in the higher levels of perceived noise. Since the correlations between noise stratum number (a more or less physical estimate of noise level) and perceived noise level are weak, we can not quantify the possible effect of this finding upon the results reported in other chapters.

We conclude that this result may cause some underestimation of the effects of environmental noise as studied in the next chapters. Since the effects of migration are small we neglect their influence in the results, reported in the next chapters.

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# 6. PSYCHOSOCIAL ASPECTS IN THE NOISE HEALTH RELATIONSHIP

I. van Kamp

# 6. PSYCHOSOCIAL ASPECTS IN THE NOISE HEALTH RELATIONSHIP

## 6.1 Introduction

This chapter deals with the psycho-social variables, that mediate or moderate the noise health relationship. Only a summary of the research findings is given. For an elaborate description of psychometric evaluations and research findings we refer to van Kamp (1986, 1988).

Research has shown, that environmental noise can cause mental and physiological changes, that only under certain conditions and in certain people will lead to permanent health problems (see: Cohen and Weinstein, 1982; Kryter, 1985 for reviews). The only definite health effect of noise is hearing loss as a result of high intensity noise (Kryter, 1985; van Dijk, 1984). In spite of a growing body of research on stress in general and environmental stress specifically, scientific evidence on the role of psychosocial factors in the stress-illness relationship is still limited. It is generally assumed, that psychological, physiological as well as situational factors and an interaction between these play a role in the process that leads from chronic and repetitive stressors to serious health problems (Singer, Baum, 1986).

The problem of noise and health is in this chapter studied from a stress-theoretical perspective, based on an integration of a biological and a psychological stress approach (Ursin, 1978, 1985; Lazarus c.s., 1966, 1977, 1978). According to this model, the noise health relationship is mediated by a process of noise appraisal, activation and coping behavior.

Two basic questions have to be answered in this part of the research:

1. In what way does the process of noise appraisal and coping behaviour mediate the noise health relationship?
2. What are the implications of the findings on a theoretical and policy making level?

In this chapter we will focus on the underlying psycho social mechanisms in the noise health relationship. We restrict ourselves to health effects on a subjective level, such as stress feelings attributed to noise, psychosomatic symptoms and sleep complaints.

In § 2 the conceptual framework is treated in general terms; a more detailed description is given in van Kamp (1988).

In § 3 some methodological issues will be discussed. A summary will be given of the evaluation of the psychosocial measures in terms of reliability and validity, as reported elsewhere (van Kamp, 1986).

In § 4 the research problem will be redefined in terms of themes and hypotheses.

In § 5 and § 6 the major findings will be summarized. A distinction is made between a descriptive (§ 5) part and a hypothesis testing part (§ 6). Section 6.5. will describe psycho social effects of noise using the dose effect and the individual difference approach. Section 6.6. deals with the mediating role of coping strategies and other psycho social variables in the noise health relationship. The discussion (§ 7) will summarize the major results and focus on the theoretical and policy making consequences of these findings.

## 6.2 Theoretical framework

### 6.2.1 Introduction

Research has shown that environmental noise activates the central nervous system and causes changes in physiological processes such as the cardiovascular, endocrine, respiratory and digestive system (see: McClean and Tarnapolsky, 1977; Cohen and Weinstein, 1982; Kryter, 1985 for reviews). Noise can therefore be defined as a stressor: an excessive internal or external demand that causes a discrepancy between the actual and the required state of the organism in a given situation.

We consider a stress theoretical approach to the problem of noise and health as fruitful, since it enables us to study the process by which noise can lead to permanent health problems. Our point of departure (van Kamp, 1986) is a stress model based on an integration of the psycho biological approach (Selye, 1976; Ursin, 1978, 1985) and a psychological approach to stress and health as formulated by Lazarus (1966). Central concepts in this integrated model are stressors, appraisal, coping, activation and stress (see chapter 3 and van Kamp, 1988). In this chapter these concepts will be described in more detail on the basis of recent stress research.

### 6.2.2 Types of stressors

A basic distinction can be made between physical and psychological stressors. Lazarus and Cohen (1977) discern three classes of stressors: Major life events; Critical events; Daily hassles. In this present context we are primarily interested in stressors of the third type.

Daily hassles refer to stable and daily returning problems that in itself place a minor demand, but through their chronic nature can deplete the adaptive resources of a person (Kanner et al., 1981; Evans and Cohen, 1987; Fleming et al., 1984, p.947). Noise pollution, as well as other types of pollution and crowding can be considered as examples of such repetitive, chronic stressors alternately referred to as daily hassles (Lazarus, Cohen, 1977) environmental stressors (Evans and Cohen, 1987) or ambient stressors have the following features in common (Campbell, 1983):

1. They are chronic
2. Perceivable, but not necessarily noticed all the time
3. They are not urgent in a toxicological sense
4. They are usually appraised as negative
5. They are not under the direct control of individuals

Two other features are important to mention. Environmental stressors affect large numbers of people in a given area (Bachrach, Zautra, 1985) and usually come in clusters (Fidell, 1984). As an example we can mention the combination of noise and air pollution in road traffic areas. Moreover we can assume that environmental stressors are appraised in another way than most personal problems; they actually leave very little room for interpretation. It is not as much an appraisal of threat or harm, but the appraisal of the degree to which the stressor interferes with activities, personal goals, values and ideals. The personal and situational context in which the stressor occurs will define whether the stressor is salient (Stokols, 1979). Someone who tries to sleep, for example, will appraise environmental noise as more disturbing, than someone who is shopping.

In the next section a summary of relevant research findings is given on the appraisal of stressors, coping with stressors and its physiological consequences. We focus primarily on chronic stressors with a physical character.

### 6.2.3 Stress research

The stress process has been a major point of psycho biological research in the past 40 years (Cannon, 1943; Selye, 1956; Mason, 1975; Lazarus, 1966). Much research has recently been conducted on the relationship between appraisal and coping on the one hand and physiological responses on the other hand. Early studies were aimed at coping with specific stressors in short term situations such as exams, surgery and traditional laboratory stress tests: cold pressor, high intensity noise, task performance. Recently attention has been shifted to the long term health effects of coping with chronic stressors (Pearlin and Schooler, 1978; Pearlin et al., 1981; Billings and Moos, 1980; Folkman, Lazarus, 1980; Caplan et al., 1984).

If we want to study the relationship between noise and health cognitive, behavioral, as well as physiological parameters should be integrated into one model (for arguments see van Kamp, 1988). In chapter 3 this model was outlined in general terms. In this part we will describe the mediating process of APPRAISAL in more detail (see figure 3.3). We distinguish four stages in the process:

1. Primary appraisal
2. Secundary appraisal
3. Activation
4. Coping

In figure 6.1 the integrated stress model is schematically represented.

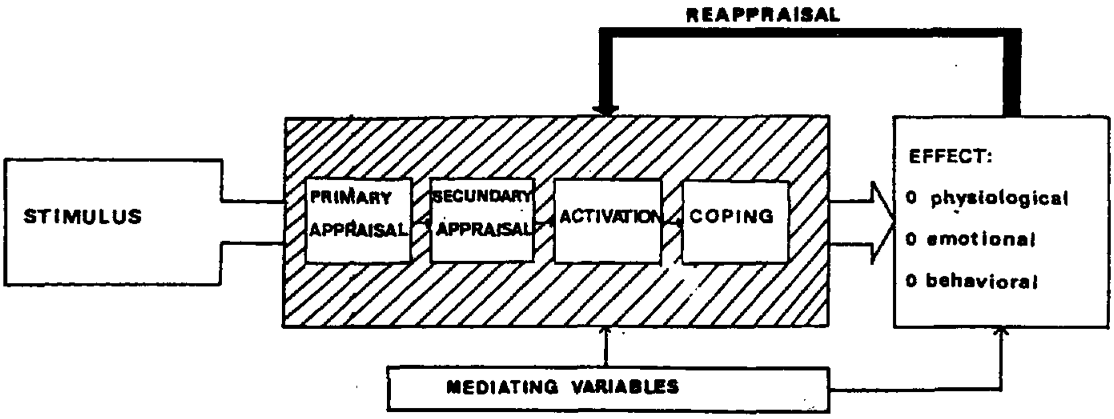
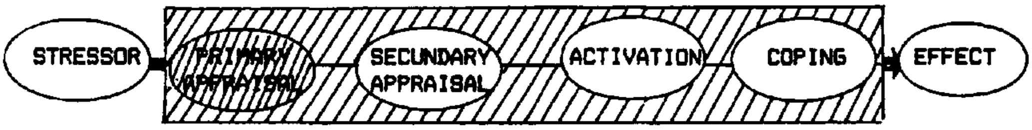


Figure 6.1 An integrated stressmodel

Below these stress theoretical constructs will be described on the basis of recent stress research.

Primary appraisal



PRIMARY APPRAISAL was defined as:

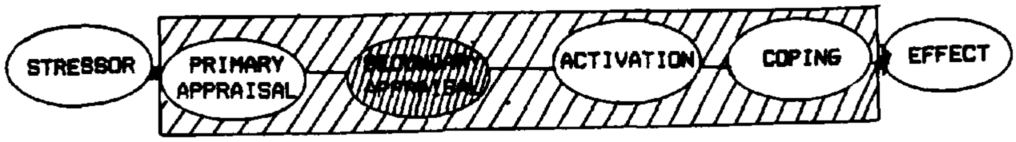
> The evalution of internal or external stimuli in terms of threat, loss or challenge.

Research has shown, that not so much the physical characteristics of a stressor, but the appraisal of a situation as threatening results in physiological and neuro endocrine reactions (Lazarus, 1966; Lazarus, Launier, 1978; Frankenhaüser and Lundberg, 1974; Mason, 1975). On the other hand we must take into account that some physical stressors can have damaging health effects independent of appraisal (Baum, Singer, Baum, 1981), such as cigarette smoking, extreme heat and high intensity noise.

The primary appraisal of noise has alternately been defined in terms of signal detection (perceived loudness) and annoyance. Research has shown, that the physical characteristics of noise are a poor predictor of individual reactions (see chapter 3). Recent noise research has therefore focused on the mediating role of variables that influence the noise effect relationship (Evans and Tafalia, 1987; Weinstein, 1978; Sörenson, 1970; Tarnapolsky et al., 1980; Graeven, 1975; Broadbent, 1972; Frankenhauser, 1974; Jonah et al., 1981; Moreira, Bryan, 1972; Weinstein, 1976; Griffith and Delauzon, 1977; Schultz, 1978; de Jong and Beurs, 1978).

On the basis of these studies we can conclude that the primary appraisal of noise is influenced by a variety of aspects on social and psychological level, that refer to an actual or perceived lack of control over the situation. Scientific insight in the mediating role of primary appraisal in respect to physiological changes due to noise is still limited. The role of subjective stress responses as anxiety, anger, frustration and irritation needs further attention (see under activation). The influence of noise on health might be primarily moderated by this emotional and physiological response (Weinstein, 1978; Evans and Cohen, 1987).

### Secundary appraisal



SECUNDARY APPRAISAL was defined as:

The evaluation of a stressor in terms of control possibilities.

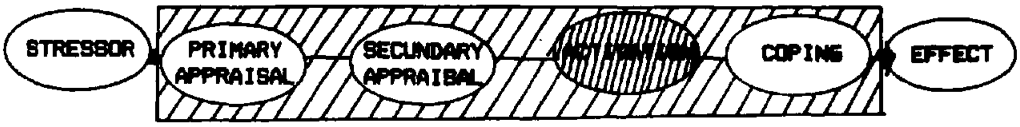
The next step in the process is the appraisal of a stressor in terms of control possibilities (perceived control). It is noted that perceived control may differ from the actual control one has (Thompson, 1981). Here we focus on perceived control (see: Averill, 1973; Thompson, 1981 for reviews). Perceived control has been identified as an important mediator in the stress-illness relationship (Dohrenwerd, 1981; Rabkin, Struening, 1976).

Glass and Singer (1972) and Frankenhaüser and Lundberg (1974) have shown that the perception of control moderates the physiological reaction to task performance under exposure to high intensity noise. Animal studies also have shown that uncontrollable, aversive stimuli lead to a 'giving up' syndrome, usually referred to as 'learned helplessness' (Seligman, 1975). On the other hand some researchers have found a high positive correlation of perceived control and the physiological effects of the stressor (Stokols, 1979; Folkman, 1982, 1984; Kaplan, 1978).

Most environmental studies also focus on the moderating role of secundary appraisal or perceived control. One of the main features of environmental stressors is, that they are not under the direct control of the individual. It is not as much a question of direct control, but a wish to control the negative consequences of the stressor. Research has consistently shown that environmental stressors that are uncontrollable or unpredictable cause more stress in human beings (Evans and Cohen, 1987; Stallen and Tomas, 1986; Cohen, 1981; Evans, 1979).

Secundary appraisal is assumed to be related to the type of coping strategy people choose. Research has shown (Campbell, 1983; Evans et al., 1982; Collins et al., 1983) that uncontrollable (actual or perceived) situations result in giving up or denial of the stressor instead of problem-oriented behavior.
The idea that noise can be avoided or controlled also has a moderating influence on the <u>after</u> effects of noise exposure in laboratory research. Manipulation of control in the laboratory reduced the negative consequences of noise on the task performance and physiological level (Glass, Singer, 1972; Rotton et al., 1983). Field studies that tried to replicate the findings of Glass and Singer (1972) are rare. Guski et al. (1978) conclude that perceived noise control does indeed reduce annoyance and interference with activities. The relationship of perceived control with physiological imbalance (self report) however was weak.

## Activation

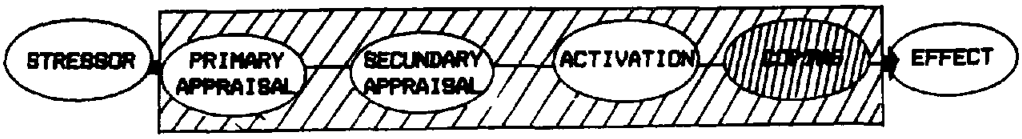


Ursin (1985) defines ACTIVATION as:

> <u>the process in the Central Nervous System by which brain activity is increased</u>.

Activation is the response to new, difficult or threatening situations and implies changes on a physiological, emotional and behavioral level. Increased activation motivates the person to seek a response strategy (coping) to undo the discrepancy between the demands of the situation and the perceived control possibilities. When it is not possible to reduce the level of activation both on emotional and physiological level we can speak of sustained activation (Ursin, Knardahl, 1985). This sustained activation is assumed to be related to serious health problems when the stressor is chronic and recovery is therefore not possible. Very little attention has been payed to the emotional aspect of activation. It might be primarily this emotional response that mediates the relation between noise and health effects (Evans and Cohen, 1987).

## Coping



In line with Lazarus and Folkman (1984) we have defined COPING as

> any attempt on behavioral and cognitive level to master, tolerate, minimize or reduce the negative consequences of internal and external demands and conflicts between them which tax or exceed personal resources.

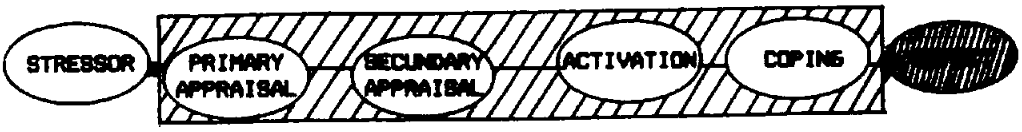
This can happen by either trying to change the environment (Problem oriented coping), changing the perception of the situation (Comforting cognitions), by avoiding the situation (Avoidance) or on a physiological level by trying to change the internal state (Effort). Coping has as a primary goal to restore a sense of control over situation (Baum, Fleming, Singer, 1983).

In line with Lazarus coping is a priori defined as a function of the appraisal process. We can assume that variables such as context, motivation, learning processes and personality traits influence the choice of coping behavior as well. The stability of coping styles over different situations has proven to be poor (Folkman, Lazarus, 1980) and to be partly dependent on the type of stressor under study, with an explained variance of 2%-16% (McCrae, 1984).

Conchrite and Moos (1984) found a relatively strong relationship between coping styles and stress manifestations, such as depressive symptoms, psychosomatic complaints and alcohol consumption. Problem oriented coping was associated with a decrease of symptoms, whereas avoidance was correlated with an increase of subjective symptoms. Comforting cognitions did not change the level of complaints. It is generally hypothezised, that problem oriented coping promotes general well being, because it gives people a sense of control (Caplan et al., 1984; Billings and Moos, 1980).

The influence of differential coping styles upon the effects of environmental noise has not yet been studied in detail. Some relation between an active coping style and education, socio-economic status and sex has been established (McKennel, 1973; Goodman, Clary, 1976). Also it was found that people with an internal locus of control as measured by the Internal-External control scale of Rotter are found to be strongly annoyed by noise and apt to political activity (= problem oriented behavior). Medalia (1964) on the other hand suggests that a high level of annoyance prevents adequate coping behaviour. One might expect a high correlation between annoyance and specific types of coping (compare Stallen, Tomas, 1986). Active coping through community involvement might serve as an outlet for frustration and through this reestablish a sense of control over the environment (Tarnapolsky et al., 1980). However a constant concern for control and constant effort to master a problem that is not under the direct control of the individual, might deplete the resources and diminish the capability to cope with more accute problems. This can have detrimental health effects. In other words: it can be stated that each coping strategy has its own type of costs (adaptive costs).

## Health effects



HEALTH was defined as:

> A state of complete physical, psychological and social well-being and not only the absense of disease.

This definition (WHO, 1948) was taken as a point of departure for further operationalization of the concept. A distinction can be made between short and long term health effects. Moreover we distinguish health effects on a physiological, subjective and task performance level. In this part of the research we restrict ourselves to health effects on a subjective level.

Subjective health effects have usually been measured independent of (short term) physiological effects and task performance effects. General feelings of 'unwellbeing' are by some researchers considered as indicator for stress (Cullen, 1984). Others argue that unspecific health complaints are indicators of general vulnerability that do not fluctuate as a function of environmental stressors (Ormel, 1980). Many studies have indentified anxiety, depression, tension and nervousness as a result of exposure to different types of stressors. The stress response is then defined in terms of self reported complaints (Pearlin, Schooler, 1978; Siegrist, 1984; McIntyre and Jenkins, 1984; Lazarus, 1966; Mason, 1975), such as psycho somatic complaints, sleep complaints and mental health problems.

Overall we must conclude that evidence on the development of unspecific health complaints and actual diseases as a result of sustained activation is still limited (Siegrist, 1984; Baum et al., 1981).

As for health effects due to noise it has been found, that noise exposure is related with self reported sleep complaints (see: Rossi, 1983; van Dormolen et al., 1988 for reviews), depression, psycho somatic and psychological complaints (see Cohen, Weinstein, 1982; McClean, Tarnapolsky, 1977; Kryter, 1985 for reviews). Most of these complaints can be considered as manifestations of stress. Most health effects are however not convincingly proven, due to methodological problems (Cohen, Weinstein, 1982; van Dijk, 1984; Thompson, 1983).

### 6.2.4 Summary and conclusion

The transactional stress approach of Lazarus has been proven to be highly stimulating and in many different research areas although the model is primarily heuristic. We conclude that research findings suggest that the appraisal of the stressor, perceived control and coping are essential in predicting health effects of exposure to daily returning chronic stressors like environmental noise.

Results of laboratory and field studies sometimes seem contradictory. Active coping (problem oriented) has been found to be associated with short term reactivity and a decrease of psychosomatic symptoms and tonic activation. Avoidance behavior in its turn is found to be associated with lower levels of reactivity, but an increase in psychosomatic symptoms and after effects on the physiological level (Ursin and Knardahl, 1985).

A lack of perceived control has been consistently shown to moderate the stressor effect relationship. However by some investigators (Folkman, 1984) perceived control was found to be related with an increase in physiological reactivity. Part of these seemingly contradictory results are due to methodological difference. A clear cut distinction must be made between short and long term effects and between reactivity in phasic or tonic activation. Moreover a clear distinction must be made between effects on physiological, subjective and task performance level. These effects are not necessarily synchronized as was shown by Frankenhaüser and Lundberg (1974).

Specific findings in respect to environmental noise show that noise is indeed a stressor, that can lead to disturbances on different levels. Only at extreme levels these effects are immidiate (e.g. hearing loss). In most cases they seem to be moderated by a complex process of appraisal, coping and sustained activation. Research in this area is still limited. Also the long term health effects of chronic noise exposure are still mostly hypothetical.

We can conclude, that an integrated stress approach offers important clues to study the underlying psychological and physiological mechanisms that play a role in the noise health relationship.

Problems concerning a transactional model are mostly of a methodological nature. The concepts of appraisal and coping are hard to measure. The most important methodological restriction is that most research methods do not fulfill the conditions to study dynamic processes. This problem can partly be solved when a combination of research methods is used and a longitudinal element is added to the research set up (see also chapter 1 and 4).

## 6.3 Material and methods

### 6.3.1 Introduction

A field survey was chosen as a method to study the mediating psychological process between noise and long term health effects. The general methodological structure of the survey, the sampling method and sample features were described in chapter 4. Here we will concentrate on specific methodological issues such as the choice if psycho-social instruments, their reliability and validity of the psycho-social measures and consequences of these findings for the measurement model.

### 6.3.2 Material

#### 6.3.2.1 Method of scale construction and evaluation

The noise related psycho social concepts were defined in terms of a stress process (and thus measured) as was described in § 2. In choosing measures we could partly rely on existing scales, partly it was necessary to develop new instruments and specify the questions for noise situations such as a measure of noise appraisal, perceived noise control and coping with noise. An extensive evaluation of the measures was thus a necessary condition for further analysis. For an elaborate description of the construction and evaluation process we refer to van Kamp (1986). Here we restrict ourselves to a brief overview of the successive steps taken in scale construction and evaluation and the main results and conclusions.

#### 6.3.2.2 Choice of measurement instruments

Literature on noise research suggests that chronic exposure to noise can be defined as a stressor because it activates the system and leads to changes on a physiological, performance and subjective level. This happens through the appraisal of the situation as negative, annoying, interfering with personal goals, frightening etc. At high intensities noise can result in immediate changes, such as high bloodpressure or damage e.g. hearing loss. These effects are independent of how the stressor is appraised (Kryter, 1985; Fleming, Baum, Singer, 1984). At lower levels we deal with a moderating or mediating appraisal and coping process, that can result in sustained changes.

The moderating role of primary and secundary appraisal has been shown in laboratory studies as well as in field studies. Findings on the role of coping styles and states in the noise-effect relationship are still limited.

The conceptual distinction between primary appraisal and annoyance seems hard to make. Most noise studies have concentrated on aspects of annoyance, that might be defined as part of general (un)well being. Noise appraisal and annoyance are shown to be influenced by many factors. We have to study the noise health problem in relation with these mediating or confounding variables. In one study we cannot be conclusive in studying all the different influences. We restrict ourselves to the question what the relative contribution of noise is in the development of subjective health complaints in comparison to influences other than noise, such as residential situation, age, the appraisal of other aspects of the life situation. On the basis of a survey of the literature the following categories of mediating variables were selected:

1. Noise specific variables such as length of residency, exposure per 24 hours, insulation, annoyance from other noise sources
2. Residential situation such as type of home, quality, motive for migration, residential satisfaction
3. Appraisal of stressors other than noise (Perceived daily hassles) such as financial situation, recent life events, work, family, social situation
4. Biographical aspects such as age, sex, educational level, socio-economic status, type of work, shiftwork

The following assumptions underlie the construction and/or choice of measures:

1. We assume that the appraisal and coping process is noise specific.
2. We use different measures for the same concept in order to cover a broad scope of annoyance, subjective health and well-being. Results will therefore be less dependent on one method.
3. On the other hand we adopt an economic point of view: per scale we use as little items as possible.

In scheme 6.3.1 a review of constructs, measurement instruments and source is given.

Scheme 6.3.1 Constructs, indicators and source/type of measure

| CONSTRUCT | INDICATOR | TYPE |
|---|---|---|
| PRIMARY APPRAISAL | Perceived Loudness | Semantic Differential |
| | Activ. Interference-freq. | Bitter scale (1964) |
| | Activ. Interference-int. | Mokken scale |
| | Non specific Annoyance | One question |
| SECUNDARY APPRAISAL | Perceived Noise Control | Adapted scale (Lazarus, Folkman, 1984) |
| COPING | General Coping | Multidimensional scale based on UCL (Schreurs et al., 1984) |
| | Coping with noise<br>* Problem oriented<br>* Avoidance<br>* Comforting cognitions | Multi dimensional Scale based on UCL. |
| ACTIVATION | Stress due to noise | Stress-scale (King et al., 1983) |
| HEALTH | Subjective Health Compl. | Hopkins Symptom Checklist (Luteijn et al., 1984) |
| | * SOMAT | Sub-scale HSCL |
| | * PSYCH | Sub-scale HSCL |
| | Sleepquality | Groninger Sleep Quality Scale (Mulder-Hajonides et al. 1980) |
| MEDIATORS: | Daily Hassles | Newly constructed scale |
| | Residential Satisfaction | Residential Satisfaction Scale (De Jong and Beurs, 1978) |

### 6.3.3 Procedure of scale construction and evaluation

In the course of time a number of psychometric criteria have been developed to evaluate multi-item scales (de Groot, 1961; Burisch, 1984; Cook & Campbell, 1976; Nunnally, 1978). Two main criteria can be distinguished:

1. Reliability
2. Validity

Simply said we can define reliability as the extent in which we have measured anything at all. Validity refers to the extent in which a scale measures what it was meant to measure (Meerling, 1980).

We distinguish four steps in the evaluation of reliability:

1. Analysis of factor structure in multi-dimensional scales
2. Invariance of this structure over different samples
3. Internal consistency
4. Economy

Factor structure and invariance. The a priori structure of scales was investigated with PEKON (Computerprogram by Camstra, 1985) and RUM (Brokken, 1975). Invariance is in RUM expressed in Tuckers coefficient of congruence phi (ten Berge, 1977; 1986). With values of 85 we can conclude that the factors are comparable in terms of interpretation. With PEKON we analyzed the strenght of the factors. Of course these steps are only taken in multi-factor scales.

Internal consistency. Item analysis was carried out in the context of classical test theory as well as a latent trait model (Mokken 1971, 1982). These models differ in the sense that they assume different characteristics of a scale. Cronbach's alpha (Cronbach, 1951) is used as a measure for internal consistency. Values of .80 are considered desirable for generalized use (Molenaar, 1981). The lower limit is set on an alpha .60 (Nunnally, 1978). Scales with an assumed cumulative structure where analyzed with computer program Mokken (Stap, users manual, 1980; Debets, Sijtsma, Molenaar, 1987). Loevinger H values of .30 on item level and .40 on scale level were used as a minimal norm.

Economy. In selecting items on the basis of item analysis we kept the economy principle in mind (Burisch, 1984). This means that we try to keep the scale as short as possible and remove redundant items that do not contribute to the internal consistency of the scale or correlate extremely highly with other items. In existing scales this criterium is ignored in view of the comparability with other research findings.

Validity. The validity of the scales was then evaluated by studying the zero-order correlations according to the model of Campbell and Fiske (1959).

In figure 6.3.2 the stepwise evaluation process is summarized. The main feature of the procedure is, that we start with analyzing the a priori structure in one sample and cross validate this result in the three other samples. Next the internal consistency is studied in all four subsamples, only making alterations in the first step. Only when the results are not agreeable to our premisses about the scale, an exploratory study was done. Items were removed on the basis of low item-rest correlations. In some cases factors were combined, when the sumscores on the scales that were based on factor loadings correlated high.

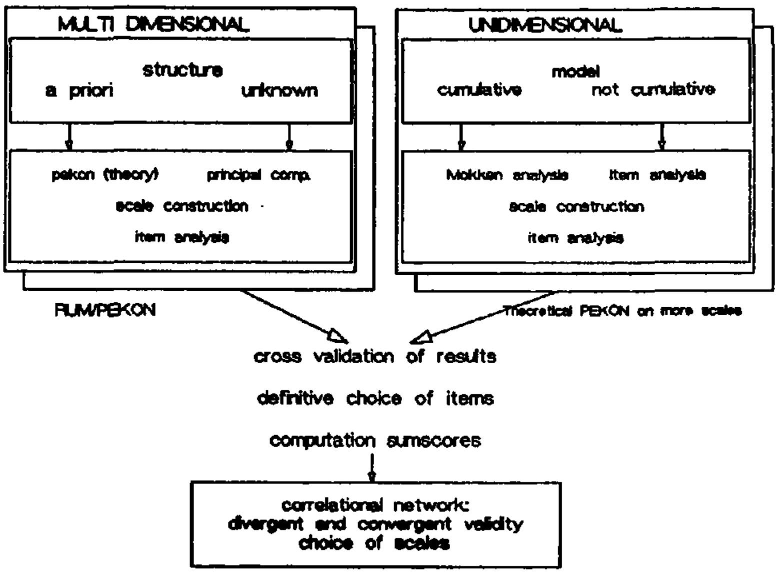


Figure 6.3.2 Review of steps in evaluation process

### 6.3.4 Results

Below a brief summary of the results per scale will be given.

Stress sources other than noise

The psychosocial construct was operationalized into a 'Perceived daily hassle' scale and a 'residential satisfaction' scale (de Jong and Beurs, 1978). The daily hassle scale and the residential satisfaction scale, that are both one-dimensional, show a moderately high internal consistency with a mean alpha of respectively .75 and .74. The interscale correlation is moderately high with a Pearson correlation of r = .30. It can be concluded that there is a conceptual distinction between these two scales.

Primary Appraisal of noise was measured in four subscales each measuring a different aspect of the subjective appraisal of noise: Perceived Loudness, Interference with activities in terms of frequency (Bitter and Schwager, 1964), Interference in terms of intensity, Non-Specific Annoyance. We consider these as different aspects of noise appraisal that play a role at different stages in the stress process. All annoyance questions are asked for three types of environmental noise: road traffic, air traffic, neighbor noise.

The scales show high internal consistency for all noise sources with alpha ranging from .80 - .85. The scales are highly intercorrelated with r ranging from .50 - .85. This is slightly lower than found by others (Borsky, 1980). The assumed hierarchic structure of the interference with activities scales (Weinstein, 1982; Goodman and Clary, 1976; Guski et al., 1978) is relative and varies as a function of noise source. Different noises disturb different activities. Where aircraft noise for example is highly disturbing while telephoning for 57% of the respondents, only 10% reports this disturbance in the traffic-noise sample.

On the basis of the correlational pattern it can be concluded that we can hardly make a distinction between annoyance, perceived loudness, and interference they belong to the same structural domain.

Secundary Appraisal

The items of this scale are based on a scale used by Lazarus and Folkman (1978). The items are supposed to be cumulative, but validity data are not reported by the authors. Mokken analysis was used to evaluate the scale. The results are unsatisfactory: only in the two aircraft subsamples we can construct a scale with Loevinger H of .40. The predictive power of the scale however is strong. The intercorrelations with the other annoyance measures and the appraisal measure ranges from .25-.50. An additional study was done with a new scale. Results will be presented in van Kamp (1988).

Activation

The emotional aspect of activation was measured in the stress scale of the Stress ans Arousal Scale (King, 1976) and is referred to as: Stress feelings due to noise. Again the questions are asked for three noise sources. The internal consistency is good with a mean alpha of .78.

The interscale correlation with the annoyance scales is high (r in range of .37-.60).

Coping

Both a general and a specific coping scale were used, based on the Utrecht Coping List (UCL, Schreurs et al., 1984). This scale is frequently used in Dutch research (Schreurs, et al, 1984; Kompier et al., 1983, 1988) and validated. The total scale is assumed to measure coping behavior as a trait and consists of seven scales, each supposed to measure a different coping strategy. The scales are moderately reliable (a range of .62-.82) and the factor structure fairly stable. We reduced the a priori structure of seven factors into a three factor one, based on a theoretical study of the coping concept (Pearlin, Schooler, 1978; Ray et al., 1982):

1. Problem oriented coping
2. Avoidance coping
3. Comforting cognitions

Results on the noise coping scale show highly invariant factors with Tucker phi values of .95-.98. This implies that the theoretical structure is satisfactory reflected in the empirical data. The strength of the factors is comparable as well for subsamples, based on age, sex and noise area (explained variance ranging from .33-.37). The internal consistency of the scales ranges from .63-.88, with the problem oriented scale having the highest alpha and the comforting cognition having the lowest. Scale 1 and scale 2 (problem-avoidance) show intercorrelations between .33-.46, whereas scale 3 is highly independent of the other two.

The intercorrelations with the general coping scales are .20. The internal consistency of these general scales however is relatively low due to the low number of items per scale (Alpha= .50-.63). The price for being too economic is paid in this case. It is arqued that we need more items when we want to measure a heterogeneous concept such as coping. The complete UCL has been taken up in a follow up study (for results see van Kamp, 1988).

Subjective Health Three scales were used to measure aspects of subjective health:

1. Somatic complaints on the Hopkins Symptom Checklist (Derogatis et al., 1974; Luteijn et al, 1979, 1984).

2. Psychological Complaints on the HSCL.
3. Groninger Sleep Quality Scale (Mulder-Hayonides van der Meulen et al., 1980).

The Hopkins Symptom Checklist The HSCL consists of 57 items and is supposed to measure psycho somatic well being in a broad sense. Two subscales can be used as well (SOMAT and PSYCH). The HSCL has been shown in the past to be rather reliable and valid. The two factor-structure is also in our material highly invariant (phi= .99, .93). A three factor structure is invariant as well (phi= .92, .89,.94; van Kamp, 1986; van Kamp, Stoop, 1986). The additional factor consists of items referring to depression (Derogatis et al., 1974; Beck et al., 1961). Especially in noise research this can add to our insight in the kind of complaints that people develop as a result of noise. Depression can be seen as a stress-indicator (Pearlin and Schooler, 1978). The intercorrelations between the scales range from .36-.55. The discriminating power of the scales is strong when we compare the score for people with a somatic disease, people who are under treatment for psychological problems and a 'normal' population. Especially the differential value of the depression scale is promising. People with a physical illness have a higher score on the depression scale but not on the social anxiety scale (van Kamp, Stoop, 1986).

Sleepquality. The GSQS has only been used in studies with small homogeneous groups (Mulder-Hayonides van der Meulen et al., 1980; Kompier et al., 1983, 1988; de Vries-Griever et al., 1982; Mokken, Lewis, 1982). The GSQS consists of a general and a specific sleep quality scale, that have both been shown to be strong Mokken scales with an average coefficient of scalability of H=50. We only used the general sleep quality scale since we are not interested in short term changes, but more in general sleep quality in relation to environmental noise.

Mokken analysis on our material shows a scale that fulfills the criteria of cumulativity and unidimensionality. The scale is robust over different subsamples. The intercorrelations with noise related sleep problems ranges from .24-35. This implies that about a quarter of the sleep complaints are attributed to noise. The intercorrelation with the HSCL-scales ranges between .28-.40. In table 6.3.2 the results of scale evaluation are summarized per noise source.

Table 6.3.2 Review Results Scale Analysis Airtraffic (N = 911)

| Scale | items | alpha/rho | item total/H | m | range | stand. dev | median |
|---|---|---|---|---|---|---|---|
| Resid. Satisf. | 9 | .73 | .40 | 36.4 | 9-45 | 4.8 | 36.49 |
| Daily hassles | 9 | .74 | .41 | 20.3 | 9-45 | 5.2 | 19.73 |
| $1^e$ appraisal | 5 | .84 | .64 | 18.1 | 5-25 | 6.2 | 19.71 |
| $2^e$ appraisal | 3 | .66 | .55 | 4.5 | 2-6 | 1.5 | 4.51 |
| Coping with Noise: | | | | | | | |
| Problem | 7 | .88 | .64 | 15.8 | 7-35 | 8.5 | 13.65 |
| Avoidance | 7 | .61 | .32 | 11.4 | 7-35 | 4.2 | 10.52 |
| Comf. Cogn. | 6 | .64 | .32 | 18.7 | 6-30 | 5.2 | 19.22 |
| Coping General: | | | | | | | |
| Problem | 4 | .62 | .40 | 10.6 | 4-16 | 2.2 | 10.4 |
| Avoidance | 4 | .51 | .29 | 7.9 | 4-16 | 1.9 | 7.8 |
| Comf. Cogn. | 4 | .52 | .31 | 9.8 | 4-16 | 2.1 | 9.6 |
| Bitter | 7 | .76/.83 | .40 | 3.4 | 0-7 | 2.1 | 3.56 |
| Interference | 9 | .90 | .60 | 20.3 | 9-45 | 9.5 | 17.66 |
| Stress | 5 | .81 | .54 | 13.0 | 5-25 | 4.7 | 12.94 |
| Somat (old) | 8 | .66 | .36 | 3.0 | 0-24 | 2.8 | 2.30 |
| Somat (new) | 6 | .75 | .44 | 2.9 | 0-18 | 2.8 | 2.28 |
| Psych (old) | 17 | .88 | .48 | 7.5 | 0-51 | 6.1 | 6.22 |
| Soc. Anxiety | 8 | .80 | .53 | 6.7 | 0-24 | 6.8 | 5.04 |
| Depression | 6 | .78 | .51 | 3.3 | 0-18 | 5.3 | 1.30 |
| Sleep (old) | 14 | .83 | .36 | 2.1 | 0-14 | 2.7 | 1.23 |
| Sleep (new) | 10 | .83 | .43 | 1.2 | 0-10 | 1.9 | .50 |

(Table 6.3.2 continued)
Review Results Scale Analysis Road Traffic (N = 1075)

| Scale | items | alpha/rho | item total/H | m | range | stand. dev | median |
|---|---|---|---|---|---|---|---|
| Res. Sat. | 9 | .76 | .42 | 32.4 | 9-45 | 5.2 | 32.76 |
| Daily hassles | 9 | .75 | .42 | 21.4 | 9-45 | 5.7 | 20.90 |
| $1^e$ appraisal | 5 | .77 | .55 | 12.0 | 5-25 | 7.6 | 13.49 |
| $2^e$ appraisal | 3 | .51 | .35 | 3.3 | 2-6 | 1.9 | 3.97 |
| Coping with Noise: | | | | | | | |
| Problem | 7 | .88 | .65 | 17.2 | 7-35 | 8.5 | 15.72 |
| Avoidance | 7 | .66 | .37 | 12.2 | 7-35 | 4.8 | 11.10 |
| Comf. Cogn. | 6 | .63 | .34 | 18.1 | 6-30 | 5.1 | 18.38 |
| Coping General: | | | | | | | |
| Problem | 4 | .57 | .34 | 10.6 | 4-16 | 2.1 | 10.7 |
| Avoidance | 4 | .48 | .27 | 8.0 | 4-16 | 2.0 | 7.9 |
| Comf. Cogn. | 4 | .48 | .27 | 9.9 | 4-16 | 2.1 | 9.9 |
| Bitter | 7 | .82/.74 | .39 | 1.9 | 0-7 | 1.8 | 1.37 |
| Interference | 9 | .83 | .40 | 13.2 | 9-45 | 5.8 | 11.03 |
| Stress | 5 | .82 | .60 | 11.0 | 5-25 | 4.4 | 10.47 |
| Somat (old) | 8 | .68 | .37 | 3.2 | 0-24 | 3.2 | 2.36 |
| Somat (new) | 6 | .74 | .40 | 3.1 | 0-18 | 2.9 | 2.2 |
| Psych (old) | 17 | .89 | .49 | 8.3 | 0-51 | 6.9 | 6.62 |
| Soc. Anxiety | 8 | .80 | .53 | 7.0 | 0-24 | 7.3 | 5.0 |
| Depression | 6 | .78 | .51 | 4.8 | 0-18 | 6.5 | 2.4 |
| Sleep (old) | 14 | .83 | .37 | 2.9 | 0-14 | 3.2 | 1.95 |
| Sleep (new) | 10 | .85 | .46 | 1.7 | 0-10 | 2.3 | 1.00 |

### 6.3.5 Distribution of the sumscores

Distribution per sample (Road vs Air)

Most statistical methods of analysis assume that the variables are normally distributed. Extreme deviations from normality can influence the analysis in a negative way, eg. an underestimation of correlations. When we study the frequency distributions of the scale scores, we see a slight deviation on the health measures, as can be expected in a normal population. The same counts for the problem-oriented and avoidance coping scales. Theoretically a transformation of the variables could lead to a more linear relationship and thus to higher correlation coefficients. Results show, however, that the change in correlation after loglinear transformation is minimal. In another context (Van Kamp, 1988) these results will be described in more detail.

Table 6.3.3 Prevalence of complaints (values 4 and 5)

|  | % highly disturbed |  | Mean/SD |  | T-value |
|---|---|---|---|---|---|
|  | Road | Air | Road | Air |  |
| Primary appraisal | 38 | 75 | 12/.3 | 18/.2 |  |
| Interference (frequency) | 33 | 65 | 1.8/1.8 | 3.1/1.9 | 16** |
| Secundary appraisal | 35 | 50 | 3.3/.06 | 4.5/.05 |  |
| Non specific annoyance | 15 | 36 |  |  |  |
| Stress due to noise | 12 | 28 | 11/.15 | 13/.16 |  |
| Interference (intensity) | 2 | 17 | 13/.20 | 20/.33 |  |
| Coping: Comforting cognitions | 49 | 55 | 18.1/5.1 | 18.7/5.2 | 2.7* |
| Problem oriented coping | 33 | 27 | 17.2/8.5 | 15.8/8.5 | -3.6** |
| Avoidance behaviour | 5 | 4 | 12.2/4.8 | 11.4/4.2 | -3.0* |
| Somatic complaints | 22 | 22 | 3.1/3.1 | 3.0/2.8 | ns |
| Sleep complaints | 21 | 15 | 2.9/3.2 | 2.1/2.7 | 5.2** |
| Daily hassles | 14 | 10 | 21.4/5.6 | 20.3/5.2 | 4.6** |
| Depression | 8 | 4 | 1.7/2.3 | 1.2/1.8 | 5.4** |
| Social anxiety | 6 | 4 | 2.4/2.6 | 2.4/2.4 | ns |
| Resid. dissatisfaction | 8 | 4 | 32.4/5.3 | 36.4/4.9 | -17.4** |

## Prevalence of complaints per source and area

In table 6.3.3 and in figure 6.3.3 to 6.3.6 the percentage of highly annoyed and disturbed is given per noise source (Road and Air) and per noise area (Low and High). Highly annoyed or disturbed is defined as an extreme score of 4/5 (true, extremely true). Results show, that the percentage of highly annoyed is sytematically higher in the air traffic sample. We also see a significant difference on the coping scales: In the road traffic sample people score higher on the problem oriented and avoidance scale. In the air traffic sample the comforting cognitions score significantly higher. As for subjective health complaints we see a significant higher score in the road traffic sample on the GSQS and Depression. When we look at the mean score on these scales we can conclude a slightly higher score on the somatic complaint scales and the sleep complaint scale than expected in a normal population.

The average score on the somatic scale of the HSCL in a normal population is 2 (Luteyn et al., 1984). Standards for the GSQS are not available. A score between 1-3 is referred to as light sleep complaints (Kompier, 1988).

Figure 6.3.3

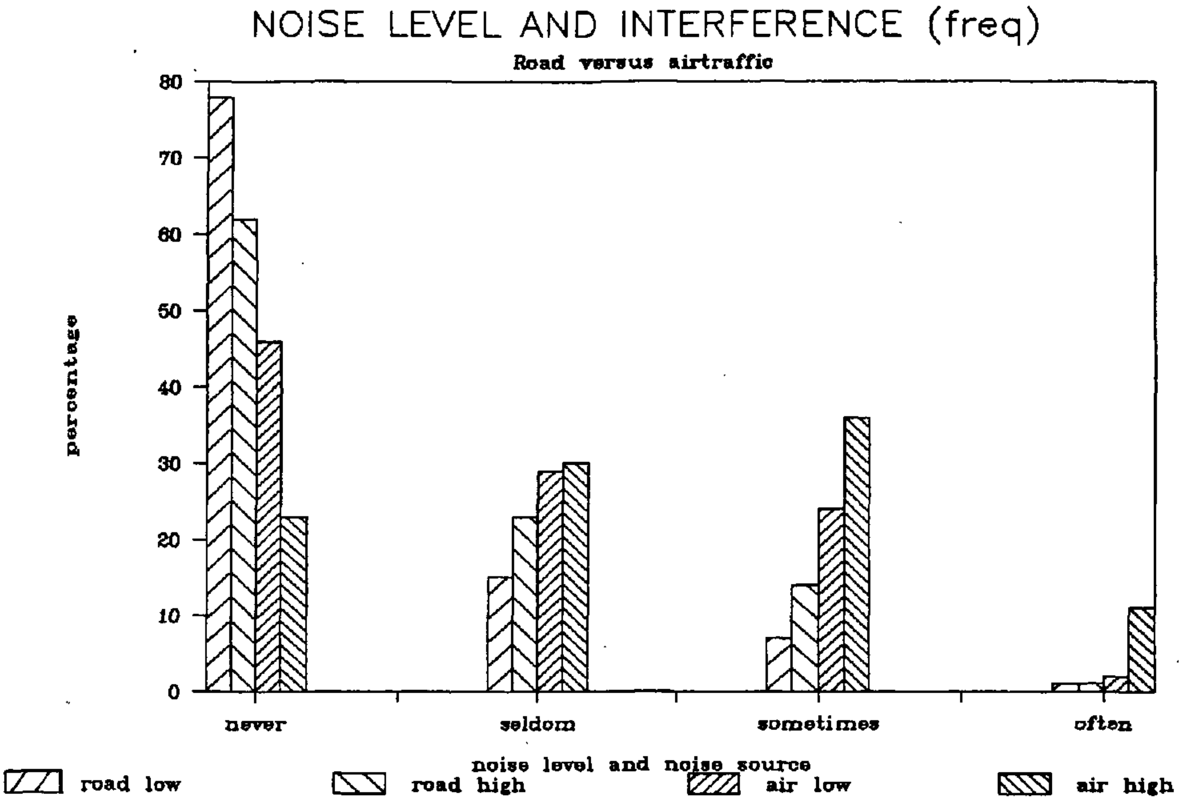


Figure 6.3.4.

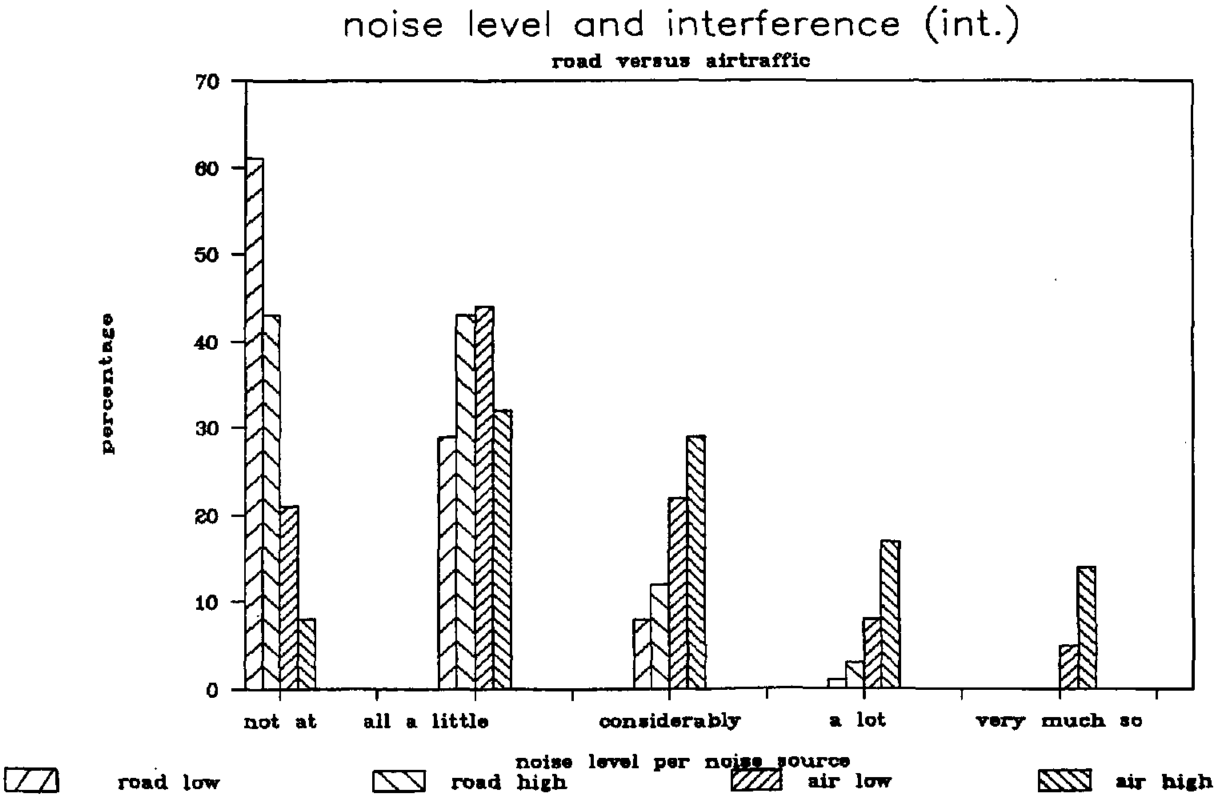


Figure 6.3.5

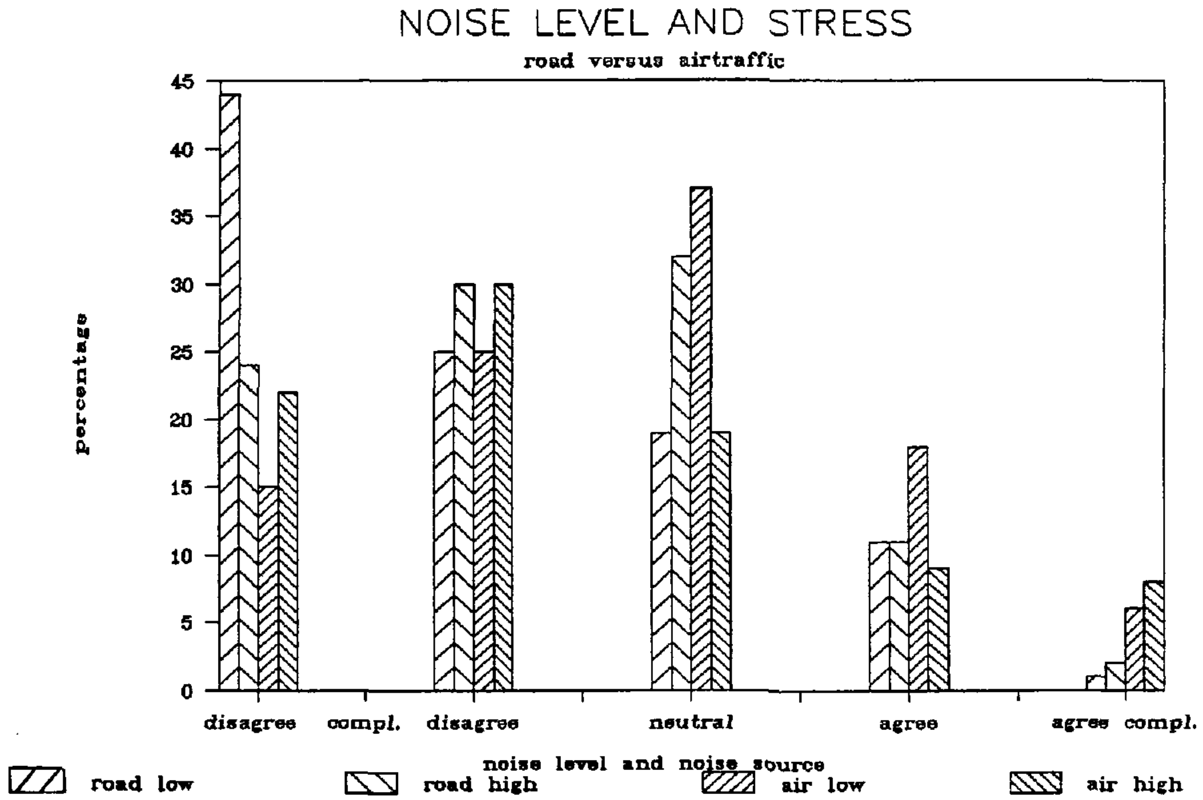
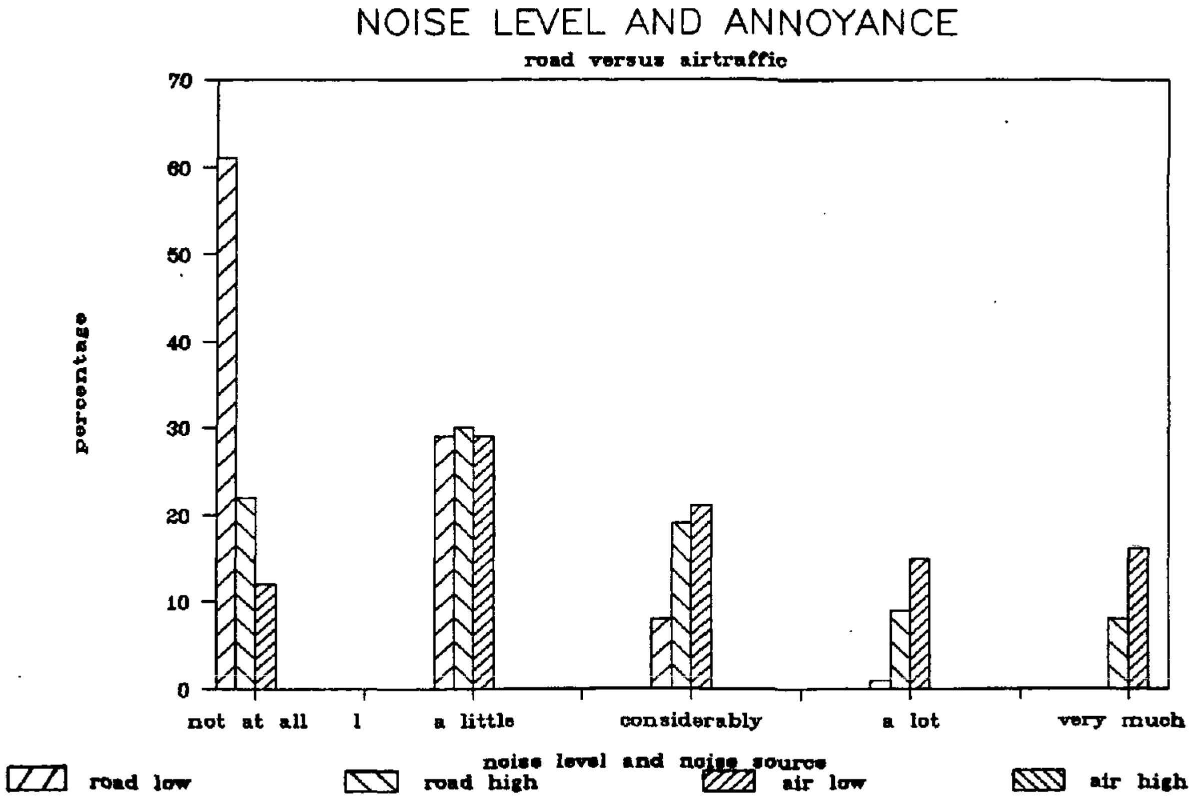


Figure 6.3.6



The percentage of highly disturbed was also studied per noise area (low vs high). We find a significant difference on all annoyance scales in the air traffic sample. In the road traffic sample the pattern is comparable with the exception on the perceived loudness scale.

### 6.3.6 Conclusions

Most of the psycho social scales fulfill our psychometric criteria. The internal consistency ranges from .65-.90. The results are comparable in four subsamples in terms of invariance, inter-item correlations and internal consistency. Only the general coping scale and the perceived noise control scale are not fully reliable. Additional research has been done and will be reported elsewhere (van Kamp, 1988).
The intercorrelations between the scales in one sample show a pattern that is consistent with our theory.

* The primary apparisal and annoyance scales are higly intercorrelated and can therefore be considered as indicators of one construct (Annoyance).
* The subjective health scales can also be considered as different indicators of one stress syndrome.
* The correlations of appraisal and annoyance scales with noise-level ranges between .16-.39. In later sections we will elaborate on this subject and compare these results with other findings (Langdon, 1976; De Jong and Beurs, 1978; Weinstein, 1978).

To some extent these results imply a simplification of our model.
In the next section the measurement models will be described in connection with the structural model.

## 6.4 Models, themes and hypotheses

On the basis of theoretical considerations, the literature survey and the psychometric evaluation of our instruments the psycho social research model can be described in more detail. In figure 6.4.1 the complete model is represented on structural and measurement level.

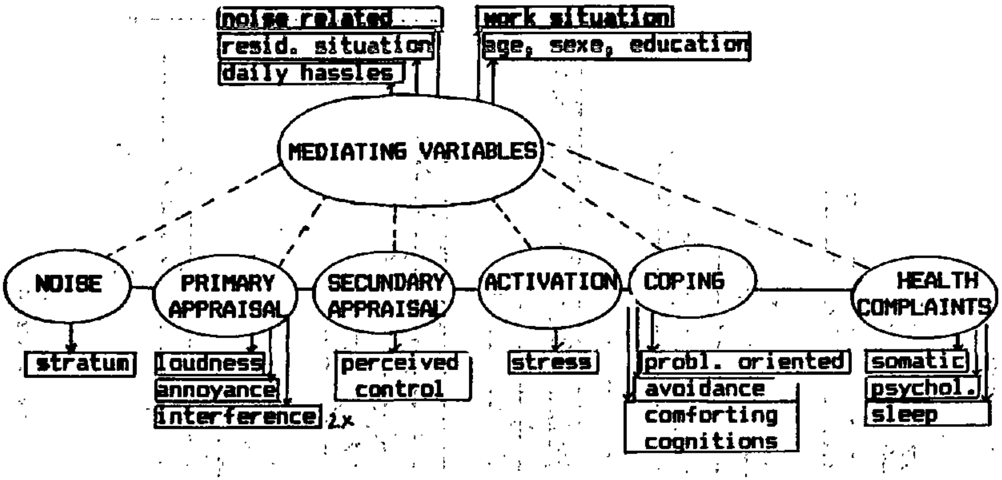


Figure 6.4.1 Measurement model in connection with constructs

On the basis of this model the following relevant research questions can be formulated:

1. Is there a simple dose effect relation between noise and annoyance and noise and subjective health complaints?

On the basis of literature we expect that the noise dose explains at maximum 25% in psycho social effects (chapter 3; section 6.2).

2. What is the influence of mediating variables?

On the basis of literature we expect that a great number of variables influence the score on annoyance and health complaint measures. Five categories of relevant variables were selected (section 6.2). These variables will be treated as covariates.

3. What is the influence of stress related variables?
3a. What is the relation of primary, secundary appraisal and subjective activation with subjective health complaints?
3b. What strategies do people use to cope with the negative consequences of chronic noise exposure?
3d. What is the differential effect of coping strategies on subjective health complaints?

From the research model as described in chapter 3, section 6.2 and figure 6.4.1 we derive the following hypotheses.

1. The appraisal of noise is a function of the noise characteristics, the social context and personal characteristics of the exposed individual.

This will show in high negative correlations between residential satisfaction and different aspects of appraisal and high positive correlations between daily hassles and different aspects of appraisal.

2. A negative appraisal of noise and a low perceived control will result in an increase of subjective activation.

This will show in high positive correlations between appraisal and stress feelings due to noise.

3. Activation motivates any type of coping behavior.

This will show in a high positive relationship between stress feelings due to noise and all coping scales.

4. Coping styles result in an increase or decrease of subjective (health) complaints.

On the basis of stress literature we can make the following predictions (§2; p. 10):

- 4a. A problem oriented coping style is related with a low level of subjective health complaints.
- 4b. An avoidant coping style is related with a high level of subjective health complaints.
- 4c. A comforting cognition style has no relation with levels of subjective health complaints.

In the next sections the findings will be presented in line with these questions and hypotheses.

## 6.5 Results; Descriptive

### 6.5.1 Introduction

Different statistical techniques were applied to analyse the data. We make a distinction between a descriptive (6.5) and a hypotheses testing part (6.6), using univariate and multivariate methods respectively. In both

sections the empirical findings are reported in a stepwise fashion analoguous to the classes of models as described in chapter 3. First an analysis of simple dose effect relations will be presented between noise and annoyance and noise and health respectively. This will be done per location in 6.5 and per noise source in 6.6. The reasons for a detailed study of dose effect relations per location are twofold. In the first place it enables us to compare the findings with previous research. In the second place information per location might be relevant for policy making.
In the next step the univariate influence of relevant covariates such as insulation, lenght of residency, duration of exposure, quality of the house, work related variables and biographical features will be presented. Next the univariate influence of process variables on health effects (appraisal and coping) will be described.

Dose effect relations per location
   * ANNOYANCE
   * HEALTH COMPLAINTS
Univariate influence of mediating variables on ANNOYANCE and HEALTH
   * biographical features
   * noise related variables
   * residential situation
   * daily hassles
   * work related variables
Univariate influence of process variables on HEALTH
   * Primary Appraisal
   * Secundary Appraisal
   * Coping

Figure 6.5.1 Plan of analysis

### 6.5.2 Dose effect relations

The goal of most noise research has been to study dose response curves, relating individual annoyance scores to physical noise metrics. In the noise literature this curve is presented in a number of ways. The mean or modal score on an annoyance scale is frequently used, but not completely adequate when discrete noise classes are used (Weinstein, 1976). Often the percentage of highly annoyed is related to the noise metric, by means of a weighted function (de Jong, 1978; Vallet, 1979; Schultz, 1978). Weinstein points at the arbitrary nature of standards above which we speak of highly annoyed/disturbed. When we want to test hypotheses about the dosage effect curve we preferably make use of continuous data. In this research we are unfortunately restricted to discrete noise-metrics. For the annoyance and health measures continuous data will be used. As a first description of our data the % of highly annoyed per noise class and per location will be presented. In addition the correlations were computed for the individual data (using the mean score).

### 6.5.2.1 Noise annoyance relation per location

Is there a significant relation between noise and annoyance?

Below the percentage of highly annoyed is presented per area, in combination with correlational data.

Figure 6.5.2

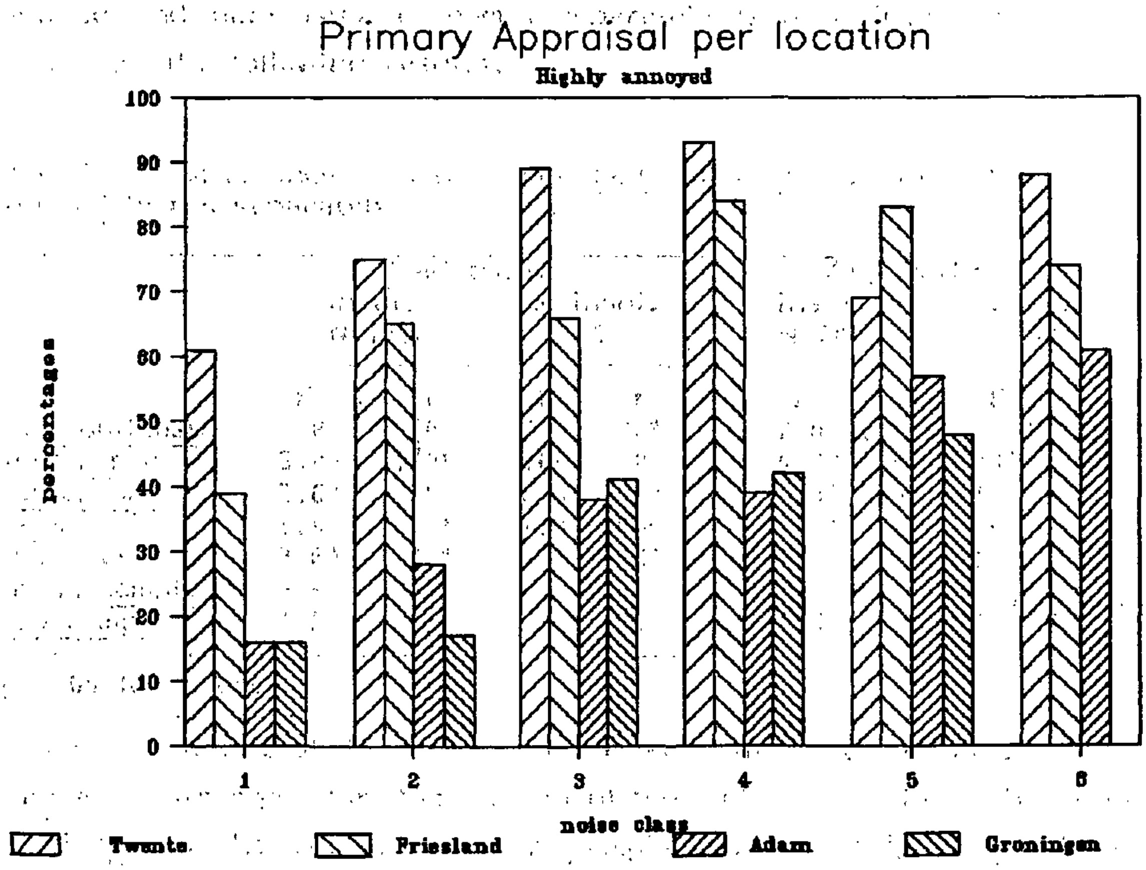


Figure 6.5.3

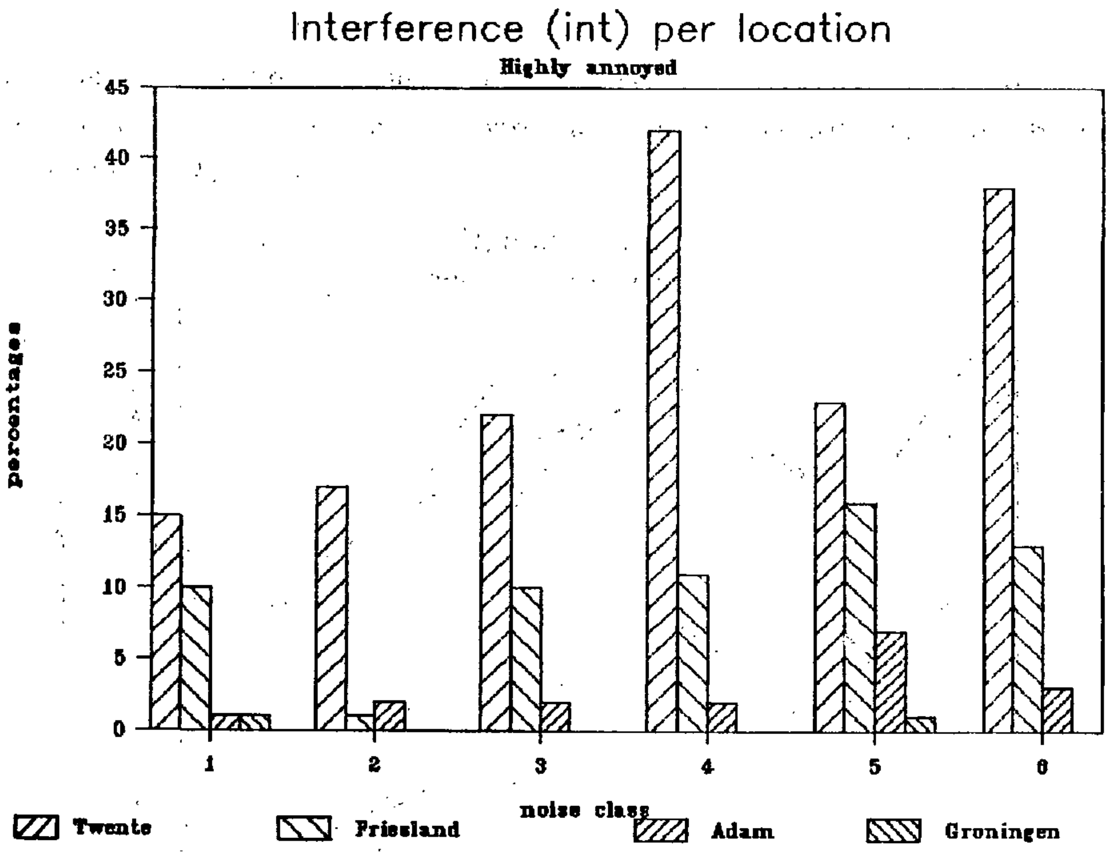


Figure 6.5.4

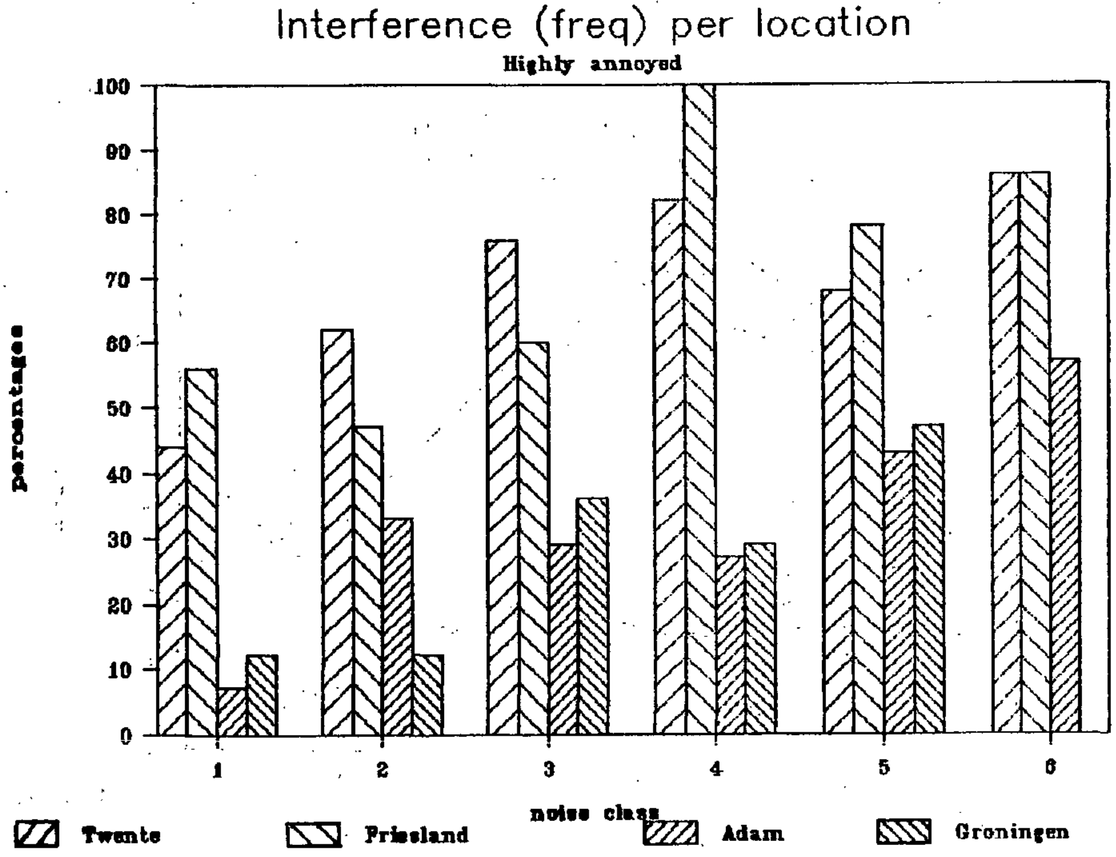


Figure 6.5.5

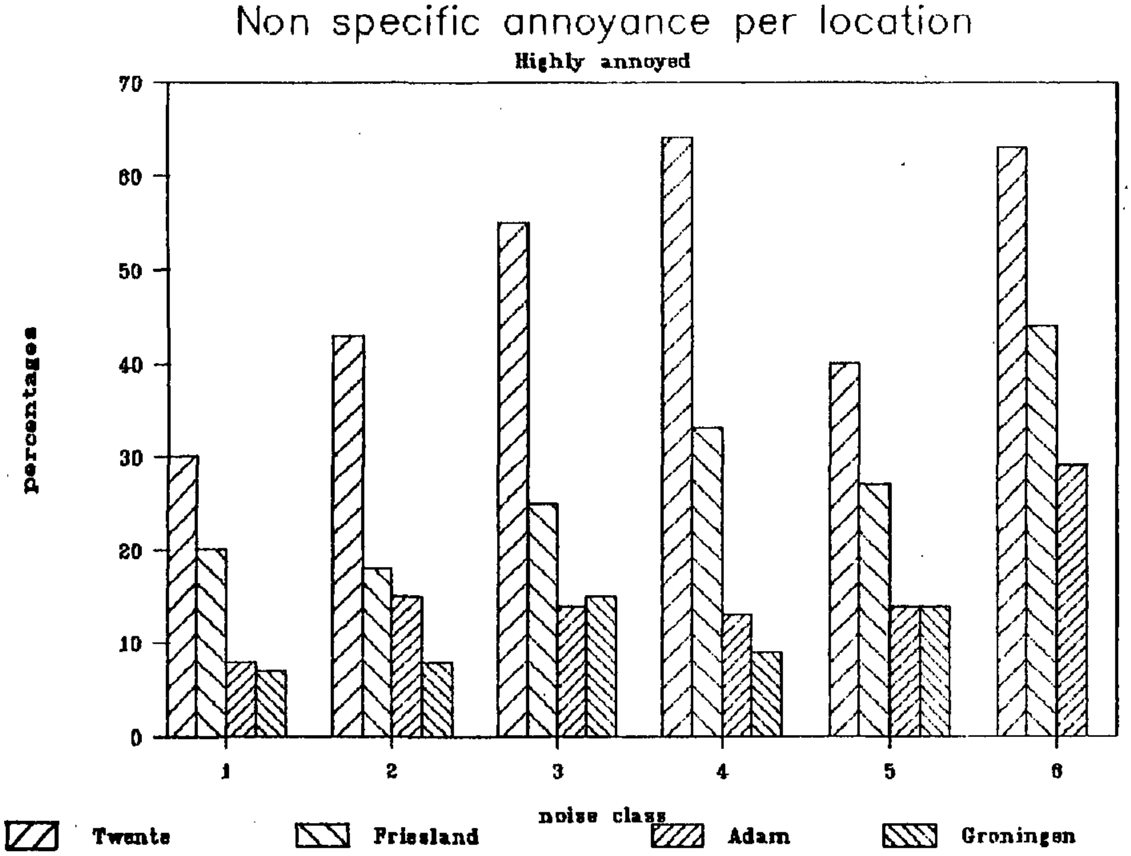


Figure 6.5.6

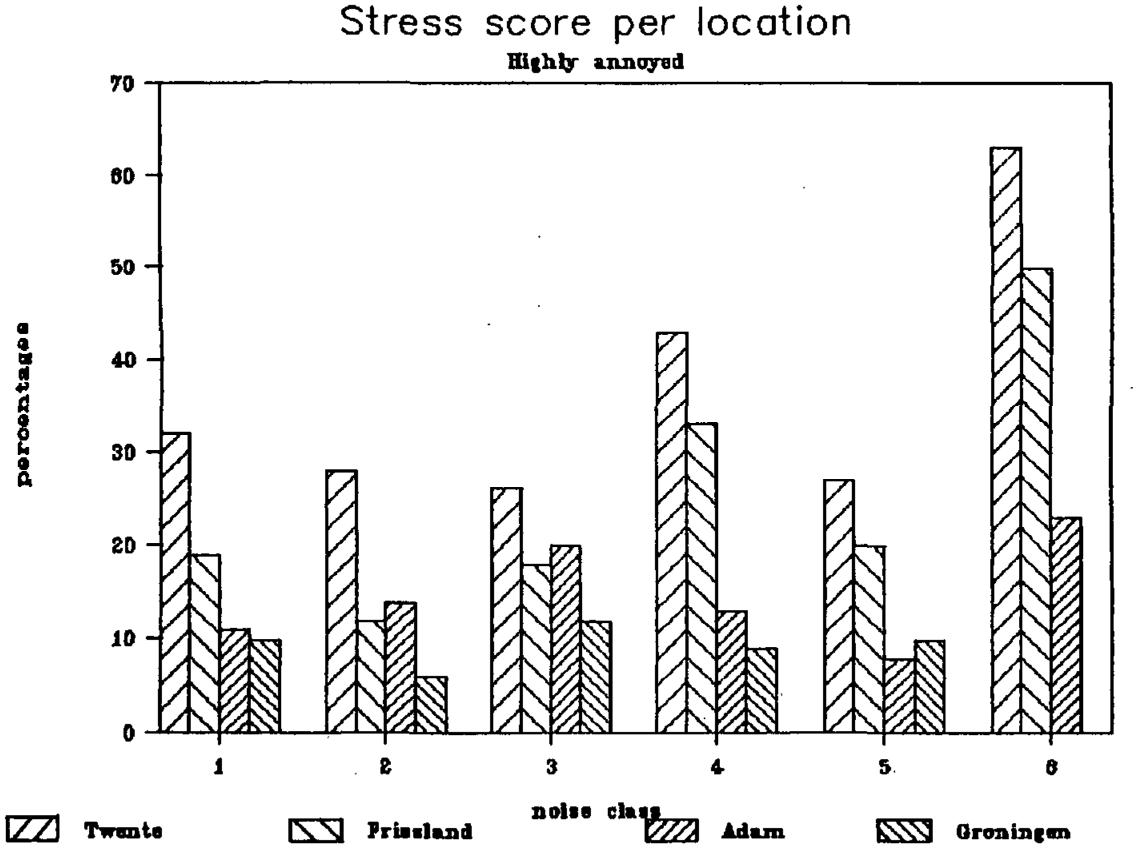


Table 6.5.1 Product-Moment correlation between noise-stratum and annoyance

| | AIR TRAFFIC | | ROAD TRAFFIC | |
|---|---|---|---|---|
| | TWENTE | FRIESLAND | AMSTERDAM | GRONINGEN |
| Activity interference (frequency) | .33 | .28 | .36 | .34 |
| Activity interference (intensity) | .24 | .19 | .13 | .13 |
| Perceived noise loudness | .22 | .13 | .40 | .31 |
| Non Specific Annoyance | .21 | .15 | .15 | .07 |
| Perceived control | .13 | .07 | .21 | .14 |
| Stress Feelings due to noise | .13 | .17 | .01 | .03 |

All correlations significant on p .03 level except .01/.03

Analysis of the percentage of highly annoyed per noise class and per location gives a comparable pattern in all locations, although the strength of the relationship, as measured by the product moment correlation differs per location. The percentage of highly annoyed is considerably higher in both aircraft samples than in the road traffic samples. This result is comparable with findings of others (Vallet, 1979; Langdon, 1976). When we study the univariate trend between stratum and the different annoyance scales we see a significant deviation of linearity in both aircraft samples, with a dip in noise-class five. The average percentage of highly annoyed is highest in Twente. The same pattern was found by De Jong and Beurs (1978) on this location.

We can see that the Activity Interference Scale (Bitter, 1963) consistently correlates higher with the noise dosage than the other scales. Friesland shows a remarkable deviation from the general correlational pattern. These specific patterns per location might have different causes. One of the causes could be that also in the lower classes there is a relatively high number of people who score high on the annoyance scales. Another explanation may be found in the fact that during the time of the interview redevelopment plans of the area around the Friesland airport were vaguely known to the public.

When we compare the fraction of explained variance ($r^2$) we see a range between .02 - .16. The results are comparable with those found by others (de Jong and Beurs, 1978; Vallet, 1982; von Gierke, 1987).
We can assume that the noise-annoyance relationship is attenuated by several causes. In the first place it is probable that the reduction to six noise classes influences the strength of the correlation. Moreover it can be assumed on the basis of previous research that individual differences account for the correlational pattern (Weinstein, 1976; von Gierke and Harris, 1987).
In section 6.5.3 these influences will be studied.

### 6.5.2.2 Noise and subjective health

Is there a significant relation between noise and subjective health complaints?

The univariate relationship between noise level and subjective health was studied in the same fashion as described above. Below the percentage of highly disturbed is given per location and per stratum. Again these graphs are combined with correlational data (using mean score on the scales).

Figure 6.5.7

Somatic complaints per location

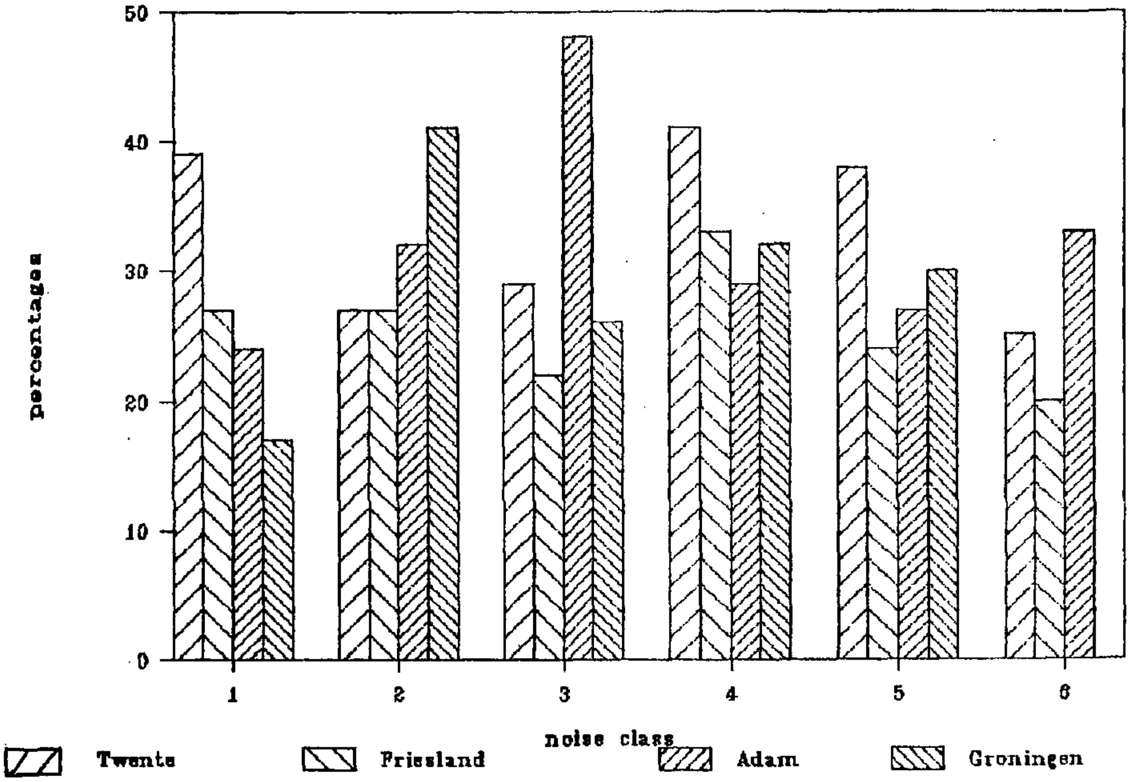


Figure 6.5.8

Depressive complaints per location

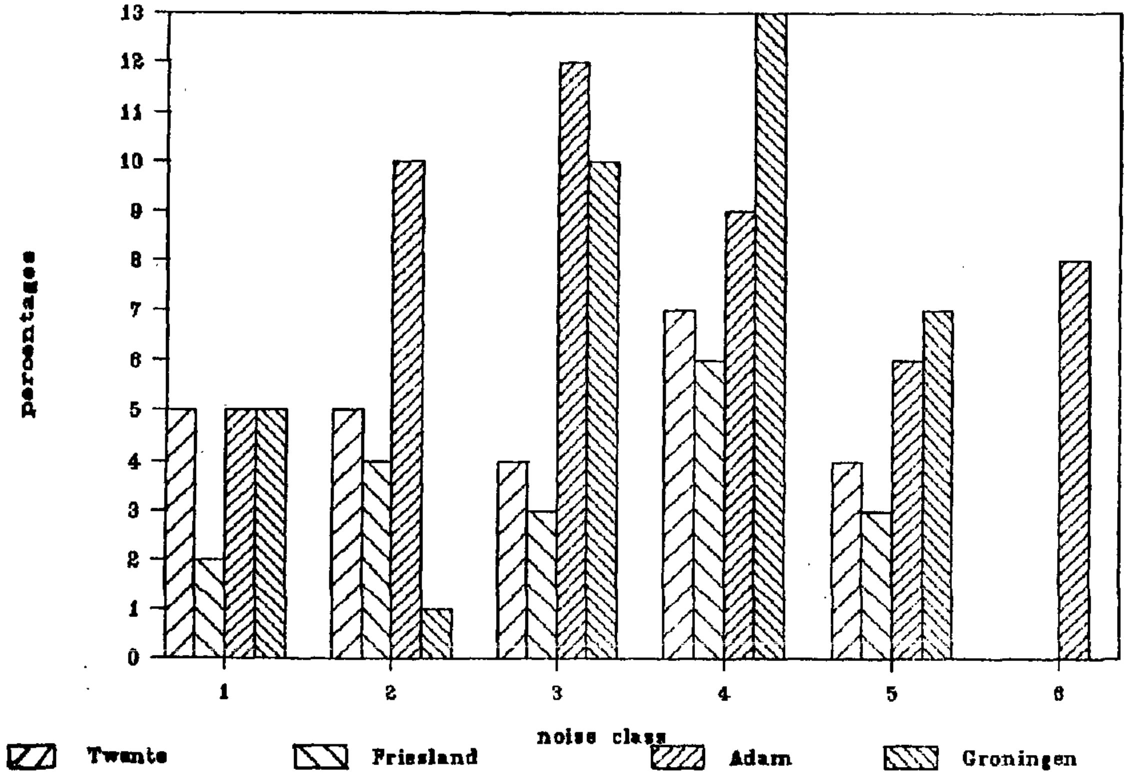


Figure 6.5.9

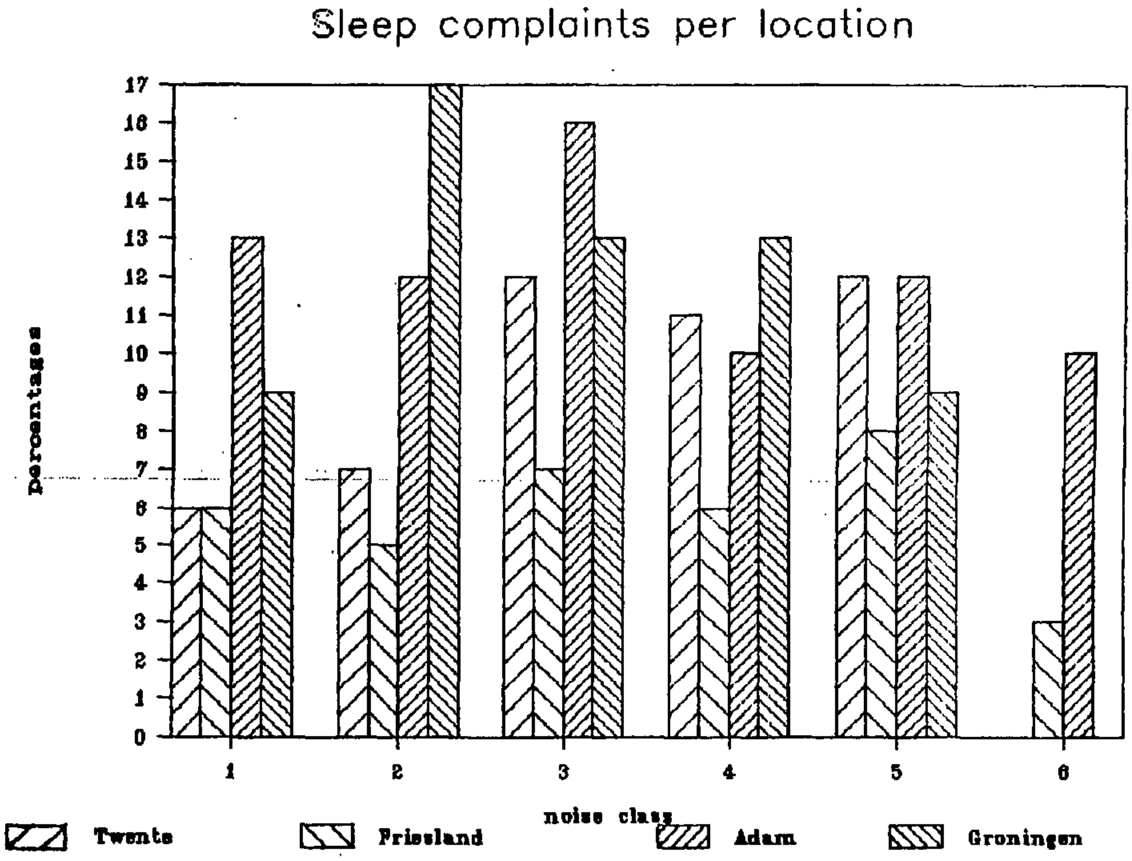


Figure 6.5.10

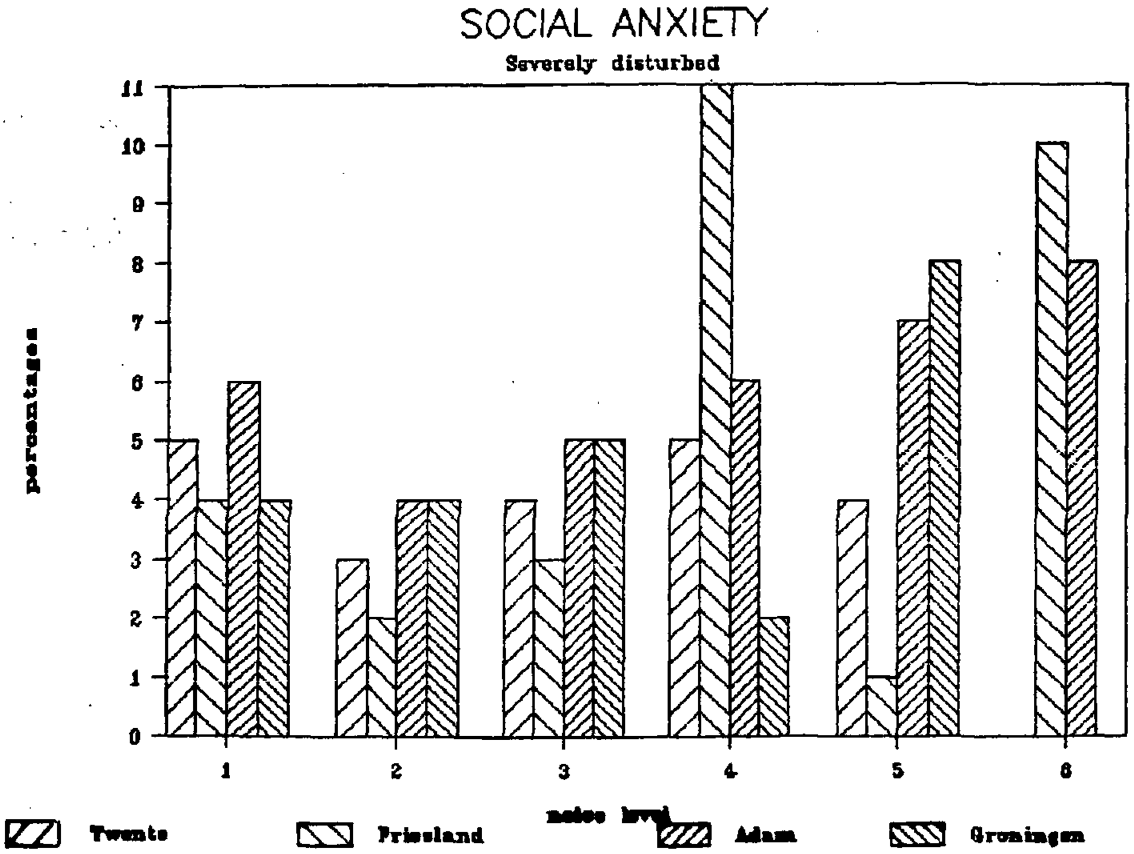


Table 6.5.2 Product-Moment correlations between noise stratum and subjective health complaints

| | AIR TRAFFIC | | ROAD TRAFFIC | |
|---|---|---|---|---|
| | TWENTE | FRIESLAND | AMSTERDAM | GRONINGEN |
| Sleepcomplaints | .06 | .00 | -.03 | .00 |
| Somatic complaints | .05 | .01 | .01 | .08 |
| Depressive compl. | .00* | .02* | .00 | .06 |
| Social Anxiety | .10 | -.09 | .02 | .04 |

* p .05

We systematically see a weak relationship between noise stratum and health complaints.

### 6.5.2.3 Univariate influence of mediating variables

What is the univariate influence of mediating variables on annoyance and health complaints?

We can assume that the noise-effect relationship is attenuated by several causes and influenced by variables, such as residential quality, insulation, length of residency, perceived stress other than noise and aspects of the work situation. Below a review of the univariate influence of these variables will be given.

Biographical variables. The influence age, sex and education on all primary appraisal scales is negligible as was found by others (e.g. de Jong and Beurs, 1978). The influence of age and education on somatic and sleep complaints is systematic (r in range of .12 - .19).

Duration of exposure. The univariate influence of length of residency is significant in the aircraft sample on all annoyance scales (r in range of .06 - .18). In the road traffic sample length of residency is not related to annoyance. No univariate relationship was found between duration of exposure per day and annoyance or health complaints.

Residential features. We refer here to variables related to the residential situation on a nominal level. That is:

variable 3 (see questionnaire): rented/owned home
variable 4 (see questionnaire): type of home.

In the air traffic sample there is a systematic relation of the annoyance and health scales with the variable 3 (owned, rented) t-values range from 2.09 to 4.06, p .04. People who live in rented homes report more annoyance and more health complaints. Type of home is also significantly related to several annoyance values (t-values: 2.6 - 4.8, p .0001). People in lower quality homes report more annoyance. In the road traffic sample however, we find a reversed pattern. Sample features per noise stratum might explain these differences (see Chapter 4).

Insulation. There is no univariate relationship between annoyance and insulation in the air traffic sample. In the road traffic sample people in not insulated homes appraise noise as louder (t-value: 3.3, p .001) and report more stress (t-value: 2.2, p .02). When we study the relationship only for the higher noise classes (4,5,6) we see significant t-values for all annoyance scales in the air traffic sample as well (t-values: 2.0 - 3.4, p .001). In the road traffic sample as well (t-values: 2.0 - 3.4, p .001). In the road traffic sample we do not find significant relationships.

When we study the relationship between noise level and annoyance for insulated and non-insulated homes separately with a difference of means test we get the following results.

Table 6.5.3 Difference of means per <u>noise stratum</u> for <u>insulated</u> and <u>not insulated</u> homes separately

| | Road traffic | | | | Air traffic | | | |
|---|---|---|---|---|---|---|---|---|
| | insul.<br>N=170 | | no insul.<br>N=665 | | insul.<br>N=244 | | no insul.<br>N=667 | |
| | F | r | F | r | F | r | F | r |
| Perc. loudness | .8 | .14* | 34* | .30* | 2.0* | .13* | 11.3* | .21* |
| Interference | 3.0* | .24* | 16* | .30* | 4.3* | .24* | 23* | .34* |
| Interference | 2.6* | .09* | 9.3* | .21* | 6.3* | .20* | 13* | .16* |
| Stress | 1.9 | .19* | 1.3 | .00 | 4.4* | .12* | 9* | .20* |
| Annoyance | 3.6* | .26* | 11* | .23* | 7* | .15* | 12* | .21* |
| Somatic compl. | --- | --- | --- | --- | --- | --- | --- | --- |
| Sleep compl. | 1.5 | .16* | --- | .03 | 1.6* | .18* | 1.8* | .04 |

* p .05 for F and r

We can conclude that in general the relationship between noise and annoyance is stronger for the not insulated sub group in both samples. Remarkable is the result on sleep complaints. The relationship between noise and sleepcomplaints is stronger in the insulated homes (r = .16/.18) in both samples although the meanscore is higher in the not insulated houses. This might be related with a lack of ventilation possibilities (Scharnberg et al., 1982).

Figure 6.5.11

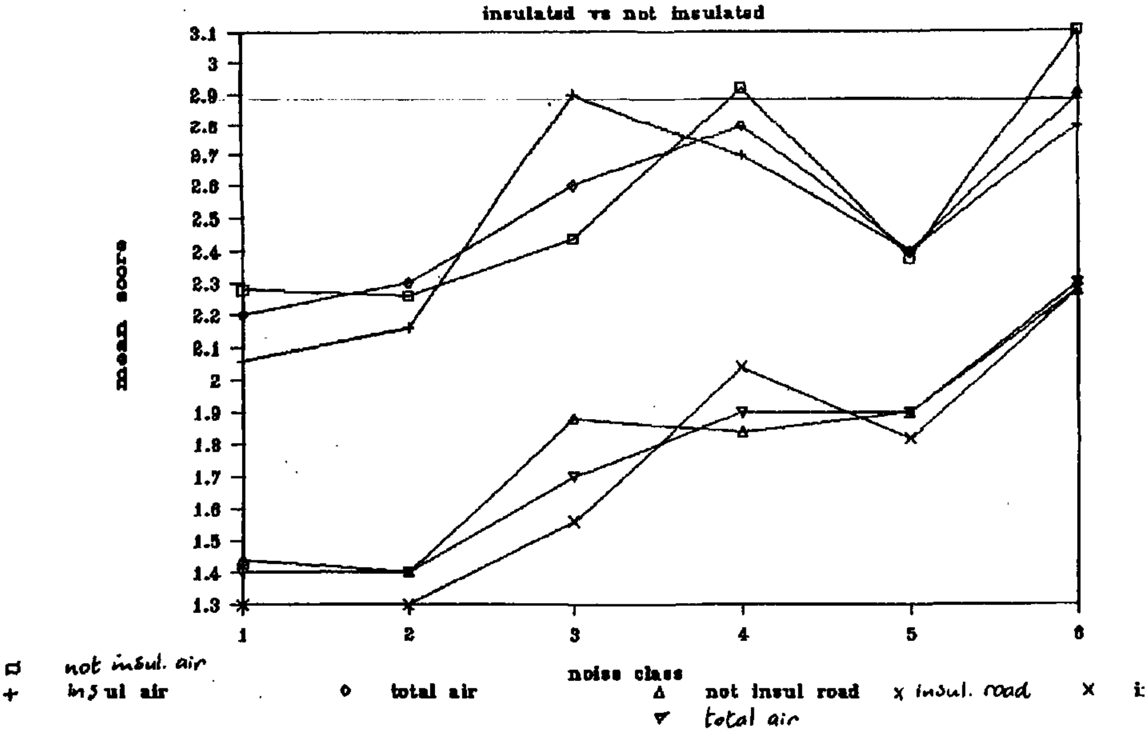

Stress Score

Figure 6.5.12

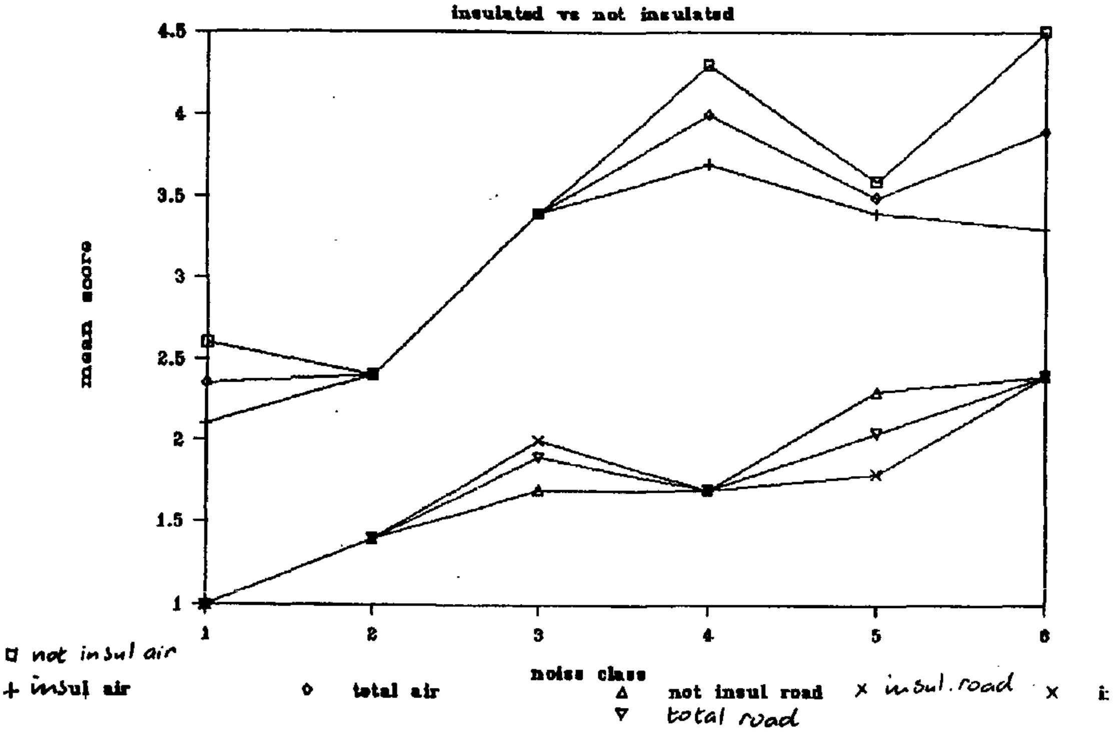
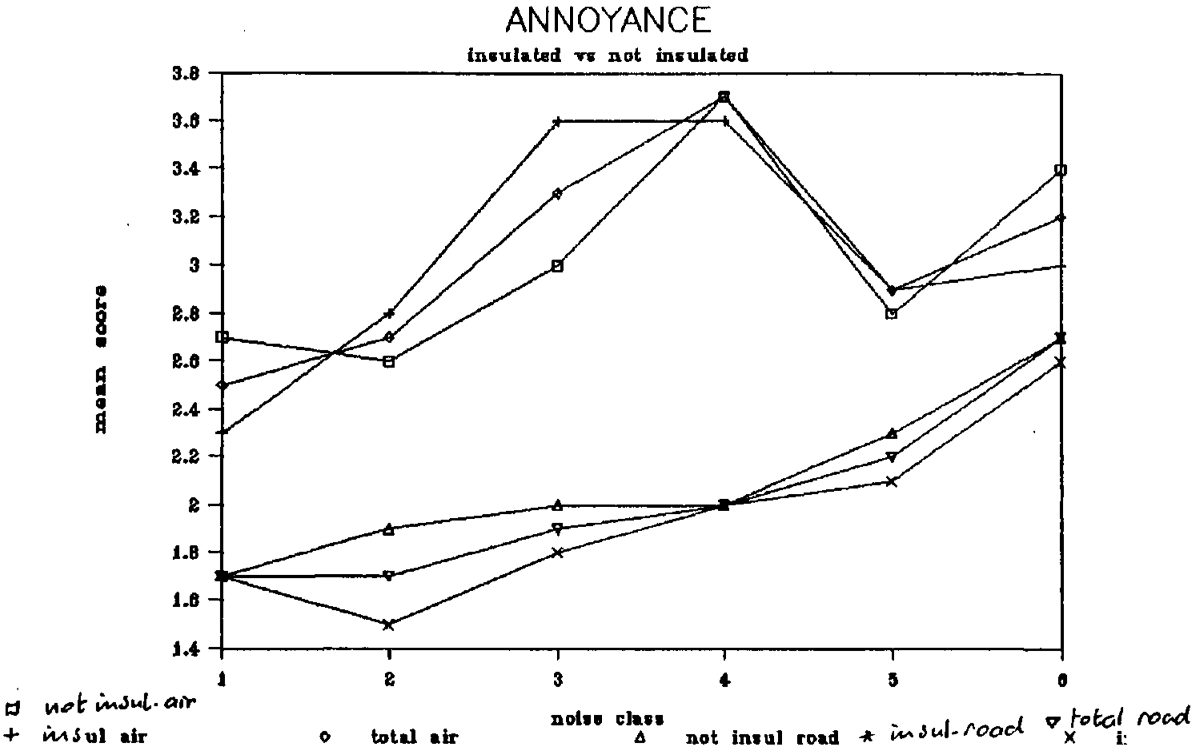
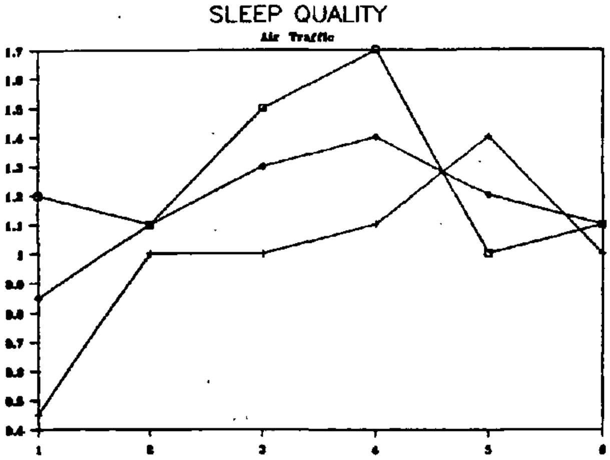

Interference (freq)

Figure 6.5.13





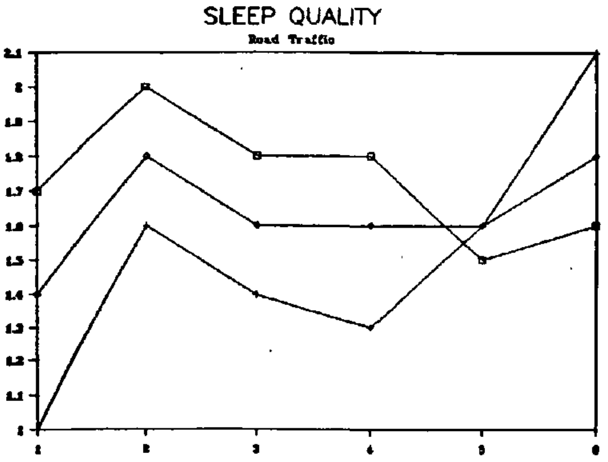


Figure 6.5.14

Figure 6.5.15

## Residential Satisfaction

In chapter 5 the relationship between annoyance and residential satisfaction was discussed in detail. Here we restrict ourselves to results of a series of difference of means tests per noise source and additional product moment correlations.

Table 6.5.4 Univariate influence of residential satisfaction on annoyance and health complaints

| | AIR TRAFFIC | | | | ROAD TRAFFIC | | | |
|---|---|---|---|---|---|---|---|---|
| | F | r | p | N | F | r | p | N |
| Perceived loudness | 7.8 | -.02 | .242 | 872 | 13.7 | -.10 | .003 | 837 |
| Act.Interference (1)(freq) | 5.2 | -.05 | .074 | 855 | 11 | -.08 | .006 | 975 |
| Act.Interference (2)(intens) | 2.6 | -.10 | .004 | 759 | 7.4 | -.16 | .001 | 836 |
| Annoyance | 6.1 | -.09 | .005 | 859 | 20.6 | -.17 | .001 | 840 |
| Stress | 12.6 | -.09 | .007 | 858 | 14.7 | -.12 | .001 | 836 |
| Somatic complaints | 2.6 | -.08 | .011 | 860 | ns | | | |
| Depression | 9.0 | -.10 | .001 | 878 | ns | | | |
| Anxiety | 3.6 | -.08 | .003 | 880 | ns | | | |
| Sleepcomplaints | 3.2 | -.04 | .128 | 911 | ns | | | |

all F-values p .03

We see, that residential satisfaction is primarily related to annoyance, especially in the road traffic sample (compare chapter 5) and with health complaints only in the air traffic sample.

## Daily Hassles

The same analyses were done for the relationship between 'perceived daily hassles' and respectively annoyance and health complaints. The results are presented in table 6.5.5.

Table 6.5.5 Univariate influence of daily hassles on annoyance and health complaints

| | AIR TRAFFIC | | | | ROAD TRAFFIC | | | |
|---|---|---|---|---|---|---|---|---|
| | F | r | p | N | F | r | p | N |
| Perceived loudness | 3.8 | .05 | .006 | 855 | 5.7 | .10 | .005 | 837 |
| Interference (1) | 3.1 | .10 | .001 | 872 | 5.3 | .15 | .001 | 975 |
| Interference (2) | 3.3 | .07 | .004 | 759 | 7.8 | .13 | .001 | 598 |
| Annoyance | 5.2 | .09 | .003 | 859 | 9.3 | .17 | .001 | 840 |
| Stress | 9.8 | .14 | .001 | 858 | 10.47 | .21 | .001 | 836 |
| Somatic complaints | 10.7 | .18 | .001 | 860 | 34.1 | .25 | .001 | 997 |
| Depression | 66.4 | .34 | .001 | 878 | 17.2 | .38 | .001 | 1037 |
| Anxiety | 14.6 | .24 | .001 | 880 | 34.2 | .24 | .001 | 1044 |
| Sleepcomplaints | 18.3 | .19 | .001 | 911 | 29.4 | .22 | .001 | 1072 |

F-value p .03

Perceived daily hassles are primarily related with health complaints. The relationship with annoyance is, however, also systematic.

Work related variables

As was stated in chapter 4 the male part of the sample contains a relatively high number of unemployed people and shift workers.

Therefore the relationship of work related variables with the annoyance and health scales was studied in more detail. This was done for males and females separately. Again a difference of means test was used. Results show that in both samples the annoyance and subjective health scales are highly independent of work related variables.

### 6.5.4 Univariate influence of process variables

What is the univariate influence of process variables on health complaints?

Primary-secundary appraisal and subjective activation

Before analysing the influence of process variables on health complaints in a multi variate fashion, it is illustrative to take a look at the univariate influence of these variables on health complaints. This approach parallels the comparison of coping and control groups in the laboratory (see van Kamp, 1986; Veldman, 1988). Moreover, in this way we get insight in the usefulness of each of the psychosocial concepts in predicting health complaints. Groups were formed on the basis of: perceived loudness, perceived control, stress due to noise (stress). In Tables 6.5.6 to 6.5.8 the F-values are reported in combination with the correlations.

Table 6.5.6 Perceived loudness

| | ROAD TRAFFIC | | | | AIR TRAFFIC | | | |
|---|---|---|---|---|---|---|---|---|
| | F | r | p | N | F | r | p | N |
| Somatic complaints | 15 | .15 | .001 | 835 | 12 | .19 | .001 | 809 |
| Depression | 8 | .07 | .01 | 781 | ns | | | |
| Anxiety | ns | | | | ns | | | |
| Sleepcomplaints | 10 | .11 | .001 | 837 | 10 | .09 | .006 | 855 |

all F-values p .03

Table 6.5.7 Perceived Noise control

| | ROAD TRAFFIC | | | | AIR TRAFFIC | | | |
|---|---|---|---|---|---|---|---|---|
| | F | r | p | N | F | r | p | N |
| Somatic complaints | ns | .08 | .01 | 784 | 10 | .16 | .001 | 810 |
| Depression | 9.1 | .10 | .002 | 813 | 5.8 | .12 | .001 | 827 |
| Anxiety | 8.3 | .11 | .001 | 818 | 7.3 | .13 | .001 | 829 |
| Sleepcomplaints | ns | --- | --- | --- | ns | .07 | .06 | 857 |

all F-values p .03

Table 6.5.8 Stress due to noise

| | ROAD TRAFFIC | | | | AIR TRAFFIC | | | |
|---|---|---|---|---|---|---|---|---|
| | F | r | p | N | F | r | p | N |
| Somatic complaints | 34 | .21 | .001 | 788 | 5 | .30 | .001 | 811 |
| Depression | 25 | .14 | .001 | 836 | 11 | .16 | .001 | 858 |
| Anxiety | 28 | .18 | .001 | 817 | 22 | .16 | .001 | 828 |
| Sleepcomplaints | 8.5 | .18 | .001 | 822 | 11 | .20 | .001 | 830 |

all F-values p .03

We notice a significant relationship between perceived loudness, perceived control and stress due to noise on one hand and most subjective health complaints on the other hand. The stress due to noise scale is the best predictor as was suggested by Evans and Cohen (1987). The fraction of variance explained ranges between 1% to 9% ($r^2$). Concluding we can state, that the appraisal of noise in terms of threat, control and emotional response seem to be relevant mediators in the noise health relationship as far as subjective health complaints are concerned.

### Coping

A distinction was made between three coping styles: problem oriented, avoidance and comforting cognitions. In the first place the mean score on these three scales was related to the subjective health scales. Results are presented in table 6.5.9.

Table 6.5.9 Univariate relationship between coping and subjective health complaints

| | ROAD TRAFFIC | | | | AIR TRAFFIC | | | |
|---|---|---|---|---|---|---|---|---|
| Problem oriented | F | r | p | N | F | r | p | N |
| Somatic complaints | 2.1 | -.05 | .150 | 969 | .49 | -.02 | .482 | 827 |
| Sleepcomplaints | 7.6 | -.09 | .006 | 969 | 1.6 | -.04 | .305 | 827 |
| Depression | .12 | .01 | .724 | 969 | .72 | -.03 | .350 | 827 |
| Anxiety | .73 | -.03 | .392 | 969 | 2.4 | -.05 | .120 | 827 |
| Avoidance | F | r | p | N | F | r | p | N |
| Somatic complaints | 21 | .15 | .000 | 969 | 32 | .19 | .000 | 827 |
| Sleepcomplaints | 11 | .11 | .000 | 969 | 28 | .18 | .000 | 827 |
| Depression | 56 | .23 | .000 | 969 | 30 | .19 | .000 | 827 |
| Anxiety | 36 | .19 | .000 | 969 | 27 | .18 | .000 | 827 |
| Comforting cogn. | F | r | p | N | F | r | p | N |
| Somatic complaints | 20 | .14 | .000 | 969 | 10 | .11 | .002 | 827 |
| Sleepcomplaints | 17 | .13 | .000 | 969 | 8.6 | .10 | .004 | 827 |
| Depression | 16 | .13 | .000 | 969 | .05 | .01 | .818 | 827 |
| Anxiety | 27 | | .000 | 969 | 11 | .12 | .001 | 827 |

The correlational pattern partly supports our assumptions. Problem oriented coping is not or negatively related with subjective complaints. Avoidance is relatively highly correlated. Contrary to our prediction in § 6.4, the comforting cognition style also shows relatively high positive correlations with subjective health complaints. One of the features of coping is, according to Lazarus, that people can use different strategies combined and alternately. If we want to take this phenomenon into account we have to look at all possible combinations of coping strategies. On the basis of the mean score (high/low) on the three coping scales 8 coping types were formed as reported in table 6.5.10.

Table 6.5.10 Frequencies of coping types per noise source

| | | Freq.<br>ROAD | % | Freq.<br>AIR | % |
|---|---|---|---|---|---|
| 1 | Active coping high | 111 | 10 | 76 | 8 |
| 2 | Avoidance high | 42 | 4 | 40 | 4 |
| 3 | Comforting Cognitions high | 198 | 19 | 245 | 27 |
| 4 | Active + Comforting | 86 | 8 | 80 | 9 |
| 5 | Active + Avoidance | 144 | 13 | 79 | 9 |
| 6 | Avoidance + Comforting | 96 | 9 | 75 | 8 |
| 7 | All scales high | 140 | 13 | 92 | 10 |
| 8 | All scales high | 242 | 23 | 212 | 23 |

Figure 6.5.16 Frequency of coping types in the air traffic sample

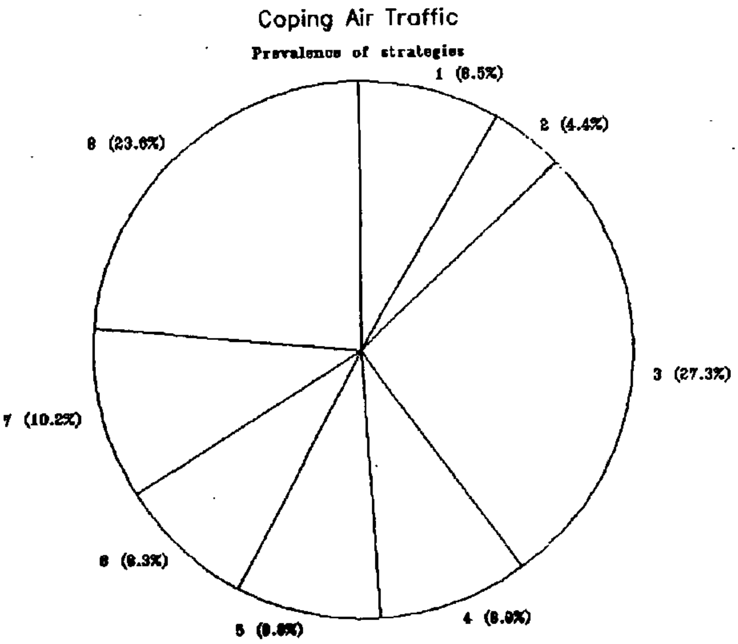
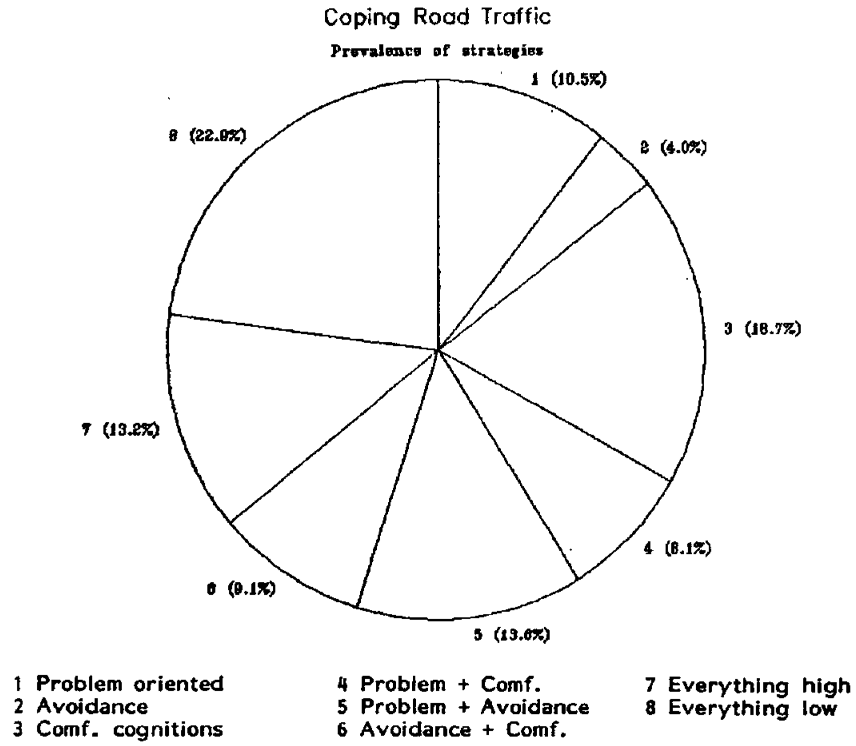


Figure 6.5.17 Frequency of coping types in the road traffic sample



Over these 8 groups a series of difference of means tests were carried out to study the relationship between type of coping and health complaints. It is important to note, that no significant relation was found between coping style and stratum. The groups are ordered as much as possible according to assumed risk. Per noise source we obtain the following results:

Table 6.5.11 Difference of means between coping types on stress and subjective health

| Subjective activation (stress) | ROAD | | AIR | |
|---|---|---|---|---|
| | mean | s.d | mean | s.d |
| Problem oriented = active coping high | 9.6 | 3.6 | 12.9 | 4.8 |
| All low | 10.2 | 3.9 | 10.8 | 3.9 |
| Comf. high | 10.8 | 4.5 | 12.7 | 4.1 |
| Problem oriented + Comf. | 10.7 | 4.2 | 13.3 | 4.8 |
| Problem oriented + Avoidance | 10.9 | 4.5 | 14.1 | 5.3 |
| Avoidance + Comf. | 14.0 | 4.4 | 16.5 | 4.3 |
| All high | 11.6 | 4.4 | 14.4 | 4.7 |
| Avoidance high | 12.9 | 4.6 | 14.4 | 4.4 |
| | F = 7.9 | p .000 | F = 16 | p .000 |
| | Eta$^2$ | .06 | Eta$^2$ | .12 |
| **Somatic complaints** | | | | |
| Problem oriented | 2.1 | 2.5 | 2.3 | 1.9 |
| All low | 2.9 | 2.9 | 2.5 | 2.6 |
| Comf. | 3.5 | 3.3 | 2.9 | 2.7 |
| Problem oriented + Comf. | 3.6 | 3.2 | 2.8 | 2.4 |
| Problem oriented + Avoidance | 3.0 | 3.3 | 2.7 | 2.6 |
| Avoidance + Comf. | 4.4 | 3.8 | 4.7 | 3.2 |
| All high | 3.3 | 2.7 | 3.6 | 3.6 |
| Avoidance | 3.9 | 4.2 | 3.3 | 2.6 |
| | F = 5.2 | p .000 | F = 6.1 | p .000 |
| | Eta$^2$ | .04 | Eta$^2$ | .05 |

| Depression | mean | s.d | mean | s.d |
|---|---|---|---|---|
| Problem oriented | 1.0 | 2.4 | 1.0 | 1.4 |
| All low | 1.2 | 1.8 | 1.0 | 1.9 |
| Comf. | 1.4 | 2.2 | 1.0 | 1.4 |
| Problem oriented + Comf. | 1.7 | 2.2 | 1.0 | 1.4 |
| Problem oriented + Avoidance | 1.9 | 2.3 | 1.4 | 1.7 |
| Avoidance + Comf. | 2.9 | 3.0 | 1.9 | 2.2 |
| All high | 2.0 | 2.6 | 1.6 | 2.4 |
| Avoidance | 3.0 | 3.4 | 1.6 | 1.9 |
|  | F = 9.0 | p .000 | F = 4.2 | p .000 |
|  | Eta$^2$ | .06 | Eta$^2$ | .03 |

| Anxiety |  |  |  |  |
|---|---|---|---|---|
| Problem oriented | 1.6 | 1.9 | 1.8 | 1.7 |
| All low | 1.9 | 2.2 | 2.0 | 2.4 |
| Comf. | 2.8 | 2.8 | 2.4 | 2.4 |
| Problem oriented + Comf. | 2.6 | 2.5 | 2.0 | 2.8 |
| Problem oriented + Avoidance | 2.5 | 2.3 | 2.6 | 2.8 |
| Avoidance + Comf. | 3.5 | 3.2 | 3.7 | 2.8 |
| All high | 2.7 | 2.7 | 2.7 | 2.7 |
| Avoidance | 3.3 | 2.8 | 3.0 | 2.8 |
|  | F = 6.8 | p .000 | F = 5.8 | p .000 |
|  | Eta$^2$ | .04 | Eta$^2$ | .05 |

| Sleep complaints |  |  |  |  |
|---|---|---|---|---|
| Active | 1.8 | 2.5 | 1.3 | 2.0 |
| All low | 2.7 | 2.8 | 1.8 | 2.6 |
| Comf. | 2.9 | 3.3 | 2.0 | 2.7 |
| Active + Comf. | 2.5 | 2.9 | 1.7 | 1.7 |
| Active + Avoidance | 2.5 | 2.9 | 1.6 | 1.9 |
| Avoidance + Comf. | 4.7 | 3.9 | 3.6 | 3.7 |
| All high | 3.1 | 3.2 | 3.0 | 2.8 |
| Avoidance | 4.1 | 4.1 | 3.1 | 3.0 |
|  | F = 8.1 | p .000 | F = 8.2 | p .000 |
|  | Eta$^2$ | .05 | Eta$^2$ | .06 |

We consistently see a significant difference in means between the 8 coping groups on the subjective health complaints. As predicted (§ 6.4) the active coping group scores lowest on all health complaint measures, whereas the avoidance group scores relatively high. Remarkable is that the Avoidance and Comforting Cognitions (6) group score highest on all health scales. A theoretical explanation is not close at hand.

### 6.5.5 Summary and Conclusion

Overall we can conclude that there is a significant relation between noise and annoyance scale, with an exception of the stress scale in the road traffic sample. The percentage of explained variance ($r^2$) lies in the range of .02 - 16%, a result comparable to most previous results.
The influence of biographic features such as age, sex, education, length of residency, exposure per 24 hours and quality of housing is negligible. The most outstanding influence on annoyance comes from 'daily hassles' and 'residential satisfaction'. The level of annoyance is considerably higher in the air traffic sample, but this does not imply that the strength of the relationship between noise and annoyance per location is different.
There is no simple relationship between noise dosage and subjective health complaints. Important mediators are age, education, daily hassles and some of the work related variables.
As for the univariate influence of the process variables we can conclude the following. Primary and secundary appraisal and subjective activation show a significant relationship with most of the health complaints. Subjective activation (stress) seems to be the best predictor of health complaints. This is in line with our predictions as formulated in 6.2 and 6.4.
Coping behaviour is indeed related to the level of health complaints. The pattern shows, that problem oriented behaviour is related with low levels of complaints, whereas avoidance and avoidance combined with comforting cognitions result in higher levels of health complaints. Again this supports our predictions based on recent stress research.
Overall we can conclude, that the fraction of explained variance in annoyance and health effects by noise dose is low. The univariate predictive power of appraisal, stress due to noise and coping is somewhat stronger with an explained variance in a range of 1% to 12%.
Psychological and contextual variables such as 'residential satisfaction' and 'stressors' other than noise (daily hassles) show relatively strong relations with annoyance and subjective health complaint measures. The variance explained ranges between 2% to 25%. Both categories of variables (mediating variables and stress related variables) seem to improve our understanding of the relationship between noise and subjective health. In the next paragraph this hypothesis will be tested in a multivariate way.

## 6.6 Results; Hypotheses testing

### 6.6.1 Introduction

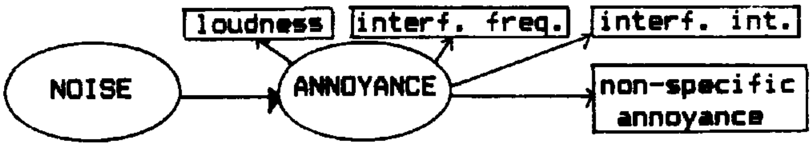
After this rather detailed description of the noise efffect relationship per location and the univariate influence of covariates and process variables, we want to give an overall picture of our findings on model level. The data were analysed with Multivariate analysis (Manova) in combination with multiple stepwise regression analysis. First the results of simple dose response analysis will be given. Then covariates will be introduced into the analysis. Next the model will be tested in a stepwise fashion in line with the questions and hypotheses as formulated in section 6.4.
The structure of analysis is as follows:

- Multivariate analysis of simple dose-response relationships ANNOYANCE scales
- Introduction of covariates
- Test of equal slopes
- Multivariate analysis of simple dose-response relationships HEALTH scales
- Introduction of covariates
- Test of equal slopes
- Stepwise multiple regression analysis over Subjective Activation and Coping
- Stepwise multiple regression analysis over the different health complaint scales
    - Somatic complaints
    - Depression
    - Sleepcomplaints

## 6.6.2 Multivariate dose-effect relationships

### 6.6.2.1 Dose response relationship between noise and annoyance

1. The appraisal of noise as a function of the noise characteristics



When we study the relationship between noise level and the annoyance scales in a multivariate way we get the following results:

Table 6.6.1 Multivariate analysis of the noise annoyance relationship

|  | Road Traffic (N = 975) |  |  | Air Traffic (N = 675) |  |  |
|---|---|---|---|---|---|---|
| Multivariate | F = 6.9 | p = .000 |  | F = 11.0 | p = .000 |  |
| Univariate | F-value | p | r | F-value | p | r |
| Interference (freq) | F = 24.0 | .000 | .36 | F = 51 | .000 | .32 |
| Prim. Appraisal | F = 13.0 | .000 | .25 | F = 16.9 | .000 | .16 |
| Interference (int) | F = 8.2 | .000 | .14 | F = 36.6 | .000 | .24 |
| Non Specific Annoyance | F = 4.7 | .000 | .13 | F = 19.9 | .000 | .17 |
| Stress-feelings due to noise | ns |  | ns |  |  |  |

Table 6.6.2 Trend analysis

| Polynomials | $1^{st}$ order |  | $1^{st}$ order |  |
|---|---|---|---|---|
| Prim. appraisal | T = -4.3 | .000 | -4.7 | .000 |
| Interference (freq) | T = -4.8 | .000 | -9.0 | .000 |
| Stress feelings due to noise | T = .12 | ns | -3.1 | .000 |
| Non Specific Annoyance | T = -1.2 | .24 | -4.8 | .000 |
| Interference | T = -2.1 | .03 | -7.2 | .000 |

Figure 6.6.1

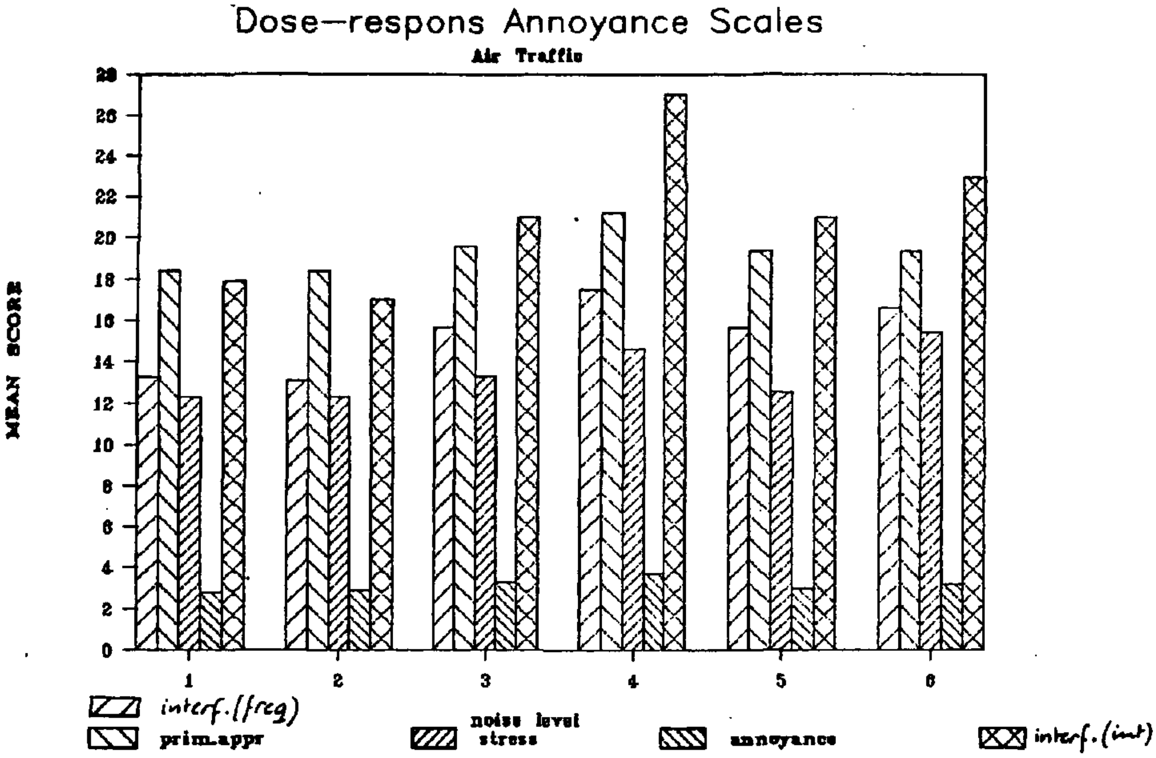
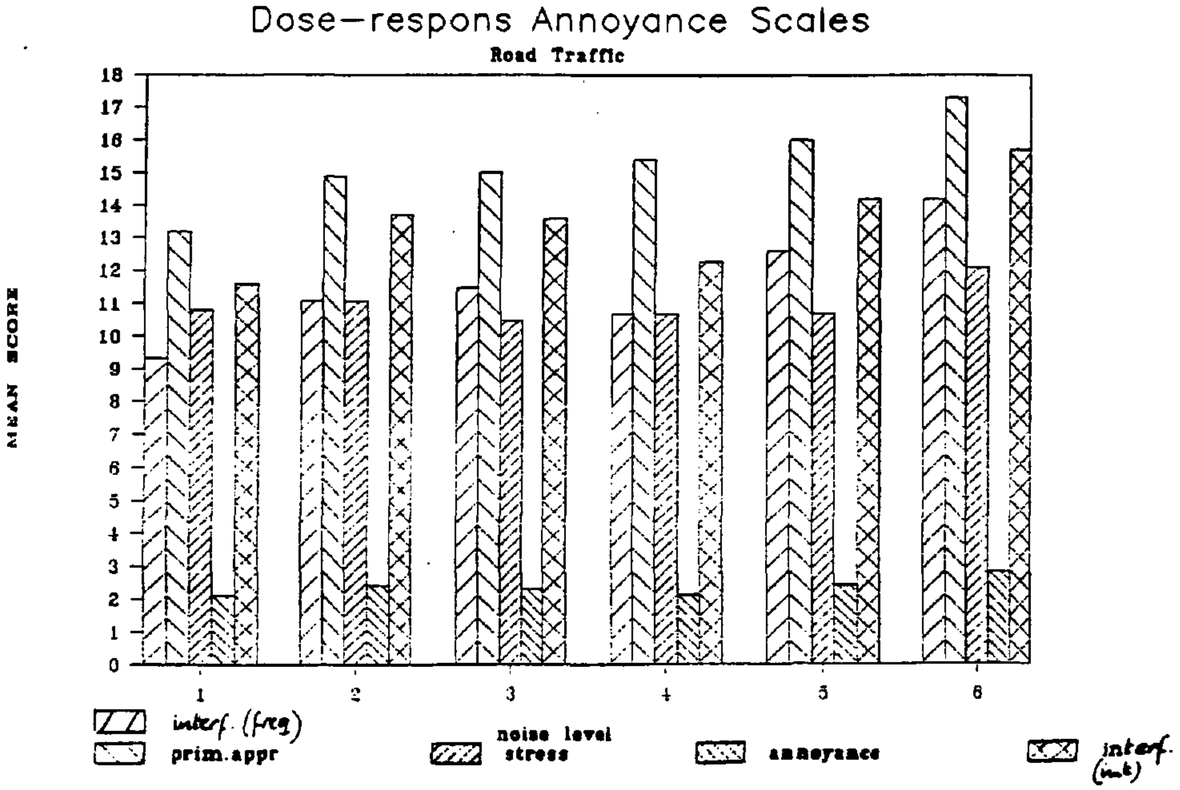
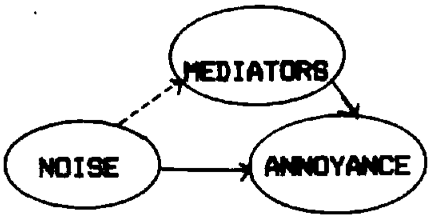


Figure 6.6.2



### 6.6.2.2 Introduction of covariates in the noise annoyance relation

### 2. The appraisal of noise as a function of the noise characteristics and individual differences



When age, sex, educational level, exposure per day, type of house, insulation and are corrected for we get the following results:

Table 6.6.3 Multivariate analysis of annoyance with covariates

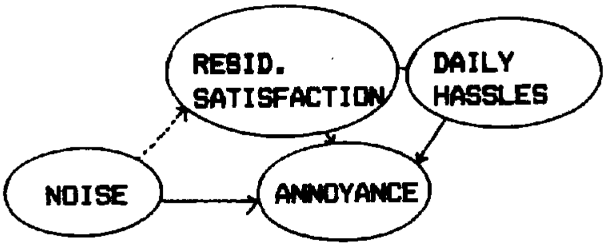
| | Road traffic | | Air traffic | |
|---|---|---|---|---|
| Multivariate | F = 5.7 | .000 | F = 9 | .000 |
| Interference (freq) | F = 18.1 | .000 | F = 39 | .000 |
| Perc. loudness | F = 10.1 | .000 | F = 13 | .000 |
| Interference | F = 6.5 | .000 | F = 22 | .000 |
| Non Specific Annoyance | F = 2.4 | non sp. | F = 14 | .000 |
| Stress feelings due to noise | F = non spec. | | F = 16 | .000 |

We see a slight reduction of F-values after correction for confounders. In the road traffic sample the relationship with non-specific annoyance vanishes when we correct for age (t = 2.2/.04) and education level (t = 2.5, p = .01). The relationship with the other covariates is not significant. Only perceived loudness is significantly related with insulation (t = 2.9, p = .01). In the air traffic sample the influence of covariates is somewhat stronger. Here again non-specific annoyance is influenced by age (t = 2.7, p = .01). Type of home has a significant relationship with interference (t - 1.9, .05), perceived loudness (t - 3.2, p = .00) and stress (t = 2.2, p = .03). Insulation influences both interference scores (t = 2.9, p = .00/ 2.9, p = .00).

Including covariates in multivariate analysis assumes that the slopes of the relationship between covariate and effect are equal in all classes. To test this assumption we studied the interactions between noise class and covariates. In the road traffic sample this results in a significant interaction of noise level x insulation (F = 1.6, p = .03). In the air traffic sample we see again an interaction effect of noise class x insulation (F = 1.9, p = .05) and noise class x educational level (F = 2.6, p = .001). These findings imply that we either have to do a within analysis, or take up both variables as predictors instead of covariates.

Contextual variables In the next step we are interested in the influence of contextual and personal factors, measured in residential satisfaction and daily hassles in order to test hypothesis 1 (see 6.4).

1. The appraisal of noise as a function of noise characteristics, social context and psychological context.



'Residential satisfaction' and 'daily hassles' including their interaction have a significant relationship with the annoyance scales in the road traffic sample. There is no interaction with noise class so we can include both variables as covariates in our analysis. In the air traffic sample only residential satisfaction is a significant predictor of annoyance.

Table 6.6.4 Multivariate influence of daily hassles and residential satisfaction on annoyance

| | Road traffic | Air traffic |
|---|---|---|
| Residential Satisf. | F = 6.1, p = .00 | F = 3.0, p = .00 |
| Daily hassles | F = 2.4, p = .01 | ns |
| Res. x Daily Hass. | F = 1.7, p = .02 | ns |

When we study the direction of the relationships we see a lineair relationship with residential satisfaction (t = -4.7) and a curvilinear trend between daily hassles and annoyance (t = 3.7).

The difference between the air and road traffic sample is remarkable. As was expected the influence of peak noise seems to be more 'direct', than that of continuous noise. In this stage this conclusion can only be of speculative nature.

Figure 6.6.3

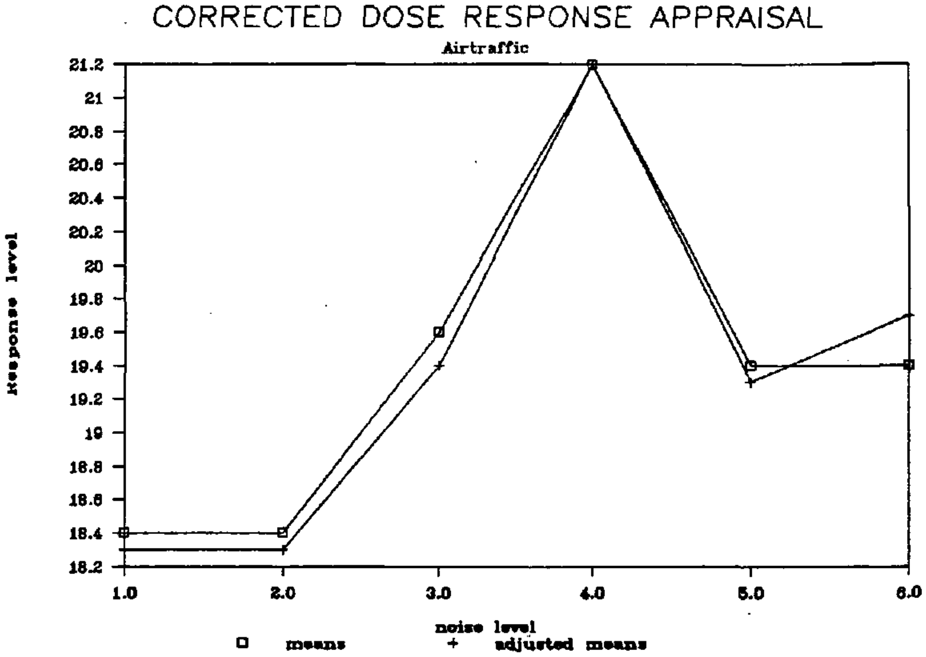
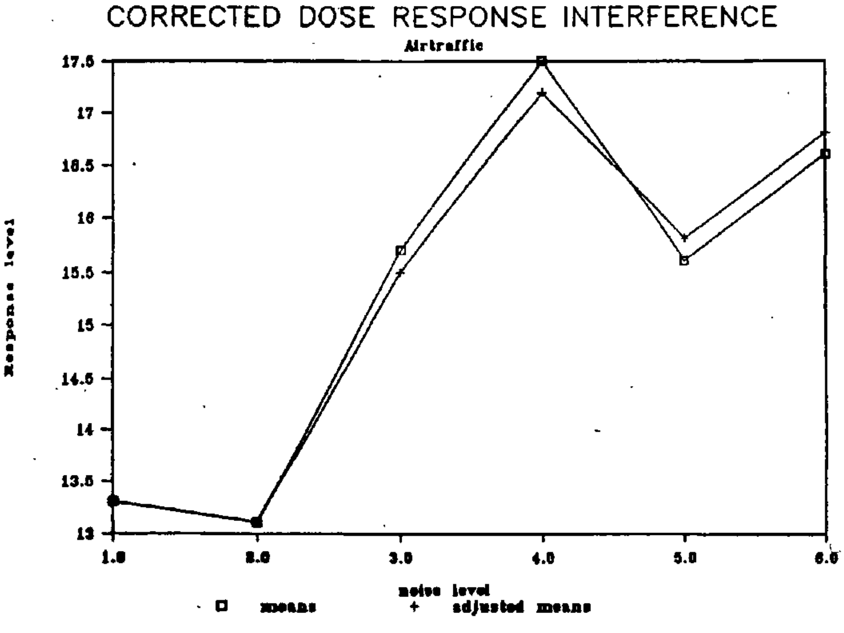
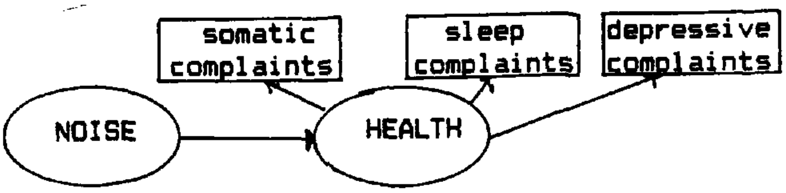


Figure 6.6.4



### 6.6.2.3 Dose effect relationship between noise and health

<u>*Subjective health as a function of noise dosage*</u>.

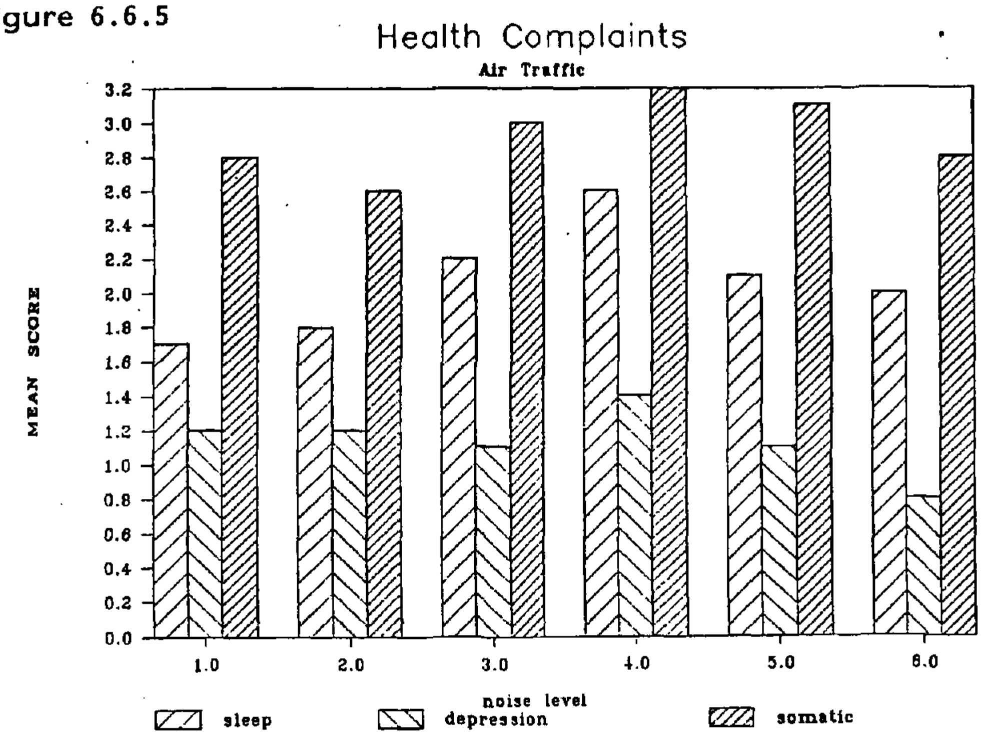


When we study the dose effect relationship between noise level and several subjective health measures in a multivariate fashion, we find a significant multivariate relationship between noise and health in the road traffic sample (F = 2.3, p .01) and only a univariate relationship between noise level and sleep complaints (F = 2.3, p .03) in the air traffic sample.

Table 6.6.5 Dose effect Health measures

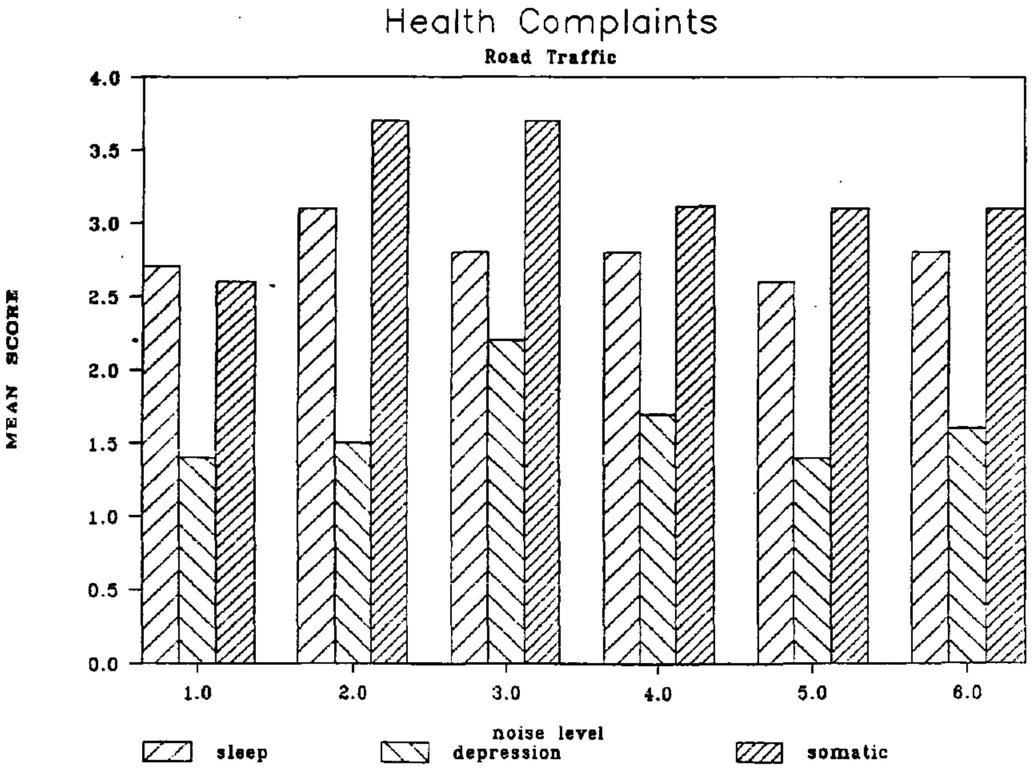
| | Road traffic | Air traffic |
|---|---|---|
| Multivariate | F = 2.3, p .01 | F = ns |
| Univariate | | |
| Sleep complaints | ns | F = 2.3, p = .03 |
| Somatic complaints | F = 2.7, p = .02 | ns |
| Depression | F = 3.6, p = .00 | ns |

Figure 6.6.5



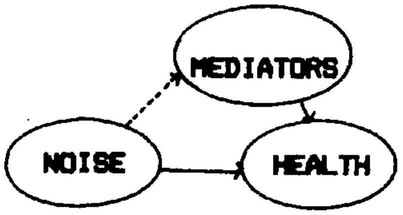
6.6.5

Figure 6.6.6



### 6.6.2.4 Introduction of covariates in the noise-subjective health relationship

#### Subjective health as a function of the noise characteristics



Correction for relevant covariates (age, sexe, education, exposition, residential satisfaction and daily hassles) results in a slight change of the pattern. The multivariate relationship is not significant anymore. However the relationship of noise level with somatic complaints in the road traffic sample remains (F = 2.3, p .04) as well as the relationship with sleep complaints in the air traffic sample (F = 2.3, p. .04).

The relationship between covariates and health measures is as follows (T-values):

Table 6.6.6 Influence of covariates on health measures (T-values)

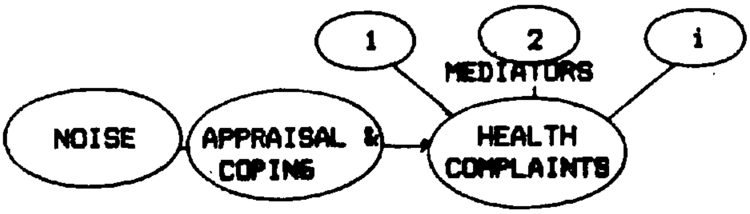
| | Sleep complaints | | Somatic complaints | | Depression | |
|---|---|---|---|---|---|---|
| | Road | Air | Road | Air | Road | Air |
| education | -3.6 | ns | -3.8 | -3.7 | ns | ns |
| daily hassles | 10.4 | 7.8 | 10.4 | 7.1 | 18 | 13 |
| age | ns | 2.4 | 3.7 | 4.4 | ns | ns |
| res. satisf. | ns | -2.1 | ns | ns | ns | ns |
| sexe | ns | ns | 3.7 | 3.7 | ns | ns |

We see a comparable pattern in both samples.

A test for equal slopes of the covariates and effect variables shows an interaction between noise class and daily hassles (F = 1.9, p .02) with a peak in noise class four. Univariate this only affects sleep complaints and explains the relationship between noise class and sleep problems. In the road traffic sample we find equal slopes.

### 6.6.3 Introduction of process variables

Subjective health effects as a function of the appraisal of noise, activation level and the way people cope with the negative consequences of noise

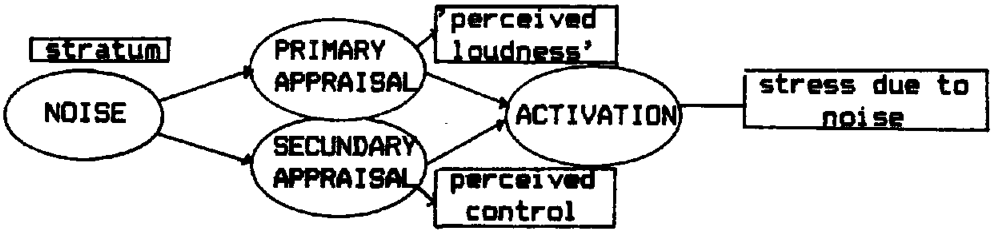


On the basis of the findings mentioned above we can state that there is no simple multivariate relationship between noise level and subjective health measures. The relationships that were found were either non linear or could be explained by contamination. It is clear that both for the annoyance measures and health measures we need other variables to explain more of the variance. Our model assumes, that the appraisal of noise and the way people cope with the negative consequences of noise are crucial in predicting stress and health effects.

In the next section these hypotheses (see 6.4) will be tested in a step wise fashion. First we predict the level of subjective activation, in the survey measured as stress feelings due to noise. Noise level, primary appraisal, secundary appraisal, insulation and lenght of residency are used as predictors of stress feelings, such as the model dictates.

### 6.6.3.1 Prediction of subjective activation (stress)

Hypothesis 1: <u>A negative appraisal of noise and a low perception of control results in an increase of activation level.</u>



A stepwise multiple regression analysis was carried out in both samples (five steps). The product terms of the separate variables were also included in the analysis.

Table 6.6.7 Regression analysis Stress.

Air traffic sample

| Step | Variable | F-value | p | R | R² | r |
|---|---|---|---|---|---|---|
| 1 | noise level | 17.6 | .000 | .14 | .02 | .14 |
| 2 | length of residency | 4.8 | .03 | .16 | .03 | .09 |
| | insulation | --- | --- | .16 | .02 | -.01 |
| 3 | residential satisfaction | 36 | .00 | .26 | .07 | .20 |
| | daily hassles | 18.6 | .00 | .29 | .09 | .19 |
| 4 | perceived control | 285 | .00 | .56 | .32 | .52 |
| | perceived loudness | 89 | .00 | .62 | .38 | .49 |
| 5 | noise level x perceived control x insulation x length of res. | 4.6 | .03 | .63 | .39 | .28 |

Simple r

Table 6.6.8 Regression analysis Stress

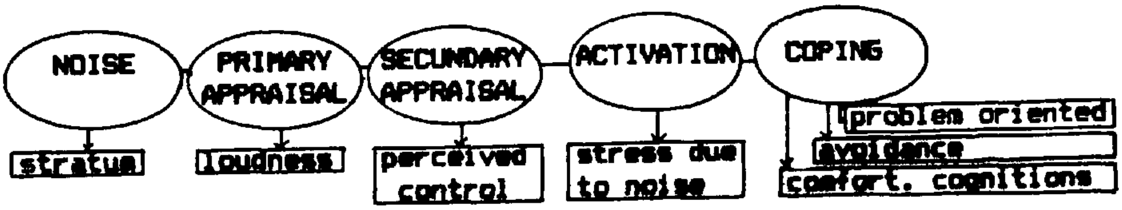
Road traffic sample

| Step | Variable | F-value | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | noise level | --- | --- | .03 | .00 | .03 |
| 2 | insulation | --- | --- | .06 | .00 | .05 |
|  | length of residency | --- | --- | .06 | .00 | -.03 |
| 3 | residential satisfaction | 47 | .00 | .24 | .06 | .23 |
|  | daily hassles | 27 | .00 | .30 | .09 | .24 |
| 4 | perceived control | 119 | .00 | .45 | .20 | .40 |
|  | perceived loudness | 77 | .00 | .52 | .27 | .39 |
| 5 | noise stratum x perc. control x *insul x length | 17.4 | .00 | .53 | .28 | .16 |

In both samples we have improved our prediction of subjective activation tremendously by introducing psychosocial variables into the prediction. The variance explained is 39% and 28% respectively. In both samples mediating variables explain 9% of the variance and stress related variables respectively 30% and 19%. In both cases we see that the interaction between noise class x perceived control x insulation x length of residency is significant. However only 1% additional variance is explained by the interaction term. In another context these interactions will be described in more detail (van Kamp, 1988).

#### 6.6.3.2 Prediction of coping strategies

Hypothesis 2: Coping is a function of noise level, appraisal of noise, activation level and the psychosocial context of exposure.



The determinants of the three coping strategies were also studied in a step wise multiple regression analysis. Per noise source we obtain the following results (only significant relations are mentioned).

Table 6.6.9 Regression analysis coping (Air traffic)

Problem oriented coping

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | education | 34 | .000 | .19 | .04 | -.20 |
| 4 | stress | 16 | .000 | .24 | .06 | .12 |
| 5 | Stravas* | 20 | .000 | .29 | .08 | .11 |

Avoidance

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | education | 4 | .05 | .07 | .01 | .07 |
| 2 | res. satisf. | 27 | .00 | .20 | .04 | .16 |
| 3 | stress | 112 | .00 | .39 | .16 | .35 |
|  | perc. loudness | 4 | .05 | .40 | .16 | .11 |
| 4 | Stravas | 26 | .00 | .43 | .19 | .23 |

Comforting Cognitions

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | sex | 21 | .00 | .16 | .02 | .16 |
|  | education | 11 | .00 | .19 | .04 | -.12 |
|  | age | 5 | .02 | .21 | .04 | .09 |
| 2 | noise level | 4 | .05 | .22 | .05 | .07 |
| 4 | stress | 35 | .00 | .29 | .09 | .21 |
| 5 | Stravas* | 4 | .06 | .31 | .09 | .15 |

* Stravas = interaction noise * appraisal * activation

The analysis shows, that only a small fraction of the variance in coping styles is explained by covariates and/or stress related variables (6% to 19%). The relationship with noise level is weak. As was found by others (McKennel, 1973; Goodman, Clary, 1976) problem oriented coping is used more by men with a higher level of education, where the 'comforting cognition' style is used more by older people of the female sexe. We can conclude, that coping style is primarily influenced by other, not measured features and not by noise related variables as the Lazarus model suggests.

Table 6.6.10 Regression analysis coping (Road traffic)

Problem oriented coping

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | education | 14 | .00 | .13 | .02 | -.13 |
|  | sex | 6 | .01 | .16 | .02 | -.06 |
| 2 | noise level | 9 | .003 | .19 | .04 | .10 |
| 4 | perc. loudness | 6 | .02 | .22 | .05 | .11 |
| 5 | *Stravas | 8 | .005 | .24 | .06 | .05 |

*Stravas = interaction noise * appraisal * activation

Avoidance

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | sex | 7 | .007 | .09 | .01 | .09 |
|  | education | 10 | .001 | .14 | .02 | .09 |
| 3 | noise level | 5 | .03 | .17 | .03 | -.05 |
| 4 | res. satisf. | 10 | .002 | .20 | .04 | .11 |
| 5 | stress | 20 | .00 | .25 | .06 | .18 |

Comforting Cognitions

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | age | 17 | .00 | .14 | .02 | .14 |
|  | sexe | 14 | .00 | .19 | .04 | .14 |
| 3 | res. satisf. | 7 | .01 | .22 | .05 | .05 |
| 4 | Perc. loudness | 13 | .00 | .25 | .06 | .15 |
|  | stress | 5 | .03 | .26 | .07 | .13 |

### 6.6.3.3 The prediction of subjective health complaints

Hypothesis 4:

Different coping styles result in an incrased or decreased level of subjective health complaints, whereby:

a. Problem oriented coping results in a decrease of complaints.

b. Avoidance behaviour results in an increase of complaints.

c. Comforting cognitions does not influence health complaints.

The analyses were done for the subjective health measures separately.

## Somatic complaints

A step wise regression analysis (5 steps) was carried out in both samples. The results are shown in tables 6.6.11 and 6.6.12

Table 6.6.11 Regression analysis Somatic Complaints

Air traffic sample

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | age | 30.5 | .00 | .19 | .04 | .19 |
|  | education | 15.1 | .00 | .23 | .05 | -.17 |
|  | sex | 7.8 | .01 | .25 | .06 | .10 |
| 2 | noise level | --- | --- | .25 | .06 | .04 |
| 3 | daily hassles | 44 | .00 | .34 | .11 | .23 |
|  | resident. satisf. | --- | --- | .34 | .11 | .04 |
| 4 | stress | 55 | .00 | .41 | .17 | .30 |
|  | perceived loudness | --- | --- | .42 | .17 | .19 |
|  | perceived control | --- | --- | .42 | .17 | .16 |
| 5 | avoidance | 8.9 | .00 | .43 | .18 | .20 |
|  | problem oriented | 4.3 | .04 | .43 | .19 | -.02 |
|  | comf. cognitions | --- | --- | --- | --- | --- |

Table 6.6.12 Regression analysis Somatic Complaints

Road traffic sample

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | education | 32.7 | .00 | .20 | .04 | -.20 |
|  | sex | 15.4 | .00 | .24 | .06 | -.17 |
|  | age | 11.7 | .00 | .27 | .07 | .18 |
| 2 | noise level | --- | --- | .27 | .06 | .02 |
| 3 | daily hassles | 113 | .00 | .44 | .19 | .36 |
|  | resident. satisf. | --- | --- | .44 | .19 | .07 |
| 4 | stress | 20.4 | .00 | .46 | .21 | .22 |
|  | perceived loudness | --- | --- | .46 | .22 | .15 |
|  | perceived control | --- | --- | .47 | .22 | .08 |
| 5 | avoidance | 9.2 | .00 | .47 | .23 | .18 |
|  | problem oriented | --- | --- | .48 | .23 | -.05 |
|  | comf. cognitions | --- | --- | .48 | .23 | .13 |

19% and 23% respectively of the variance in somatic complaints could be explained, 3% is explained by noise related variables. We see a comparable pattern in both samples. Daily hassles account for most of the variance.

### Sleep complaints

The same model was tested for sleep complaints and gives the following results:

Table 6.6.13 Regression analysis Sleep Complaints

Air traffic sample

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | sleeping pills | 34.5 | .00 | .20 | .03 | -.20 |
| | education | 16.5 | .00 | .24 | .06 | -.14 |
| | age | 3.34 | .07 | .25 | .06 | .12 |
| | sex | --- | --- | .25 | .06 | .05 |
| | earplugs | --- | --- | .25 | .06 | -.07 |
| 2 | noise level | --- | --- | .26 | .07 | .05 |
| 3 | daily hassles | 59 | .00 | .36 | .13 | .28 |
| | residential satisfaction | 5.2 | .02 | .37 | .13 | .13 |
| 4 | stress | 4.9 | .03 | .37 | .14 | .16 |
| | perceived loudness | --- | --- | .37 | .14 | .09 |
| | perceived control | --- | --- | .37 | .14 | .07 |
| 5 | avoidance | 11.6 | .00 | .39 | .15 | .18 |
| | problem oriented coping | 3.8 | .05 | .39 | .15 | -.04 |
| | comforting cognition | --- | --- | .39 | .16 | .10 |

Table 6.6.14 Regression analysis Sleep Complaints

Road Traffic sample

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | sleeping pills | 42 | .00 | .22 | .05 | -.22 |
| | education | 23 | .00 | .27 | .06 | -.17 |
| | earplugs | 3.4 | .07 | .28 | .08 | .00 |
| | sex | --- | --- | .28 | .08 | .11 |
| | age | --- | --- | .29 | .08 | .13 |
| 2 | noise level | --- | --- | .29 | .08 | .00 |
| 3 | daily hassles | 93 | .00 | .42 | .18 | .35 |
| | residential satisfaction | --- | --- | .42 | .18 | .08 |
| 4 | stress | 3.4 | .05 | .43 | .18 | .14 |
| | perceived loudness | --- | --- | .43 | .19 | .11 |
| | perceived control | 5.0 | .03 | .43 | .19 | .00 |
| 5 | avoidance | 8.4 | .00 | .44 | .20 | .16 |
| | problem oriented coping | 11.5 | .00 | .46 | .21 | .10 |
| | comforting cognitions | --- | --- | .46 | .21 | .11 |

16% and 21% respectively of the variance can be explained in sleep complaints, of which noise related variables explain 3%. Again 'daily hassles' is the best predictor of sleep complaints.

Depressive complaints

Following the same procedure as before we obtain comparable results on the depressive symptom scale:

Table 6.6.15 Regression analysis Depressive Complaints

Air Traffic sample

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | age | --- | --- | .06 | .00 | .06 |
|  | education | --- | --- | .07 | .00 | -.05 |
|  | sex | --- | --- | .07 | .00 | .00 |
| 2 | noise level | --- | --- | .07 | .00 | .00 |
| 3 | daily hassles | 181 | .00 | .42 | .19 | .43 |
|  | residential satisf. | --- | --- | .43 | .19 | .15 |
| 4 | stress | 5.4 | .02 | .44 | .19 | .16 |
|  | perceived loudness | --- | --- | .44 | .19 | .05 |
|  | perceived control | --- | --- | .44 | .20 | .12 |
| 5 | avoidance | 12.2 | .00 | .46 | .21 | .19 |
|  | problem oriented coping | 4.0 | .05 | .46 | .21 | .02 |
|  | comforting cognitions | --- | --- | .46 | .21 | .04 |

Table 6.6.16 Regression analysis Depressive Complaints

Road traffic sample

| Step | Variable | F | p | R | $R^2$ | r |
|---|---|---|---|---|---|---|
| 1 | education | --- | --- | .06 | .00 | -.06 |
|  | sex | --- | --- | .07 | .00 | .04 |
|  | age | --- | --- | .07 | .01 | .00 |
| 2 | noise level | --- | --- | .08 | .01 | .03 |
| 3 | daily hassles | 296 | .00 | .52 | .27 | .52 |
|  | residential satisf. | --- | --- | .53 | .28 | .11 |
| 4 | stress | 6.3 | .01 | .53 | .28 | .18 |
|  | perceived loudness | --- | --- | .53 | .28 | .08 |
|  | perceived control | --- | --- | .53 | .28 | .11 |
| 5 | avoidance | 33.1 | .00 | .56 | .31 | .26 |
|  | problem oriented coping | --- | --- | .56 | .31 | -.01 |
|  | comforting cognitions | --- | --- | .56 | .31 | .11 |

21% and 31% respectively of the variance in the depression scale can be explained. Only a small fraction is again explained by noise related variables (2% and 4%).

### 6.6.4 Summary and conclusions

Multivariate analysis shows, that there is a significant multivariate relation between noise and all annoyance scales. When we correct for relevant covariates this results in a slight reduction in the strength of the relation. This has no consequences for the dose response curve. Important mediators are:
Insulation, length of residency and residential satisfaction.
There is a significant multivariate relation between noise and subjective health in the road traffic sample. When we correct for relevant covariates, this relation dissappears. Central covariates are: educational level and daily hassles.
When we introduce primary and secundary appraisal into the analysis we improve our prediction of subjective activation to a variance explained between 28% and 39%. Remarkable is the moderating influence of noise dose x insulation x length of residency x perceived control; people in the higher noise class, in not insulated homes, who have been living there longer than 5 years and who do not perceive control, report the highest level of subjective activation (stress).
Coping style is not a function of noise dose, perceived loudness or perceived control. This in contrast to predictions from the Lazarus model, that states that coping is a function of perceived threat and perceived control. However, stress feelings due to noise systematically predict all coping styles. In line with others (Goodman, Clary, 1976; McKennel, 1973) we find, that education, sex and age are related with coping style. Men with a higher education score higher on the problem oriented coping scale. Older people, women and people with a lower education level score significantly higher on the comforting cognition scale.
With the model employed we can predict 15% - 31% of the variance in the subjective health complaints. Daily hassles account for a great part of the variance explained ($r^2$ in range of 6% to 27%). After correction for covariates noise related variables still explain 3% - 4% of the variance. Stress due to noise is the best predictor of subjective health complaints, in line with Evans and Cohen (1987). Coping style does add to our prediction in the expected direction: problem oriented coping is negatively related with health complaints and avoidance positively related. When we correct for

these two styles, comforting coginitions are not significant anymore.
Overall we can conclude, that stress related variables increase our understanding of the relation between noise and subjective health. In comparison with other perceived stressors (daily hassles) environmental noise only has a slight but distinct influence on subjective health.

## 6.7 Discussion

The psychosocial survey was aimed at gaining insight in the underlying psychological mechanisms in the noise health relation.
Two questions have to be answered:

1. What are the theoretical implications of our findings?
2. What could be the policy making implications of our findings?

### Theoretical implications

Our findings in broad lines support the cognitive stress model of Lazarus. Incorporation of the activation concept has in this part of the research been fruitful. The emotional aspect of annoyance (anger, irritation, anxiety) offers an important link in the prediction of subjective health effects due to noise.
Further analysis might be aimed at relating this aspect of annoyance to physiological reactions. Also, the interaction between perceived daily hassles and stress due to noise should get more attention (compare Evans, Cohen, 1987).
The study of coping shows, that coping is an important mediator/moderator in the stress subjective health relation. Further analysis will be aimed at the relation between stress and subjective health within coping groups.
Overall we can conclude, that an integrated stress approach seems fruitfull to study the effects of environmental stressors on general well being.

### Policy making implications

Most noise studies have used Annoyance as a central concept. Annoyance is a multi dimensional concept that can be (and has been) measured in several ways. Especially the emotional aspect of annoyance and the aspect of perceived control seem to increase our understanding in the subjective effects of environmental noise. Results show, that the emotional reaction to air traffic noise is stronger, than that to road traffic noise. This emotional aspect of annoyance is a strong mediator in the relation between noise and subjective health in comparison to other annoyance measures.

Special attention deserves the influence of a lack of residential satisfaction on both annoyance and subjective health complaints.

Moreover results show, that we cannot study environmental noise separated from other chronic stress sources, both environmental and in the privat atmosphere (daily hassles).

Remarkable is also the influence of insulation on annoyance and health complaints. Insulation does decrease the level of perceived loudness and frequency of activity interference. However, stress feelings due to noise and sleep complaints do not systematically decrease with insulation; in insulated homes the relation between stratum and complaints (sleep complaints and stress feelings) is even stronger, both in the air traffic and in the road traffic sample. This possible negative aspect of insulation deserves further attention.

A last aspect we want to highlight is that of coping style. Results show, that problem oriented coping such as telephoning the noise producer, engaging in action, seek information, results in lower levels of subjective health complaints, whereas avoidance in combination with comforting cognitions results in high levels of complaints (above standards for 'normal population').

When we moreover consider the fact that coping is related with educational level, sex and age we can conclude, that especially the people who are exposed most (women, older people) use 'inadequate' coping strategies. We can consider these groups as riskgroups. The relation between stress due to noise and health effects (on subjective and physiological level) within coping groups should be studied in more detail to get more ingsight in these mechanisms.

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# 7. ENVIRONMENTAL NOISE AND CARDIOVASCULAR DISEASES

N.E. van Brederode

## 7. ENVIRONMENTAL NOISE AND CARDIOVASCULAR DISEASES

### 7.1 Introduction

This chapter deals with the possible health effect of noise on cardiovascular diseases (see chapter 4). Among the many cardiovascular diseases that exist, hypertension and ischaemic heart diseases (IHD) were chosen for investigation primarily because of:

1. the important role that stress (for example that induced by environmental noise) is supposed to play in the development of these diseases;
2. the assumed, but unclear, role of noise in inducing cardiovascular diseases. This enables us to try to refine current models and methods;
3. the comparatively frequent occurrence of these diseases which allows them to be studied in an epidemiological survey among the general population.

Analyses of the occurrence of hypertension and IHD are hampered by the fact that there are many causative factors other than the influence of (noise-induced) stress. In this study we measured these so-called risk factors and treated them as confounding factors.

### 7.2 Survey of the literature

#### 7.2.1 Environmental noise and cardiovascular diseases

Several epidemiological studies have already shown a relationship between environmental noise and cardiovascular diseases. In an area with an aircraft noise of 40-60 KE Knipschild (1977) found significantly more hypertension, more people who visited their general physician for control of their blood pressure, and more people with an abnormal heart shape than in an area with 20-40 KE (Table 7.1). In the former area he also found significantly more women receiving medical treatment for heart trouble and more using cardiovascular drugs.

Table 7.1 Number and percentage of survey participants with cardiovascular disease in areas with aircraft noise of 20-40 KE and 40-60 KE. 4, 7,8 and 9 are significant for both sexes ($p < 0.05$), 3 and 5 for women only (from Knipschild, 1976, Table 6.16)

| Cardiovascular disease | 20-40 KE<br>number | % | 40-60 KE<br>number | % |
|---|---|---|---|---|
| 1. angina pectoris | 99 | 2.8 | 68 | 3.0 |
| 2. atypical angina pectoris | 1232 | 34.3 | 750 | 33.6 |
| 3. under control for heart trouble | 63 | 1.8 | 55 | 2.5 |
| 4. under control for blood pressure | 264 | 7.3 | 240 | 10.7 |
| 5. using cardiovascular drugs | 197 | 5.5 | 168 | 7.5 |
| 6. ECG pathology | 158 | 4.4 | 114 | 5.1 |
| 7. abnormal heart shape | 57 | 1.6 | 55 | 2.5 |
| 8. hypertension | 139 | 3.9 | 149 | 6.7 |
| 9. DBP >100 | 109 | 3.0 | 111 | 5.0 |
| Total number of participants | 3595 | 100 | 2233 | 100 |

Von Eiff (1980) found a significantly higher incidence of treatment for hypertension in an area with traffic noise ($\geq$66 dB(A)) compared to a control area (< 51 dB(A); 22.8% vs. 14.6%; $p = 0.002$). He also found a positive relationship (significant at $p < 0.05$) between duration of stay in the survey area and treatment for hypertension. Blood pressure itself was not measured. Knipschild and Sallé (1979), on the other hand, found no relationship between traffic noise and the occurrence of cardiovascular diseases (Table 7.2). They investigated use of hypertensive drugs, measured hypertension, angina pectoris, ischaemia on the ECG and pathological heart shape in an area with a high noise level ( > 62.5 dB(A)) compared to an area with less noise (< 62.5 dB(A)).

Table 7.2 Number and percentage of people showing cardiovascular disease in areas exposed to traffic noise (from Knipschild and Sallé, 1979). None of the differences is significant at $p < 0.05$

| Cardiovascular disease | 62.5 dB(A)<br>number | % | 62.5 dB(A)<br>number | % |
|---|---|---|---|---|
| Consultation cardiologist | 103 | 7.7 | 25 | 6.3 |
| Hypertension | 126 | 9.4 | 35 | 8.8 |
| Angina pectoris | 31 | 2.3 | 6 | 1.5 |
| Ischaemia on ECG | 89 | 6.6 | 28 | 7.0 |
| Heart shape pathology | 63 | 4.7 | 18 | 4.4 |
| Total number of participants | 1342 | | 399 | |

Knipschild (1984) also found no significant difference between measured blood pressure of areas with ≥ and < 65 dB(A) of traffic noise. There was, however, a significant positive relationship between annoyance and traffic noise.

### 7.2.2 Risk factors and cardiovascular disease

#### A. Risk factors for hypertension

The most important risk factors for hypertension reviewed below are: age, sex, weight, family history of hypertension, alcohol consumption and use of oral contraceptives (Kannel, 1980; Gezondheidsraad, 1983). Each risk factor can, on average, elevate blood pressure by 0.1-5 mm Hg especially systolic blood pressure. Weight seems to be the most important risk factor. Serum cholesterol levels (Salonen, 1983) and factors not repeatedly proven to be of importance, like the use of coffee or cigarettes (Kannel, 1980), were not included in this study. Salt intake has sometimes been found to be of importance in hypertensives. Because, however, its relationship with hypertension is not all that clear (Dustan, 1979; Berglund, 1980; Gezondheidsraad, 1983) and especially because there are methodological problems associated with the measurement of salt intake (Berglund, 1980), salt intake was not included as a risk factor in this study.

##### Age and sex

It has long been established that blood pressure increases with age (e.g. Fisch, 1974; Hofman, 1984), more so in women than in men (Kannel, 1980).

##### Weight

There has long been strong evidence of a relationship between weight and blood pressure (Kannel, 1967; Clezy, 1972; Fisch, 1974; Klatsky, 1977a; Stamler, 1978; Shaper, 1981; Cairns, 1984; Conner, 1984; Editorial, Lancet, 1985; Gordon, 1986). This relationship has been confirmed by studies showing that a rise in weight is followed by a rise in blood pressure (Kannel, 1967; Chiang, 1969; Reisin, 1978; Stamler, 1978). A rise in blood pressure with weight is not associated with an increase in arm circumference (Kannel, 1967; Chiang, 1969). Klatsky (1977) and Shaper

(1981) concluded that there is still a significant relationship between weight and blood pressure is even when alcohol consumption is accounted for.

Family history of hypertension

Schweitzer (1962) concluded that members of a family in which hypertension has occurred have a greater chance of developing hypertension. Sigardsson (1983) found that this was especially true for higher age groups. Laskarzewski (1981) showed the significant importance of hypertension in the mother. It was still not clear, however, which factors were important in determining the onset of hypertension: genetic factors, social factors like food and alcohol consumption, or a combination of both. Laskarzewski (1981) and Conner (1984), for example, found a significantly higher Quetelet index in participants whose mother suffered from hypertension.

Alcohol consumption

Many studies have show a positive relationship between alcohol consumption and hypertension even when other risk factors are accounted for Dyer, 1977; Klatsky, 1977a, 1977b; Mitchell, 1980; Cairns, 1984; Gruchow, 1985; Gordon, 1986). This relationship is linear (Dyer, 1977; Mitchell, 1980; Shaper, 1981; Cairns, 1984; Gordon, 1986) and does not stabilize even when alcohol consumption exceeds more than 80 g per day (Saunders, 1981). Discontinuation and subsequent resumption of alcohol consumption leads to a fall and then rise in both diastolic and systolic blood pressure (Saunders, 1981; Potter, 1984; Gordon, 1986).

Use of oral contraceptives

There is a significant positive relationship between use of oral contraceptives (a combination of oestrogens and progestagens) and blood pressure (Kunin, 1969; Weir, 1971; Clezy, 1972; Fisch, 1974; Pellegrin, 1974; Fisch, 1977). A rise in blood pressure occurs independently of age (Kunin, 1969; Fisch, 1974; Stern, 1976; Fisch, 1977), weight (Kunin, 1969; Pellegrin, 1974; Stern, 1976), arm circumference (Kunin, 1969) and family history of hypertension (Weir, 1971). The rise occurs within several months and is neither influenced by how long contraceptives have been used (Clezy, 1972, Pellegrin 1974; Fisch, 1974; Fisch, 1977; Ramcharan, 1977) nor by the amount of oestrogen taken (Beckerhoff, 1973; Fisch, 1974, 1977). Fisch (1977) concluded that discontinuation of oral contraceptive use results in a significant drop in blood pressure, and Ramcharan (1977) found that within a few months of discontinuation there was no difference between the blood pressure of past users of oral contraceptives and of those women who had never used these drugs. A rise in blood pressure associated with oral contraceptives, consisting of oestrogens and progestagens, may be influenced by the progestagen dose (Royal College, 1977). Contraceptives consisting solely of progestagens, however, do not produce a rise in blood pressure (Herzog, 1979).

## B. Risk factors for ischaemic heart disease

The most important risk factors for IHD are smoking, blood pressure level, cholesterol and HDL-cholesterol level (Gezondheidsraad, 1984).

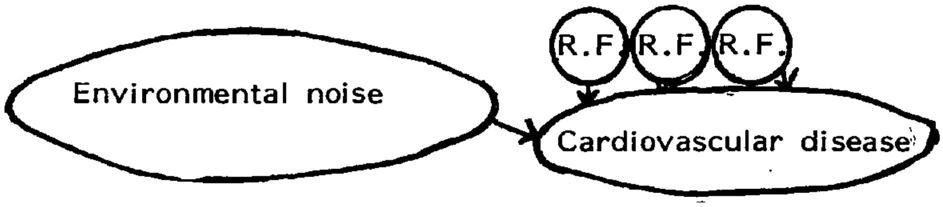
### Smoking

Both the Framingham and the Albany studies have shown that cigarette smoking contributes significantly to the risk of cardiovascular disease, especially myocardial infarction (Doyle, 1969; Gordon, 1974; Gezondheidsraad, 1984). The contribution depends on the number of cigarettes smoked and on inhalation (Doll, 1976; Schroll, 1980; Rosenberg, 1985). Ex-smokers have their risk halved (Gordon, 1974; Schroll, 1980) and after three to six months there is no difference between the risk of never-smokers and ex-smokers (Hickey, 1983). The aethiology of smoking is unknown: carbon monoxide (Wald, 1973; Thomas, 1981) and some rise in the level of serum cholesterol may be necessary (Gezondheidsraad, 1974; Thomas, 1981). In Japan, for instance, where cholesterol levels are generally low, the prevalence of IHD is low as well in spite of smoking. The use of oral contraceptives may also exacerbate the effect of smoking (Rosenberg, 1985). Some studies have shown a relationship between cigar and pipe smoking and IHD (Abelin, 1974; Gsell, 1979; Matroos, 1979; Hickey, 1983). In many studies, however, such a relationship has not been found, perhaps because they included few cigar- and pipe-smokers and also because no distinction was made between inhalers and non-inhalers (Expert group, 1973; Mulcahy, 1985). Many cigar- and pipe-smokers do not inhale. People, however, who also smoke cigarettes, or who did so in the past, do inhale although they are not always aware of it (Todd 197.; Castleden, 1973; Cowie, 1973). Gsell (1956) introduced the term Cigarette Units (C.U.): one cigarette = one C.U., one large cigar = five C.U., one pipe = two and a half C.U.

## 7.3 Models and hypothese

Several types of models were used in our analysis. We first analysed simple dose-effect relationships for cardiovascular diseases, for example the effect of exposure to environmental noise on blood pressure levels and the occurrence of IHD.

The second step was to recognize the existence of risk factors (R.F.) which may affect health. This 'individual-difference' model can be presented as:



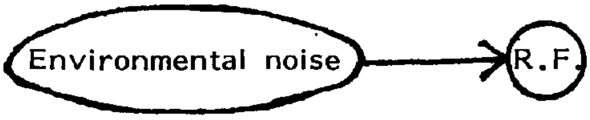
The risk factors used in our analyses are:

| for blood pressure | for IHD |
|---|---|
| quetelet index | smoking habits |
| sex | blood pressure |
| age | cholesterol |
| hypertension in family | HDL-cholesterol |
| use of oral contraceptives | |
| alcohol use | |

The third step of our analysis incorporated of psychological variables into the model. Due to limited time and to the complexity of this undertaking, we carried out only a few analyses in most of which psychological variables were treated as covariates (like the risk factors).

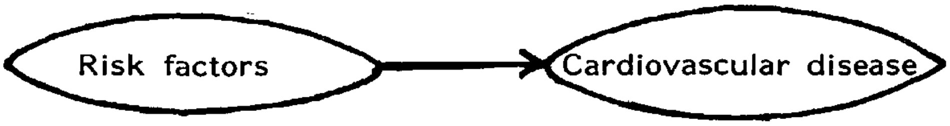
In this chapter the following questions are asked:

- Is there a relationship between noise and the risk factors?



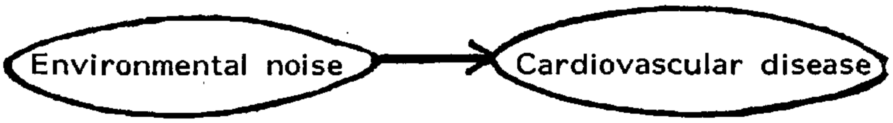
- * Is there a possible indirect effect of environmental noise on health? In other words, are (relative) weight, alcohol consumption, smoking levels and cholesterol levels higher and are HDL-cholesterol levels lower in high noise areas than in low noise areas?
- * Are the risk factors equally distributed in the six different levels of environmental noise?

- Are blood pressure and IHD affected by their respective risk factors if the influence of risk factors is accounted for?

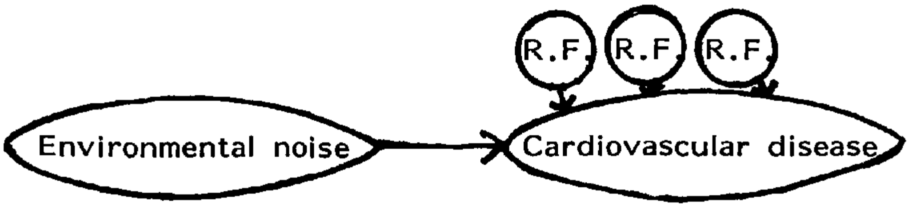


Previous studies (see par. 7.2) have indicated a positive relationship with all of these factors, except for HDL-cholesterol, for which there is a negative relationship.

- Are blood pressure and IHD affected by noise?



- Are blood pressure and IHD still affected by noise even if the influence of risk factors is accounted for?



## 7.4 Methods

### 7.4.1 Questionnaire

Over a period of 4 weeks in 1985, 2024 people were interviewed by 35 skilled interviewers. A letter had previously been sent to each person announcing the interview and introducing it under the heading 'Residence and living situation'. Selection effects may be present but in this way we avoided a selection on the specific subjects of noise, blood pressure and ischaemic heart disease.

The social and psychological parts of the questionnaire were those of Van Kamp (1987), whilst the medical part (Appendix A) was developed especially for this survey following (inter)national standards (Soto-Hartgerink, 1968; Rose, 1982; Bonjer, 1983). Several adaptations, however, were necessary in view of the length of the questionnaire, effective reference to relevant questions* and the necessity for computerized analysis. Several questions were added because of newly available data on the effect of alcohol consumption on blood pressure, and on smoking behaviour and its consequences (see 7.2.2). Other questions were added to exclude from the medical survey and the analysis, those participants with secondary hypertension or with diseases (congenital heart disease, heart valve disease, renal disease and diabetes) which can cause secondary hypertension or can influence IHD. We restricted our definition of secondary hypertension to renal disease because secondary hypertension itself is rare in the general population (Berglund, 1976) and causes other than renal are also rare (Berglund, 1976; Tucker, 1977; Danielson, 1984).

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* If, for example, there is no pain on the chest, one did not need to answer any further questions about angina pectoris and one was referred to the next subject.

### 7.4.2 Medical survey

#### A. Blood measurements

Venous blood was taken from a vein in the arm and analysed by a professional laboratory (Bergschot, Breda) within 24 hours of collection.
Levels of haemoglobin (column chromatography) and glucose (GOD/POD) were measured in venous blood and urea (diacetylmonoxim), creatinine (Jaffé), cholesterol (CHOD/POD) and HDL cholesterol (CHOD/POD) in its serum. EDTA was used as an anticoagulant for haemoglobin and for glucose measurements. NaF was used as a glycolyse inhibitor.
Cholesterol and HDL-cholesterol were used as confounding factors for IHD. Urea, creatinine and glucose were measured to exclude people suspected of having kidney disease or diabetes mellitus, and haemoglobin was measured to exclude participants with premature signs of IHD caused by anaemia. Values were assumed abnormal if they exceeded the value we got after we added or substracted twice the standard deviation of the sample to or from the normal values as given in the laboratory. Kidney damage was diagnosed if both the urea and the creatinine values were abnormal.

#### B. Measurement of blood pressure

A person's blood pressure measurement may vary. This may reflect real variation of arterial blood pressure within the participant or be caused by measurement errors by the instrument or observer (WHO, 1962; Rose, 1964). We will now describe in detail the various causes of variations in blood pressure and the measures we took to reduce them (pers. comm. dr. Montfrans; WHO, 1962; Holland, 1964; Arntzenius, 1980; Kesteloot, 1980; Rose, 1982).

- Known factors in intra-individual variations in blood pressure are recent physical activity, emotional state, position of participant, and environmental factors such as room temperature. We therefore adopted the following procedure:
    1. The medical survey took place in September and October; there was little difference between indoor and outdoor temperatures. Indoor temperature was regulated by air conditioning.

2. Smoking, eating and drinking were not allowed.
3. The venous puncture took place before breakfast between 0700 and 0800 h., the blood pressure measurments between 0800 and 1600 h.
4. The participant was undressed so there was no tight clothing on the upper arm.
5. Measurements were taken, with the participant lying down, on the right upper-arm, the arm positioned horizontally along the body.
6. Blood pressure was measured twice, with a 10 minute interval, directly before and after taking the ECG.

- Measurement errors by the observer can result from terminal digit preference (recording of blood pressure measurements in 5 mm steps), bias for or against certain pressure values and systematic errors such as problems with hearing acuity, interpretation of the Korotkow sounds, and rates of inflation and deflation of the cuff.
We therefore adopted the following measures:

1. Stethoscopes and hearing acuity of the observers were checked.
2. A continuous cuff deflation-rate of 2 mm Hg per heartbeat was used. This is sufficiently accurate because if the reaction time is 0.5 s., blood pressure will be accurate within 1 mm.
3. All observers were very experienced nurses and an extra training program was given by dr. F. Montfrans (A.M.C.). Systolic blood pressure was recorded at the first appearance of the Korotkoff sound, and diastolic blood pressure at the disappearance of the last sound, phase V. If phase V was zero, phase IV was recorded as well (Gezondheidsraad, 1983).
4. Terminal digit preference was reduced by a cuff deflation-rate of 2 mm Hg per heartbeat and recording of blood pressure in 2 mm steps.
5. Prejudice for or against certain pressure values was prevented by using a modified sphygnomanometer (Evans, 1970). We chose the random-zero sphygnomanometer, in which the true zero level can be set anywhere between 0 to 70 mm on the scale, and must be subtracted from the readings afterwards. The London School

of Hygiene and Tropical Medicine sphygnomanometer, in which the mercury column is concealed from the operator, prevents this type of error as well as terminal digit preference. It is, however, a difficult instrument to service in the field (Evans, 1970), and once the plunger of the valve is depressed, the recording has to be repeated completely if any correction is necessary (Garrow, 1963).

- Measurement errors by the instrument were avoided by:

1. The use of new, tested instruments.
2. A standard cuff size of 23 * 12 cm. If arm circumference exceeded 32 cm, as indicated on the standard cuff, we used a cuff size of 37 * 14 cm especially developed by the Hartstichting.
3. Use of a self-adhesive cuff.
4. Repetition of the measurement with a reset zero level after complete deflation of the cuff and a minute's rest.

We preferred to use a sphygnomanometer for which subjective judgements are required rather than a fully automatic one for two reasons: firstly, measurements on the latter only poorly agree with standard subjective measurements and, secondly, no automatic instruments have previously been used in epidemiological surveys (Labarthe, 1973; Edwards, 1976; Rose, 1982; Gezondheidsraad, 1983).

### C. Electrocardiogram and Minnesota Code

Electrocardiogram (ECG) were taken with an automatic 3-canal Hellige Multiscriptor (EK 27), with vacuum electrodes and a speed of 25 mm/s. Twelve standard leads were used: I-III, aVR, aVL, aVF, and V1-V6. The ECG's were coded, according to the Minnesota Code (Rose, 1982), by one skilled observer, Dr. van Herpen. The Minnesota Code was especially developed for epidemiological surveys in the general population and consists of a standardised list for handcoding in uniform, clearly defined terms. The code has nine groups, four of which are an indication of IHD: group 1-1,2,3 Q and QS patterns; group 4-1,2,3 changes in the ST-segment; group 5-1,2,3 T-wave changes and group 7-1 ventricular conduction defects. The Minnesota Code was developed for men. There are, however, considerable differences in the ECG's of men and women (Ritsema van Eck, 1977). Because of a slight backward turning of the T-axis in women, the T-waves can be negative or diphasic for a longer period: from V1 - V3, or even V4 - V6 (pers. comm. Dr. van Herpen). A corresponding code in women with no other signs of IHD is considered normal.

### D. Anthropometry

Standing height was measured once to the nearest 0.5 cm, participants being without shoes, coat or hat, and with heels, shoulders and head against the wall. Without shoes or coat participants were weighed once to the nearest 500 g, on legally stamped scales.

### 7.4.3 Selection and participation

Of the 2024 people who participated in the field survey, 54 were above or below the age limit or did not answer the questions properly because of language problems. Of the remaining 1970 people, 1444 (73%) wished to participate in the medical survey (Table 7.3). Voluntary participation can lead to differences between the samples of people in each of the surveys. For example, people in the field survey who (according to their records) have had IHD were significantly more willing to take part in the medical survey than those people who have not had IHD ($X^2$, df= 1, p= 0.034). On the other hand there was no such difference between people who were and who were not under control for their blood pressure ($X^2$, fd= 1, p= 0.16). The percentage of non-participants is not significantly different in the six different noise levels ($X^2$, df = 5, p = 0.11).

Table 7.3 Number of participants in the field survey who were willing to participate in the medical survey concerning traffic and aircraft noise in four locations and in six strata (str.); for each location and stratum we have indicated the percentage of interviewed people participating in the field survey who wished to participate in the medical survey as well

| | Location | Str.1 | | Str.2 | | Str.3 | | Str.4 | | Str.5 | | Str.6 | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % | n | % | n | % | n | % | n |
| Traffic noise | Amsterdam | 77 | 75 | 72 | 74 | 43 | 67 | 70 | 89 | 74 | 76 | 96 | 69 | 432 |
| | Groningen | 65 | 65 | 48 | 69 | 68 | 76 | 70 | 81 | 94 | 78 | 0 | - | 345 |
| Aircraft noise | Friesland | 95 | 71 | 89 | 72 | 55 | 81 | 17 | 94 | 64 | 81 | 24 | 80 | 344 |
| | Twente | 56 | 66 | 56 | 73 | 79 | 72 | 95 | 77 | 32 | 67 | 5 | 63 | 323 |
| | | | | | | | | | | | | | | 1444 |

Significant differences between those who were and who were not willing to participate in the medical survey showed up in the road traffic sample (p 0.05) in their respective scores on the three dimensions of the HSCL-scale and on sleep quality (see Chapter 6). In the aircraft noise sample these differences were not significant.

A comparison of the parameters of people who took part in the medical examination with all those who did not showed that none of the above differences is preserved.

Eighty people who wished to participate in the medical survey were excluded because they suffered either from secondary hypertension or from a disease which can cause or influence secondary hypertension or IHD (Table 7.4).

Table 7.4 Number of participants in the field survey who were excluded from the medical survey for medical reasons concerning traffic and aircraft noise in four locations and in six strata (str.); for each location and stratum we have indicated the percentage of people wishing to participate in the medical survey who were nevertheless excluded from it

| | Location | Str.1 | | Str.2 | | Str.3 | | Str.4 | | Str.5 | | Str.6 | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % | n | % | n | % | n | % | n |
| Traffic noise | Amsterdam | 5 | 7 | 4 | 6 | 6 | 14 | 3 | 4 | 7 | 10 | 5 | 5 | 30 |
| | Groningen | 1 | 2 | 2 | 4 | 5 | 7 | 3 | 4 | 6 | 6 | 0 | - | 17 |
| Aircraft noise | Friesland | 10 | 11 | 1 | 1 | 2 | 4 | 1 | 6 | 4 | 6 | 2 | 8 | 20 |
| | Twente | 2 | 4 | 1 | 2 | 6 | 8 | 3 | 3 | 1 | 3 | 0 | - | 13 |
| | | | | | | | | | | | | | | 80 |

Of the remaining 1364 people, 1307 (96%) were invited by mail for a 15 min. appointment. The invitation was sent three weeks in advance, with a reminder three days in advance. One hundred perople were unable to participate, and 344 did not appear for unknown reasons. There was no significant link between participation in the medical survey and whether or not participants were under control for their blood pressure ($X^2$, df= 1, p= 0.38). There was, however, a significant link between participation in the medical survey and whether or not participants had IHD (according to their history) ($X^2$, df= 1, p= 0.033). The proportion of people with IHD which participated in the medical survey ($p_2$= 0.118; $n_2$= 853) was significantly higher than the proportion which did not participate ($p_1$= 0.08; $n_1$= 499), according to their confidence interval for the difference between two independant proportions (Fleiss, 1981); $0.0087 < p_2 - p_1 < 0.067$). In stratum 6 the percentage of non-participants in the medical survey was significantly higher ($X^2$, df= 5, p= 0.002) than in the other strata.

After the medical examination one person was excluded because of an abnormal glucose level (16 mmol/l), seven because they exceeded the age limit by more than one year or because their stratum was unknown, and one because the husband participated in the interview and his wife in the medical survey. There were no abnormal haemoglobin values and no combination of abnormal ureum ànd creatinin values.

If participants were receiving medication or dietary treatment for hypertension, the stabilised or lowered blood pressure that resulted could have affected the analysis: blood pressure might have been lower than had been expected from the presence of risk factors. Table 7.5 shows that most of the participants, who used a diet low in salt and/or use medication to lower their blood pressure, had a blood pressure (lowest of two measurements) which was lower than the limits for hypertension indicated by the Gezondheidsraad (1983). Blood pressure measurements which may have been influenced by diet or medication were therefore omitted from the statistical analysis.

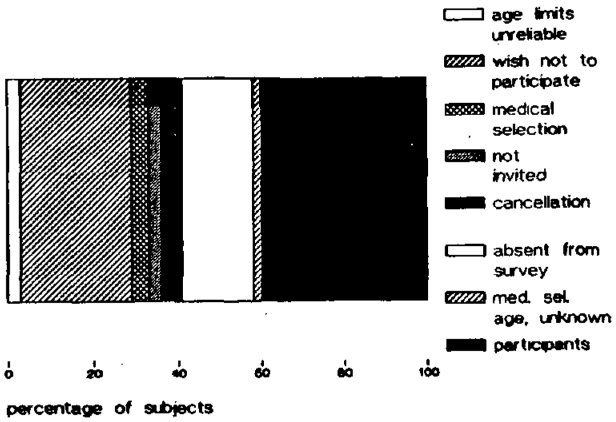
Table 7.5 Numbers and measured blood pressure levels, of participants in the medical survey who were using a diet and/or medication for hypertension; hypertension was defined when the lowest of two diastolic measurements was $\geqslant$ 90 mm Hg, and the lowest of two systolic measurements was $\geqslant$ 140 mm Hg

| | Diastolic blood pressure | | Systolic blood pressure | |
|---|---|---|---|---|
| | hypertens. | no hypertens. | hypertens. | no hypertens. |
| diet+medication | 3 | 13 | 5 | 11 |
| diet | 1 | 4 | 1 | 4 |
| medication | 1 | 3 | 0 | 4 |
| Total | 5 | 21 | 6 | 19 |

The selection and participation process is summarized in Figure 7.1. In the area of traffic noise 397 persons participated, and in the area of aircraft noise 432 (Table 7.6).

Table 7.6 Number of participants in the medical survey

| | |
|---|---|
| Traffic noise | 397 |
| Aircraft noise | 432 |
| Total | 829 |



| | |
|---|---|
| 3% | age limit, unreliable interview |
| 26% | no wish to participate |
| 4% | medical selection |
| 3% | not invited |
| 5% | cancellation |
| 17% | absent from survey |
| 1% | medical selection, age limit, unknown stratum |
| 41% | participants in the medical survey |

Figure 7.1 Percentage of participants from the field survey who did (41%) or did not (59%) participate in the medical survey (n=2024)

### 7.4.4 Reliability of data

#### A. Blood pressure

We checked the accuracy of answers to the questions about hypertension (questions 27 and 28) by comparing them with hypertension we measured. Hypertension was defined as occurring when the lowest of the two diastolic measurements was ≥90 mmHg or lowest of the two systolic measurements was ≥ 140 mmHg. Measured hypertension was defined in this way in order to reduce the influence of tensions induced before or during the medical examination. There were three possible answers to the questions about hypertension: a. no hypertension was known and no check-up was planned; b. hypertension had been diagnosed once but no check-up was planned; c. hypertension was known and a check-up was planned. The (Pearson) correlation between the latter two possibilities and measured diastolic and systolic hypertension was rather low, .24 and .19 respectively (see also Table 7.7).

Table 7.7 Number of participants in the medical survey with and without measured hypertension who had or had not planned a check-up on their blood pressure (n=821)

| | Diastolic blood pressure | | Systolic blood pressure | |
|---|---|---|---|---|
| | hypertens. | no hypertens. | hypertens. | no hypertens. |
| check-up planned | 4 | 11 | 5 | 10 |
| no check-up planned | 52 | 754 | 79 | 727 |
| Total | 56 | 765 | 84 | 737 |

The prevalence for diastolic and systolic hypertension is 7 and 10%. The sensitivity is 7 resp. 6% and the specifity in both cases 99%. The low correlation can only partly be explained by the time-lapse between the field and the medical survey. During the medical survey only seven participants said that they had been diagnosed for hypertension in this period. Because of the low sensitivity of the answers to questions about hypertension they could not be used as indicators of cardiovascular disease. The blood pressure measurements themselves have been used instead. Although this meant that the number of participants for these analyses was reduced from circa 2000 to less than 900.

B. Ischaemic heart disease

According to the medical survey and the medical records of the participants, 103 participants had one or more signs of IHD, six had signs of myocardial infarction, 21 of typical angina pectoris, 69 of atypical angina pectoris and 24 of an abnormal Minnesota Code (1, 4 or 5; code 7 was not diagnosed in our survey). Because the diagnosis IHD and no IHD from medical records often consists of a combination of many questions, a diagnosis could not be made if one or more questions were unanswered. The resulting missing values could not be defined and were classified into the non-IHD category; this influences the sensitivity and specificity in an unknown way.

The prevalence of myocardial infarction in our population sample was 1% (Table 7.8). The specifity of Minnesota code 1 for myocardial infarction is 99.5%, and the sensitivity 33%. Four people had no history of myocardial infarction but did have an abnormal Minnesota Code. They could have had silent infarctions. According to Dr. Van Herpen's expert comment, however, none of the four ECG's presumes a myocardial infarction. Four other persons had a history of infarction but no abnormal Minnesota Code. Either their medical records were incorrect or the signs on the ECG disappeared.

Table 7.8 History of myocardial infarction and the corresponding Minnesota Code among participants in the medical survey

| | History | | |
|---|---|---|---|
| | myocardial infarction | no myocardial infarction | Total |
| Minnesota Code 1 | 2 | 4 | 6 |
| Minnesota Code otherwise | 4 | 819 | 823 |
| Total | 6 | 823 | 829 |

The prevalence of IHD in our population sample was 12% (Table 7.14). Before we calculated the data given in Table 7.9, we adjusted Minnesota Code 4 for female participants (Dr. Van Herpen, pers. comm.). This increased the specificity of the Minnesota Code. The specificity of Minnesota Code 1,4 or 5 for IHD was 98%, and the sensitivity 9%. The specificity is influenced by sixteen persons who had no positive history of IHD but did have an abnormal Minnesota Code. Four of these had code 1 as described above, six had code 5 and six had a combination of codes 4 and 5. Code 5, however, is often aspecific as it can have many different (non-cardiovascular) causes. In practice these six people were not suspected of having had IHD because they had no positive history. If these ten people are supposed not to suffer from IHD, this will lower the prevalence of IHD from 12% to 11%. This will probably not influence the results considerably.

The sensitivity is low because 79 people had a history of IHD but no signs of it in the Minnesota Code. This was expected because signs of infarction can disappear from the ECG and because diagnosis of IHD was mainly made from medical records. This will not influence the analyses because we combined the results from the history with the results from the Minnesota Code.

Table 7.9 History of IHD and the corresponding Minnesota Code 1, 4 or 5 among participants in the medical survey

| | History | | |
|---|---|---|---|
| | IHD | no-IHD | Total |
| Minnesota Code 1, 4 or 5 | 8 | 16 | 24 |
| Minnesota Code otherwise | 79 | 726 | 804 |
| Total | 87 | 742 | 829 |

### C. Age

Ages reported during each of the field and medical surveys could differ from one another because of the six months time-lapse between the two. For 16 participants age differed by more than one year, for 10 by more than two years. When the latter group was asked to give their right age, seven participants responded and their age was corrected. For five of the seven the data of the field survey were correct. During the medical survey people gave their day, month and year of birth which were then recorded in reverse order, i.e. year first. Since this could clearly be a source of error, age data from the field survey were used in our analysis.

### D. Height and weight

For two participants whose given and measured weights differed by more than 20 kg, given weight was recorded as a missing value. The differences between given and measured weights are shown in Tables 7.10 and 7.11.

The difference in height was ⩽ 2 kg in 52.1% of participants, and ⩽ 5 cm in 90.2%. The difference in given and measured weight was ⩽ 2 kg in 44.9% of participants and ⩽ 5 kg. in 84.0% of participants. The differences between given and measured height and weight were not significantly different between men and women. We conclude that given height and given weight were both acceptable for use in our analysis.

Table 7.10 Distribution of the differences between reported and measured weights of participants in the medical survey in areas of traffic and aircraft noise. Where reported weight was higher than the measured weight, a minus sign is given

| Diff. weight | Total<br>n | Traffic noise<br>n | Aircraft noise<br>n |
|---|---|---|---|
| -19.99 - -17.0 | 0 | 0 | 0 |
| -16.99 - -14.0 | 1 | 1 | 0 |
| -13.99 - -11.0 | 2 | 0 | 2 |
| -10.99 - - 8.0 | 8 | 3 | 5 |
| - 7.99 - - 5.0 | 27 | 10 | 17 |
| - 4.99 - - 2.0 | 108 | 53 | 55 |
| - 1.99 - - 0.01 | 114 | 63 | 51 |
| 0.0 - 1.99 | 270 | 142 | 128 |
| 2.0 - 4.99 | 220 | 96 | 124 |
| 5.0 - 7.99 | 68 | 31 | 37 |
| 8.0 - 10.99 | 0 | 0 | 0 |
| 11.0 - 13.99 | 30 | 11 | 19 |
| 14.0 - 16.99 | 0 | 0 | 0 |
| 17.0 - 19.99 | 8 | 3 | 5 |
| Total | 856 | 413 | 443 |

Table 7.11 Distribution of the differences between reported and measured heights of participants in the medical survey in areas of traffic and aircraft noise. Where reported height was greater than the measured height, a minus sign is given

| Diff. height | Total | Traffic noise<br>n | Aircraft noise<br>n |
|---|---|---|---|
| -8.0 | 12 | 4 | 8 |
| -7.99 - -5.0 | 63 | 23 | 40 |
| -4.99 - -2.0 | 279 | 120 | 159 |
| -1,99 - -0.01 | 214 | 106 | 108 |
| 0.0 - 1.99 | 232 | 132 | 100 |
| 2.0 - 4.99 | 47 | 25 | 22 |
| 5.0 - 7.99 | 6 | 2 | 4 |
| 8.0 | 3 | 1 | 2 |
| Total | 856 | 413 | 443 |

### 7.4.5 Sources and distributions of variables

Here we explain the parameters of the model presented in par. 7.3.

Environmental noise: We chose road traffic and military aircraft as sources of environmental noise (see para. 4.3.1). Both sources were subdivided into six noise strata, 1-6. The number of medical survey participants in each noise stratum is shown in Table 7.12.

Table 7.12 Number of participants in the medical survey per stratum in areas of traffic and aircraft noise

| | Traffic noise | | Aircraft noise | |
|---|---|---|---|---|
| | dB(A) | n | KE | n |
| stratum 1 | < 50 | 74 | <35 | 96 |
| stratum 2 | 50-55 | 72 | 35-40 | 105 |
| stratum 3 | 56-60 | 53 | 41-45 | 86 |
| stratum 4 | 61-65 | 72 | 46-50 | 70 |
| stratum 5 | 66-70 | 85 | 51-55 | 59 |
| stratum 6 | >70 | 41 | >55 | 16 |
| Total | | 397 | | 432 |

Health effect: Hypertension and ischaemic heart disease (IHD) were chosen as health effects (see 7.1).

Hypertension is an elevation of arterial blood pressure, diastolic and/or systolic. Blood pressure measurements among a population are distributed normally and there is no demarcation between normotensive and hypertensive people. Whenever possible we used blood pressure as a continuous variable. We studied the relationship between noise and essential hypertension (hypertension without an apparent cause; WHO, 1962); people with secondary hypertension (where a definite cause is detectable), or a disease which can cause this, were excluded from our sample.

Blood pressure was determined as the lowest of two measurements of diastolic and systolic blood pressure (see para. 7.4.4). The distribution of blood pressure levels among the participants in the medical survey is shown in Table 7.13.

Table 7.13 Distribution of measured diastolic (DBP) and systolic blood pressure (SBP) among participants in the medical survey (lowest of the two measurements); there were no data for one participants

| DBP (mmHg) | Traffic noise | Aircraft noise | SBP (mmHg) | Traffic noise | Aircraft noise |
|---|---|---|---|---|---|
| < 49 | 7 | 1 | < 99 | 25 | 5 |
| 50- 60 | 38 | 30 | 100-109 | 76 | 49 |
| 61- 69 | 93 | 81 | 110-119 | 121 | 133 |
| 70- 79 | 171 | 200 | 120-129 | 94 | 124 |
| 80- 89 | 63 | 87 | 130-139 | 56 | 61 |
| 90- 99 | 23 | 22 | 140-149 | 16 | 36 |
| 100-109 | 1 | 8 | 150-159 | 6 | 13 |
| > 110 | - | 3 | 160-169 | 2 | 5 |
| Total | 396 | 432 | > 170 | - | 6 |
| | | | Total | 396 | 432 |

Ischaemic heart disease (IHD) is the cardiac disability, acute or chronic, arising from the reduction or arrest of blood supply to the myocardium in association with disease processes in the coronary arterial system (WHO, 1957). Atherosclerosis is by far the most frequent cause of these disease processes and our report is confined to this problem.

Categories of IHD are classified as follows (WHO, 1962; Bjurulf, 1967):

1) Angina effort= Angina pectoris
   a Typical: pain or discomfort in the chest as a result of effort which either compels the person to slow down, or to use sublingual nitroglycerine which drives away pain within ten minutes.
   b Atypical: pain or discomfort in the chest appearing in cold surroundings after eating or during an emotional episode; or pain/discomfort as a result of effort which does not disappear either when the person slows down or within ten minutes of taking nitroglycerine.
2) Myocardial infarction
   Severe chest pain which is long lasting and resistant to nitroglycerine. Confirmation of muscle necrosis is made by laboratory investigation or ECG and is usually followed by (antistol) therapy.

Asthma, bronchitis and other causes of pain or discomfort in the chest such as trauma were excluded.

Ischaemic heart disease was measured by the Minnesota Code 1-1, 2, 3 or 4-1, 2, 3 or 5-1, 2,3, or by history of IHD (myocardial infarction: questions 39 and 53 - 58; angina pectoris: question 35-53.
The distribution of IHD among participants in the medical survey is shown in Table 7.14.

Table 7.14 Distribution of IHD among participants in the medical survey (according to question 35-58 or the Minnesota Code).

|  | Traffic noise | Aircraft noise |
|---|---|---|
|  | n | n |
| IHD | 41 | 62 |
| no-IHD | 356 | 370 |
| Total | 397 | 432 |

Risk factors:

1. Age data (Table 7.15) were derived from question 136. Age was normally distributed in both environmental noise sources.

Table 7.15 Distribution of age-categories among participants in the medical survey (according to question 136)

| Age category | Traffic noise | Aircraft noise |
|---|---|---|
|  | n | n |
| 18-19 | 4 | 2 |
| 20-24 | 51 | 16 |
| 25-29 | 65 | 53 |
| 30-34 | 54 | 89 |
| 35-39 | 72 | 90 |
| 40-44 | 60 | 71 |
| 45-49 | 37 | 55 |
| 50-55 | 54 | 56 |
| Total | 397 | 432 |

2. Sex data (Table 7.16) were derived from question 135. There were few male participants.

Table 7.16 Number of men and women among the participants in the medical survey (according to question 135); there were no data for one participant

| | Men<br>n | Women<br>n | Total<br>n |
|---|---|---|---|
| Traffic noise | 118 | 279 | 397 |
| Aircraft noise | 104 | 327 | 431 |

3. Hypertension of parents data (Table 7.17) were derived from question 59.

Table 7.17 Occurrence of hypertension among parents of participants in the medical survey (according to question 59); there were no data for one participant

| | Traffic noise<br>n | Aircraft noise<br>n |
|---|---|---|
| Hypertension in parents | 168 | 171 |
| No hypertension in parents | 160 | 218 |
| Hypertension in parents unknown | 68 | 43 |
| Total | 396 | 432 |

4. Hypertension of siblings data (Table 7.18) were derived from question 60. Occurrence was rather infrequent. Age was probably the reason for this since the siblings were about the same age as participants and therefore had a smaller chance of hypertension than the parents.

Table 7.18 Occurrence of hypertension among siblings of participants in the medical survey (according to question 60); there were no data for four people

| | Traffic noise<br>n | Aircraft noise<br>n |
|---|---|---|
| Hypertension in siblings | 47 | 56 |
| No hypertension in siblings | 260 | 310 |
| Hypertension in siblings unknown | 89 | 63 |
| Total | 396 | 429 |

In some analyses it was necessary to treat the risk factors hypertension in parents and in siblings not as discrete variables with three values but as dichotomous variables with two values. Whenever these risk factors were used their quality will be indicated.

5. Relative weight data (Table 7.19) were defined by the Quetelet index which combines data on weight and height (as measured at the medical survey) in the following way: relative weight = weight * $10^4$/ height$^2$. The Quetelet index is normally distributed.

Table 7.19 Distribution of the Quetelet index among participants in the medical survey (according to data of the medical survey)

| Quetelet index | Traffic noise | Aircraft noise |
|---|---|---|
| | n | n |
| <16 | 1 | 0 |
| 16 | 0 | 1 |
| 17 | 5 | 1 |
| 18 | 12 | 7 |
| 19 | 15 | 13 |
| 20 | 54 | 24 |
| 21 | 54 | 47 |
| 22 | 50 | 61 |
| 23 | 51 | 49 |
| 24 | 42 | 46 |
| 25 | 33 | 61 |
| 26 | 20 | 34 |
| 27 | 19 | 25 |
| 28 | 15 | 14 |
| 29 | 8 | 17 |
| 30 | 5 | 7 |
| 31 | 4 | 5 |
| 32 | 2 | 9 |
| 33 | 4 | 3 |
| 34 | 0 | 3 |
| 35 | 0 | 2 |
| >35 | 3 | 3 |
| Total | 397 | 432 |

6. Alcohol consumption data (Table 7.20) were derived from questions 68, 69 and 71. Alcohol use was normally distributed.

Table 7.20 Alcohol use among participants in the medical survey (according to question 68, 69 and 70)

| Alcohol use (glass(es)/day) | Traffic noise<br>n | Aircraft noise<br>n |
|---|---|---|
| 0 | 53 | 51 |
| 1/6 | 82 | 78 |
| 1/6-1 | 145 | 202 |
| 1-2 | 68 | 69 |
| 3-4 | 34 | 21 |
| ≥5 | 15 | 11 |
| Total | 397 | 432 |

7. Oral conceptive use data (Table 7.21) were derived from question 72. 19.2% of women aged 18 to 44 years 19.2% used oral contraceptives. Other studies have reported 24-32% of women aged 18 to 44 years using oral contraceptives (Fisch, 1974; Pellegrin, 1974; Fisch, 1977; Ramcharan, 1977).

Table 7.21 Occurrence of oral contraceptive use among female participants in the medical survey (according to question 72); there were no data for two participants

| | Traffic noise<br>n | Aircraft noise<br>n |
|---|---|---|
| Oral contraceptive use | 60 | 56 |
| No oral contraceptive use | 218 | 270 |
| Total | 278 | 326 |

8. Smoking data (Table 7.22) of cigarettes, cigars and pipes, were derived from question 21 to 26. People were only classed as smokers if they inhaled or, in case of pipe and cigar smokers, if they were present or past cigarette smokers. Non-smokers far exceed smokers in numbers. Among smokers the number of Cigarette Units was normally distributed.

Table 7.22 Distribution of the number of Cigarette Units (C.U.; see 7.2.2) used per day among participants in the medical survey (according to question 21-26); there were no data for three people

| No. C.U./day | Traffic noise | Aircraft noise |
|---|---|---|
| | n | n |
| 0 | 226 | 286 |
| 1.0- 5.5 | 17 | 15 |
| 6.0-10.5 | 20 | 29 |
| 11.0-15.5 | 28 | 41 |
| 16.0-20.5 | 49 | 32 |
| 21.0-25.5 | 31 | 19 |
| 26.0-30.5 | 7 | 6 |
| 31.0-35.5 | 5 | 1 |
| 36.0-80.0 | 11 | 3 |
| Total | 394 | 432 |

9. Cholesterol and HDL-cholesterol level data (Table 7.23 and 7.24) were derived from blood analyses in the medical survey. They were both normally distributed.

Table 7.23 Distribution of cholesterol levels (mmol/l) among participants in the medical survey (according to data of the medical survey); there were no data for three people

| Cholesterol level | Traffic noise | Aircraft noise |
|---|---|---|
| | n | n |
| 2.00- 2.99 | 1 | 1 |
| 3.00- 3.99 | 28 | 32 |
| 4.00- 4.99 | 115 | 151 |
| 5.00- 5.99 | 128 | 156 |
| 6.00- 6.99 | 81 | 57 |
| 7.00- 7.99 | 33 | 23 |
| 8.00- 8.99 | 7 | 9 |
| 9.00- 9.99 | 0 | 0 |
| 10.00-10.99 | 2 | 0 |
| 11.00-11.99 | 1 | 1 |
| Total | 396 | 430 |

Table 7.24 Distribution of HDL-cholesterol levels (mmol/l) among participants in the medical survey (according to data of the medical survey); there were no data for 11 people

| HDL-chl. level | Traffic noise n | Aircraft noise n | HDL-chl. level | Traffic noise n | Aircraft noise n |
|---|---|---|---|---|---|
| 0.5 | 2 | 1 | 1.4 | 27 | 34 |
| 0.6 | 7 | 12 | 1.5 | 16 | 10 |
| 0.7 | 20 | 20 | 1.6 | 7 | 8 |
| 0.8 | 43 | 31 | 1.7 | 5 | 5 |
| 0.9 | 42 | 59 | 1.8 | 4 | 2 |
| 1.0 | 71 | 74 | 1.9 | 2 | 3 |
| 1.1 | 56 | 65 | 2.0 | 0 | 0 |
| 1.2 | 52 | 55 | 2.1 | 2 | 0 |
| 1.3 | 37 | 46 | Total | 393 | 425 |

10. Appraisal, control and coping are psychological variables which were defined by Van Kamp (1986, 1988).

Primary appraisal refers to a variety of concepts like annoyance and interference with activities and in our survey was subdivided into five categories: perceived loudness (questions 119 (road) and 125 (air)), Bitter scale (questions 158-164), Mokken scale (question 131), non-specific annoyance (questions 121 (road) and 127 (air)) and stress feelings due to noise (questions 120 (road) and 126 (air)). The distribution of total scores of primary appraisal is shown in Table 7.25.

Perceived control ("what can I do to control the negative consequences of noise") was defined by the combined scores of questions 123 (road) and 130 (air) (Table 7.26).

Coping behaviour consists of activities undertaken to change the environment (problem orientated behaviour), to change perception of the situation (comforting cognitions) and to avoid the situation (avoidance). We used a general scale (question 18) and a scale specific for behaviour induced by noise (question 134). The distribution of the scores on coping behaviour is given in Table 7.27.

Table 7.25 Distribution of total scores of primary appraisal among participants in the medical survey

| Score | Traffic noise | Aircraft noise |
|---|---|---|
| | n | n |
| 26- 34 | 14 | 2 |
| 35- 43 | 49 | 23 |
| 44- 52 | 48 | 43 |
| 53- 61 | 34 | 42 |
| 62- 70 | 32 | 67 |
| 71- 79 | 13 | 51 |
| 80- 88 | 15 | 53 |
| 89- 97 | 1 | 29 |
| 98-106 | 4 | 22 |
| 107-118 | 2 | 20 |
| Total | 212 | 352 |

Table 7.26 Distribution of scores on perceived control among the participants in the medical survey; the scores can range from 3-6

| Score | Traffic noise | Aircraft noise |
|---|---|---|
| | n | n |
| 3 | 34 | 24 |
| 4 | 161 | 164 |
| 5 | 67 | 97 |
| 6 | 42 | 122 |
| Total | 304 | 407 |

Table 7.27 Distribution of scores for coping variables among the participants in the medical survey. The scores for noise coping behaviour can range from 7-35 for problem orientated behaviour (p.o.b.) and comforting behaviour (c.b.), from 6-30 for avoidance (a.b.) and from 4-16 for three the general coping variables

| Score | noise p.o.b. | noise c.b. | noise a.b. | general p.o.b. | general c.b. | general a.b. |
|---|---|---|---|---|---|---|
| Traffic noise | | | | | | |
| 1- 5 | n.a. | n.a. | n.a. | 3 | 41 | 9 |
| 6-10 | 105 | 182 | 38 | 177 | 320 | 246 |
| 11-15 | 87 | 124 | 71 | 65 | 35 | 137 |
| 16-20 | 62 | 61 | 148 | 3 | 0 | 4 |
| 21-25 | 44 | 19 | 116 | n.a. | n.a. | n.a. |
| 26-30 | 58 | 5 | 22 | n.a. | n.a. | n.a. |
| 31-35 | 39 | 0 | n.a. | n.a. | n.a. | n.a. |
| Total | 395 | 391 | 395 | 248 | 396 | 396 |
| Aircraft noise | | | | | | |
| 1- 5 | n.a. | n.a. | n.a. | 4 | 42 | 5 |
| 6-10 | 159 | 214 | 31 | 228 | 348 | 290 |
| 11-15 | 83 | 149 | 70 | 191 | 39 | 132 |
| 16-20 | 56 | 40 | 154 | 8 | 1 | 4 |
| 21-25 | 47 | 21 | 131 | n.a. | n.a. | n.a. |
| 26-30 | 47 | 3 | 41 | n.a. | n.a. | n.a. |
| 31-35 | 34 | 0 | n.a. | n.a. | n.a. | n.a. |
| Total | 426 | 427 | 427 | 431 | 430 | 431 |

n.a.: not applicable

## 7.5 Results

### 7.5.1 The relationship between environmental noise and risk factors

A. Stress may influence consumption. We therefore checked the relationship between noise and Quetelet index, alcohol consumption, number of Cigarette Units, cholesterol level and HDL-cholesterol level.

There was no significant relationship between noise and any of the risk factors we measured (Table 7.28). These risk factors, therefore, play no role in the influence of noise on the development of cardiovascular diseases.

Table 7.28 Beta and p values in a regression analysis of the relationship between quetelet index, alcohol consumption, cigarette units, cholesterol and HDL-cholesterol levels, and noise

| | Traffic noise | | Aircraft noise | |
|---|---|---|---|---|
| Risk factor | p | beta | p | beta |
| quetelet index | .93 | -.004 | .12 | .08 |
| alcohol use | .07 | .09 | .08 | -.09 |
| cigarette units | .07 | .09 | .81 | -.01 |
| cholesterol | .21 | -.06 | .08 | -.09 |
| HDL-cholesterol | .11 | .08 | .87 | .01 |

* denotes significance at $p < 0.05$

B. Unequal distributions of risk factors over the six strata may influence the relationship between noise and cardiovascular disease. The results for the risk factors of blood pressure and the risk factors for IHD are presented seperately below.

1. Relationship between noise and risk factors of blood pressure

The distribution of risk factors for blood pressure in the six strata are equal, in both traffic and aircraft noise areas (Table 7.29). The only exception is alcohol use in traffic noise areas. The mean number of glasses of alcohol/day as used in the statistical analyses (Table 7.29) are presented in Table 7.30. Alcohol use is highest in stratum 6. If blood pressure is significantly higher in stratum 6 in areas with traffic noise, this can be caused by the high average alcohol use in that stratum, that is if no correction for alcohol use is made (see 7.5.3 and 7.5.4). Hypertension in parents and siblings were treated as discrete variables in these analyses.

Table 7.29 p values for the distribution of risk factors in the six noise strata. The first four variables were tested with $X^2$ (df = 1) the last eight with analysis of variance

| | Traffic noise<br>p | Aircraft noise<br>p |
|---|---|---|
| Risk factors for blood pressure | | |
| sex | .13 | .50 |
| hypertension parents | .72 | .55 |
| hypertension siblings | .26 | .91 |
| oral contraceptive use | .28 | .11 |
| age | .20 | .24 |
| quetelet index | .69 | .75 |
| alcohol use | .015* | .82 |
| Risk factors for IHD | | |
| cholesterol | .10 | .27 |
| HDL-cholesterol | .52 | .45 |
| cigarette-units | .08 | .07 |
| DBP | .23 | .52 |
| SBP | .035* | .01* |

* denotes significance at $p < 0.05$.

Table 7.30 Average number of glasses of alcohol used per day in each of the six strata of traffic noise

| Stratum | alcohol use | s.d. | n |
|---|---|---|---|
| 1 | 3.2 | 1.2 | 74 |
| 2 | 2.9 | 1.1 | 72 |
| 3 | 2.5 | 1.3 | 53 |
| 4 | 3.1 | 1.4 | 72 |
| 5 | 3.0 | 1.2 | 85 |
| 6 | 3.4 | 1.4 | 41 |

## 2. Relationship between noise and risk factors of IHD

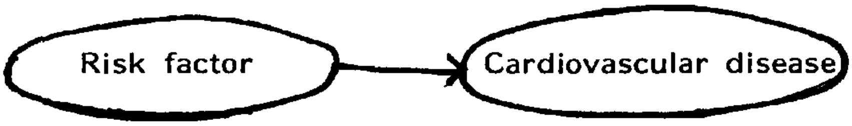
Apart from systolic blood pressure the mean distribution of risk factors for IHD in the six strata was equal (Table 7.29) The mean values for systolic blood pressure as used for the statistical analyses (Table 7.29) are presented in Table 7.31. In areas with traffic noise systolic blood pressure was significantly higher in stratum 1. In areas with aircraft noise systolic blood pressure was significantly higher in strata 4, 5 and 6 compared to stratum 2.

If the occurrence of IHD is significantly higher at the high exposure levels in aircraft noise this may be related to a higher average systolic blood pressure (see 7.5.3 and 7.5.4).

Table 7.31 Mean systolic blood pressure in each of the six strata of traffic and aircraft noise

| | Traffic noise | | | Aircraft noise | | |
|---|---|---|---|---|---|---|
| stratum | SBP | s.d. | n | SBP | s.d. | n |
| 1 | 121.4 | 14.8 | 73 | 123.6 | 15.2 | 96 |
| 2 | 116.5 | 15.2 | 72 | 119.8 | 15.3 | 105 |
| 3 | 113.8 | 12.4 | 53 | 122.2 | 12.9 | 86 |
| 4 | 118.5 | 12.5 | 72 | 127.6 | 15.2 | 70 |
| 5 | 119.2 | 12.1 | 85 | 126.3 | 15.0 | 59 |
| 6 | 117.1 | 10.3 | 41 | 126.1 | 12.4 | 16 |

## 7.5.2 The relationship between risk factors and cardiovascular diseases



We present the results for blood pressure and IHD in seperate sections of this chapter.

### 1. Relationship between each of the risk factors and blood pressure

Age and Quetelet index both had a significant positive relationship with blood pressure in both traffic and aircraft noise areas (Table 7.32). Alcohol use had a positive correlation with blood pressure in traffic noise but not in aircraft noise.

Table 7.32 Beta, p values and explained variance ($r^2$) in regression analysis of relationship between each of the continuous risk factors and blood pressure

| Risk factors | Diastolic blood pressure | | | Systolic blood pressure | | |
|---|---|---|---|---|---|---|
| Traffic noise | p | beta | $r^2$ | p | beta | $r^2$ |
| age | .000* | .28 | .08 | .003* | .15 | .02 |
| quetelet index | .000* | .34 | .11 | .000* | .29 | .08 |
| alcohol use | .007* | .14 | .02 | .014* | .12 | .02 |
| Aircraft noise | | | | | | |
| age | .000* | .32 | .11 | .000* | .27 | .07 |
| quetelet index | .000* | .40 | .16 | .000* | .38 | .14 |
| alcohol use | .24 | .06 | .00 | .48 | .00 | .00 |

* denotes significance at $p < 0.05$ (n= 396 in traffic noise, n=432 in aircraft noise)

Risk factor sex was significantly positively related with blood pressure (Table 7.33). Mean blood pressure values as used for the statistical analyses of Table 7.33 are presented in Table 7.34. Men had a significantly higher blood pressure than women (Table 7.34).

Oral contraceptive use showed no significant correlation with blood pressure in our population samples; indeed mean blood pressure was higher in women using no oral contraceptives (Tables 7.33, 7.34). Hypertension in siblings was significantly related to blood pressure. Hypertension in parents had a positive correlation in areas with aircraft noise but not in areas with traffic noise.

Hypertension in parents and in siblings were used as discrete variables. Negative response to whether there was hypertension in parents or siblings was expected to correspond to the lowest mean blood pressure, positive response to the highest and the answer "don't know" or "does not apply" to the middle one. This was so in all significant cases, except in the relationship between hypertension in siblings with systolic blood pressure in aircraft noise (Table 7.34), in which case we also tested the value for "yes" and "no" with T-test. The difference was significantly higher for the positive response ($p = 0.039$).

We conclude that all risk factors except oral contraceptive use had a significant correlation with blood pressure in traffic and/or aircraft noise areas.

Table 7.33 p values for the relationships between each of the dichotomous and discrete risk factors and blood pressure, analysed with analysis of variance. (n=396 in traffic noise, n=432 in aircraft noise)

| Risk factors | Traffic noise<br>DBP<br>p | <br>SBP<br>p | Aircraft noise<br>DBP<br>p | <br>SBP<br>p |
|---|---|---|---|---|
| sex | .002* | .000* | .002* | .000* |
| oral contraceptive use | .30 | .74 | .48 | .97 |
| hypertension parents | .70 | .91 | .006* | .017* |
| hypertension siblings | .003* | .041* | .000* | .008* |

* denotes significance at $p < 0.05$

Table 7.34 Mean values for blood pressure in analysis of variance for sex, oral contraceptive use and hypertension in parents and in siblings. For p values see Table 7.33

|  | Traffic noise<br>DBP | <br>s.d. | <br>SBP | <br>s.d. | <br>n | Aircraft noise<br>DBP | <br>s.d. | <br>SBP | <br>s.d. | <br>n |
|---|---|---|---|---|---|---|---|---|---|---|
| Men | 74.7 | 9.3 | 123.8 | 11.2 | 118 | 77.6 | 9.7 | 128.1 | 13.9 | 104 |
| Women | 71.4 | 10.1 | 115.6 | 13.4 | 278 | 74.1 | 10.0 | 122.0 | 14.9 | 327 |
| Hypertension in parents |  |  |  |  |  |  |  |  |  |  |
| present | 72.9 | 10.1 | 118.1 | 13.3 | 168 | 76.8 | 10.7 | 125.7 | 16.4 | 171 |
| unknown | 71.9 | 9.9 | 118.3 | 13.5 | 67 | 74.8 | 9.9 | 124.8 | 14.2 | 43 |
| not present | 72.1 | 9.9 | 117.7 | 12.8 | 160 | 73.6 | 9.3 | 121.5 | 13.4 | 218 |
| Hypertension in siblings |  |  |  |  |  |  |  |  |  |  |
| present | 76.1 | 7.8 | 122.1 | 15.1 | 47 | 78.3 | 9.8 | 126.7 | 15.5 | 56 |
| unknown | 73.7 | 11.1 | 119.0 | 13.9 | 88 | 77.7 | 11.6 | 127.2 | 17.6 | 63 |
| not present | 71.3 | 9.7 | 117.0 | 12.7 | 260 | 73.8 | 9.5 | 122.0 | 13.9 | 310 |
| Oral contrac. | 70.3 | 9.5 | 115.1 | 13.7 | 60 | 73.2 | 10.2 | 121.9 | 16.7 | 55 |
| No oral contrac. | 71.8 | 10.2 | 115.8 | 13.4 | 217 | 74.3 | 10.0 | 122.0 | 14.6 | 270 |

## 2. Relationship between each of the risk factors and IHD

Most of the risk factors showed no significant relationship with IHD (Table 7.35). Only in areas of aircraft noise was there a significant relationship with cholesterol and HDL-cholesterol. As expected a positive one for cholesterol and a negative one for HDL-cholesterol. There is however no significant positive relationship between Cigarette Units and IHD, and between blood pressure and IHD. The mean values for Cigarette Units and blood pressure were in some cases even lower in people who (had) suffered from IHD.

In many studies the relationship between risk factors and IHD was established at the moment that problems occur. It is possible that participants in an epidemiological study who are already aware of their IHD have changed their lifestyle and have thereby lowered the values of the risk factors, for example stopped smoking. The lower blood pressure can be partly explained by a lower cardiac output after a myocardial infarction in some people.

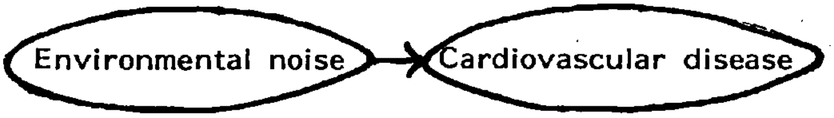
We conclude that the relationship between the risk factors and IHD was only significant for cholesterol and HDL-cholesterol in areas of aircraft noise.

Table 7.35 Mean and p values in analysis of variance (T-test) between risk factors and IHD, present and not present respectively

| | Traffic noise | | | Aircraft noise | | |
|---|---|---|---|---|---|---|
| Risk factors | no-IHD | IHD | p | no-IHD | IHD | p |
| | x | x | | x | x | |
| Cholesterol level | 5.5 | 5.7 | .33 | 5.3 | 5.6 | .033* |
| HDL-chol.level | 1.1 | 1.1 | .70 | 1.1 | 1.0 | .014* |
| Cigarette Units | 8.3 | 9.2 | .67 | 5.3 | 5.2 | .90 |
| DBP | 72.6 | 71.0 | .41 | 74.9 | 75.6 | .63 |
| SBP | 118.2 | 116.7 | .50 | 123.0 | 126.8 | .11 |
| number | 356 | 41 | | 370 | 62 | |

* denotes significance at $p < 0.05$

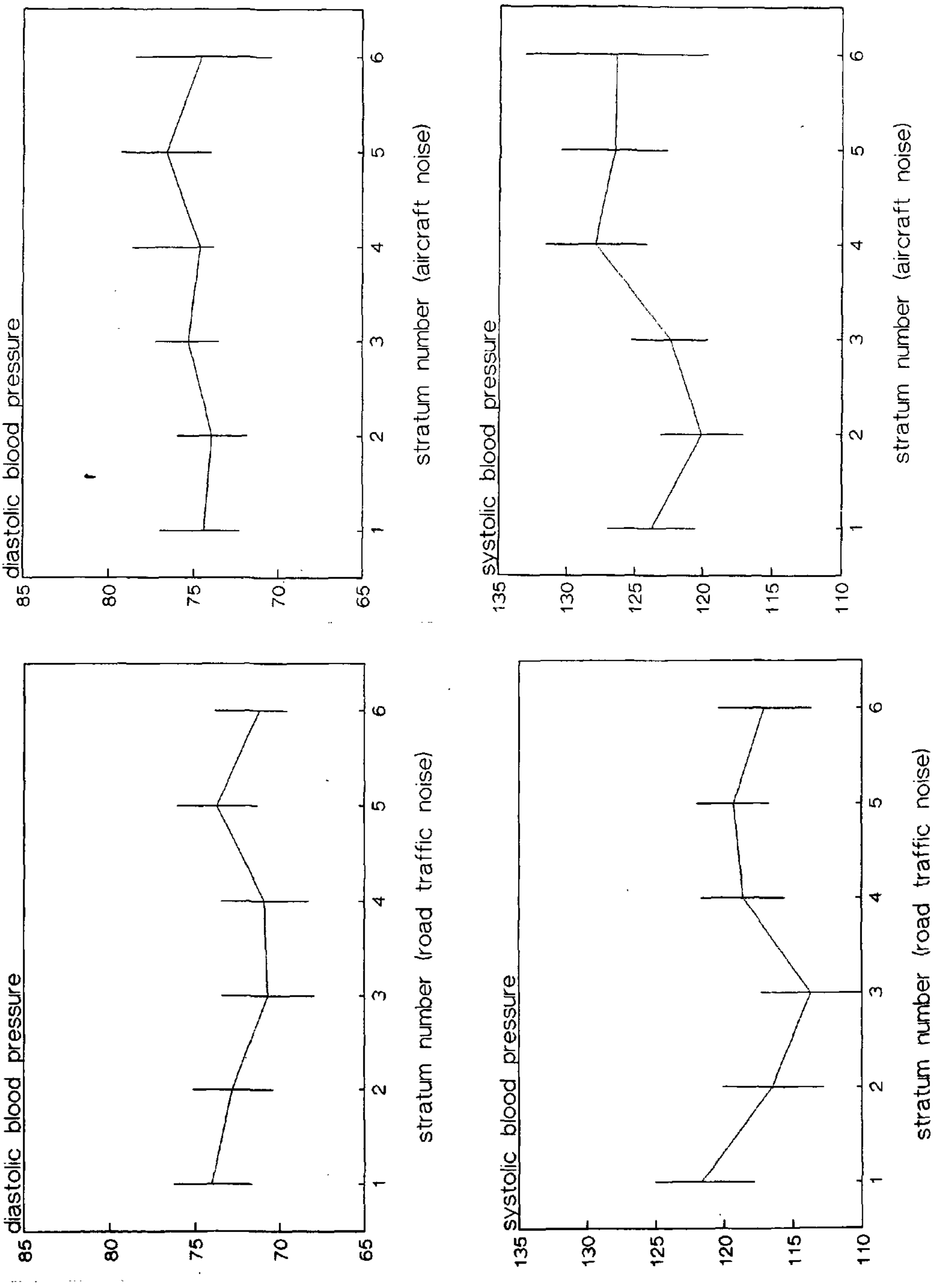
### 7.5.3 The relationship between environmental noise and cardiovascular diseases, without correcting for risk factors



Some studies did not control (sufficiently) for the presence of other risk factors. In order to compare with these we have analysed the relationships between environmental noise and blood pressure resp. IHD without correction for the presence of the risk factors. We present the results for blood pressure and IHD in seperate sections of this chapter.

1. Relationship between noise and blood pressure

Regression analysis showed a significant positive relationship between systolic blood pressure and aircraft noise with an explained variance of 1%, but not between diastolic blood pressure and aircraft noise or between blood pressure and traffic noise (Table 7.36). The mean blood pressure values as used in analysis of variance are given in Figures 7.2-7.5.
Because hypertension usely occurs above the age of 40 we repeated these analyses for people between 40 and 50 years of age. There was no significant relationship between environmental noise and blood pressure for this age group (for the relation traffic noise with DBP p= 0.90, n= 151, with SBP p= 0.44, n= 151; for the relation aircraft noise with DBP p= 0.69, n= 182, with SBP p= 0.32, n= 182).



Figures 7.2-7.5. Relationship between mean blood pressure values and environmental noise as calculated with analysis of variance. The vertical lines give the 95% confidence interval. The relationship between systolic blood pressure and aircraft noise is significant (see text)

Table 7.36 Beta and p values in regression analysis of relationship between noise and systolic and diastolic blood pressure

| | SBP | | DBP | | n |
|---|---|---|---|---|---|
| | beta | p | beta | p | |
| traffic noise | -.03 | .57 | -.05 | .37 | 396 |
| aircraft noise | .12 | .014* | .07 | .14 | 432 |

* denotes significance at $p < 0.05$

Knipschild (1977) compared percentage of hypertension in an area of aircraft noise of 40-60 KE with an area of aircraft noise of 20-40 KE, for men and for women in the age categories 35-44 and 45-54, who had lived there for longer than five years. He found significantly more men and women with hypertension ($SBP > 175$ mmHg or $DBP > 100$ mmHg) and more men and women with a diastolic blood pressure of more than 100 mm Hg in an area with aircraft noise of 40-60 KE compared to in an area with 20-40 KE (Table 7.1). We were not able to compare the same groups because numbers were too small. We forgot about the age categories, however, and compared percentage of hypertension in strata 1 and 2 of aircraft noise with strata 3-6, for men and for women, who lived there longer than five years. We found that there was not significantly more hypertension in the noisier areas (Fisher's test; p = 0.81 for men, p = 0.82 for women).
Knipschild (1979) found no more hypertension ($SBP \geqslant 160$ mmHg or DBP $\geqslant 105$ mmHg) among housewives aged 40-49 years in an area with traffic noise of more than 62.5 dB(A) compared to in an area with less than 62.5 dB(A). We found that there was not significantly more hypertension (SBP $> 160$ mmHg or $DBP > 105$ mmHg) in participants exposed to traffic noise of more than 60 dB(A) (strata 4-6) than in those exposed to 60 dB(A) or less (strata 1-3).
Knipschild (1984) found significantly more hypertension ($SBP \geqslant 160$ mmHg or DBP $\geqslant 95$ mmHg) and a higher mean systolic or diastolic blood pressure in people who lived more than five years in an area with traffic noise of more than 65 dB(A) compared to in an area with less than 65 dB(A). We found that there was not significantly more hypertension ($SBP \geqslant 160$ mmHg or $DBP \geqslant 95$ mmHg). In people exposed to traffic noise of more than 65 dB(A) (strata 5 and 6) than in those exposed to 65 dB(A) or less (strata 1-4). We did not find a significantly higher mean systolic (p= .60) or

diastolic (p= 0.54) blood pressure in strata 5 and 6 than in strata 1-4 (T-test).

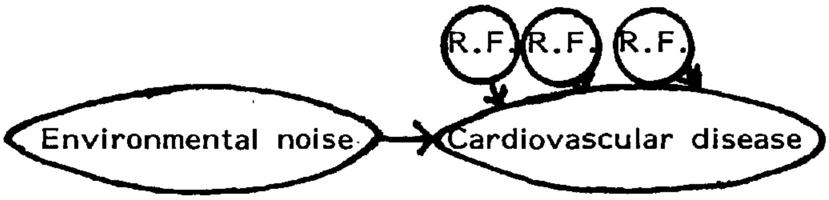
2. Relationship between noise and IHD

There was no significant relationship between noise and number of participants with or without IHD (p = 0.47 for traffic noise, p= 0.66 for aircraft noise, $X^2$, df= 5; Table 7.37).

Table 7.37 Number of participants with and without IHD in each of the six strata; p= 0.47 for traffic noise and p= 0.66 for aircraft noise ($X^2$; df= 5)

| Stratum | Traffic noise | | Aircraft noise | |
|---|---|---|---|---|
| | IHD | no-IHD | IHD | no-IHD |
| 1 | 10 | 64 | 13 | 83 |
| 2 | 10 | 62 | 11 | 94 |
| 3 | 7 | 46 | 13 | 73 |
| 4 | 5 | 67 | 14 | 56 |
| 5 | 6 | 79 | 9 | 50 |
| 6 | 3 | 38 | 2 | 14 |

### 7.5.4 The relationship between environmental noise and cardiovascular diseases including correction for risk factors



1. Relationship between environmental noise and blood pressure

a. We investigated the possibility of interrelationships of each of the risk factors and environmental noise with blood pressure; when men for example are exposed to noise, they may have a higher rise in blood pressure than do women. Similarly the rise in blood pressure may be higher in older than in younger people when they are exposed to noise. We first compared the two highest noise levels with the lowest (Figure 7.6).

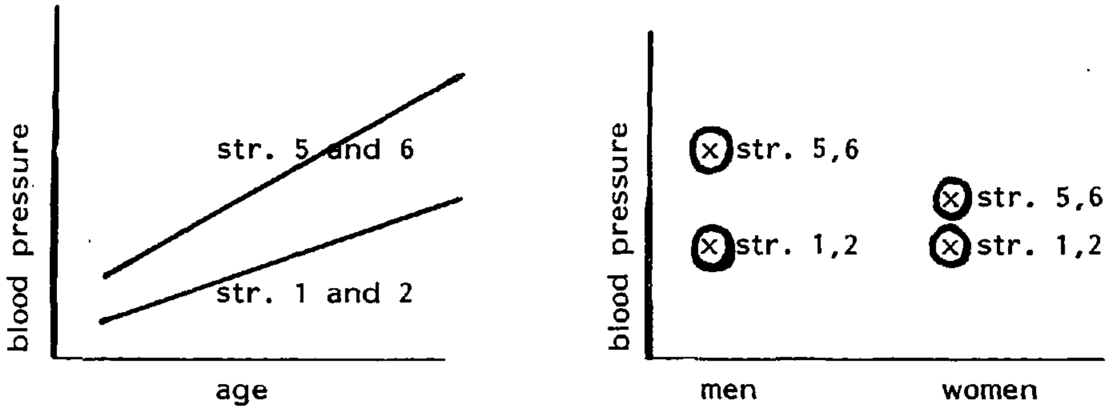


Figure 7.6. The possible interrelationship of risk factors and noise with blood pressure, when comparing strata 1 and 2 with 5 and 6.

- We compared the regression line of the relation between each of the continuous risk factors and blood pressure for strata 1 and 2 with that for strata 5 and 6 (for method see Neter, 1974; Table 7.40). The regresssion lines do not differ significantly in the case of traffic noise. The results of the analyses on aircraft noise show a significant difference for age and SBP, but for other risk factors a weaker not significant relationship was found.

Table 7.38 F values for the difference between strata 1 and 2 and strata 5 and 6 in regression lines of the relationship between the continuous risk factors and blood pressure (n = 276 for aircraft noise, n = 271 for traffic noise)

| | Traffic noise | | Aircraft noise | |
|---|---|---|---|---|
| Risk factor | DBP | SBP | DBP | SBP |
| | F | F | F | F |
| age | 0.03 | 0.60 | 2.9 | 4.2* |
| alcohol use | 0.15 | 0.05 | 1.0 | 2.8 |
| quetelet index | 0.25 | 0.65 | 2.7 | 2.7 |

* F is significant when > 3.0

- Before analysing the difference between the two groups of each of the dichotomous variables, for example men and women, we had to analyse with a T-test whether there was a siginificant difference in blood pressure of both men and women in strata 1 and 2 compared to strata 5 and 6. If there was no significant difference, then we could not compare the difference between men and women. In only a few cases was there a significant difference in blood pressure between a low and a high level of environmental noise (Table 7.39), so no further analyses on the interaction of the dichotomous variables with noise and blood pressure could be based on this.

Hypertension in parents and in siblings were used as dichotomous variables.

Table 7.39 p values for T-tests for the differences between strata 5 and 6 and strata 1 and 2 in the effects on blood pressure of the dichotomous risk factors .

| Risk factor | Traffic noise DBP | Traffic noise SBP | Aircraft noise DBP | Aircraft noise SBP |
|---|---|---|---|---|
| | p | p | p | p |
| man | .82 | .06 | .54 | .13 |
| women | .41 | .63 | .19 | .06 |
| hypertension in siblings | | | | |
| present | .84 | .82 | .58 | .04* |
| not present | .57 | .94 | .19 | .15 |
| hypertension in parents | | | | |
| present | .42 | .37 | .86 | .26 |
| not present | .67 | .54 | .03* | .08 |
| oral contracept. use | .96 | .60 | .88 | .80 |
| no oral contracept. use | .29 | .93 | .16 | .06 |

* denotes significance at $p < 0.05$

We also checked if there was a linear relationship between risk factors and noise.

- We calculated B values and 95.0% confidence intervals in regression analysis of relationships of each of the continuous risk factors (age, Quetelet index and alcohol use) with blood pressure (Table 7.40).

Table 7.40 B values and 95.0% confidence intervals (c.i.) in the regression analysis of relationships of each of the continious risk factors with with blood pressure (n = 396 in traffic noise, n = 432 in aircraft noise)

| Risk factor | DBP |  | SBP |  |
|---|---|---|---|---|
| Traffic noise | B | 95.0% c.i. | B | 95.0% c.i. |
| age | .28 | .18 - .37 | .20 | .07 - .33 |
| quetelet index | .98 | .71 - 1.25 | 1.10 | .75 - 1.48 |
| alcohol use | 1.17 | .33 - 2.02 | 1.42 | .29 - 2.55 |
| Aircraft noise |  |  |  |  |
| age | .38 | .27 - .48 | .46 | .30 - .62 |
| quetelet index | 1.10 | .89 - 1.38 | 1.60 | 1.22 - 1.97 |
| alcohol use | .54 | -.35 - 1.43 | .48 | -.85 - 1.80 |

- We then calculated B values again in multiple regression analysis of the same relationship, but accounting for the influence of noise on this relationship (Table 3.41). None of the latter B values was outside the respective 95.0% confidence intervals of the first mentioned analyses and therefore there was no interrelationship of each of the continuous risk factors and noise with blood pressure.

Table 7.41 B values in multiple regression analysis of relationships of each of the continious risk factors with blood pressure when accounting for the influence of noise (n = 396 in traffic noise, n = 432 in aircraft noise)

| Risk factor | DBP | SBP |
|---|---|---|
| Traffic noise | B | B |
| age | .28 | .19 |
| quetelet index | .98 | 1.10 |
| alcohol use | 1.22 | 1.46 |
| Aircraft noise |  |  |
| age | .37 | .46 |
| quetelet index | 1.10 | 1.60 |
| alcohol use | .60 | .62 |

- For the dichotomous risk factors (sex, oral contraceptive use and here also hypertension in parents and siblings) we compared the correlation coefficients between blood pressure and noise of each of the two groups (men-women; oral contraceptive use - no oral contraceptive use; hypertension in family - no hypertension in family) with Fisher Z transformation (Kleinbaum, 1978). The Z-values are given in Table 7.42. The risk factor sex was tested two-sided, the other three one-sided. The Z-values for the correlation between diastolic blood pressure with hypertension in siblings and parents were just significant.

We therefore conclude that there was no interrelationship of each of the dichotomous risk factors and noise with blood pressure either. There was a weak interrelationship of each of the continuous risk factors, age (significant), alcohol use and Quetelet index, and noise with systolic blood pressure in traffic noise areas. This interrelationship was not linear.

Table 7.42 Z values in the comparison of correlation coefficients between blood pressure and noise for the two groups of each of the dichotomous risk factors

| | Traffic noise | | Aircraft noise | |
|---|---|---|---|---|
| | DBP | SBP | DBP | SBP |
| Risk factor | Z | Z | Z | Z |
| sex | 0.568 | 0.164 | 0.194* | 0.482 |
| hypert. parents | 0.324* | 0.020 | 1.832 | 0.850 |
| hypert. siblings | 1.704 | 0.424 | 0.361 | -0.115 |
| oral contraceptive use | 0.154 | 0.168 | -0.753 | 0.000 |

* denotes significance of $Z > 1.96$ in a two-sided test, and $< 1.65$ in a one-sided test

b. We will now look at the relationship between environmental noise and blood pressure when accounting for risk factors.

With multiple regression analysis it was possible to eliminate the influence of the presence of all risk factors. Then the influence, if any, of environmental noise on blood pressure could be analysed. In the analysis three categories of risk factors were used, starting with independent risk factors such as sex and age, then blood pressure in parents and siblings, followed by inclusion of alcohol use and the quetelet index and finally incorporating noise level as a fourth step. Within these categories of risk factors, a specific type of multiple regression analysis can put the most important one first (SPSS, 1987). Hypertension in parents and in siblings were used as dichotomous variables. Sex, age and quetelet index made a significant contribution to predicting blood pressure levels in both traffic and aircraft noise areas; noise and alcohol gave no significant contribution at all (Table 7.43).

Beta shows the mutual comparable contribution of each of the risk factors to the explanation of blood pressure. Quetelet index was the most important risk factor in areas with aircraft noise, and was also the most significant one in connection with diastolic blood pressure in traffic noise areas. In traffic noise areas Quetelet index and sex were almost equally important risk factors in connection with systolic blood pressure. As expected almost all contributions of risk factors were positive, i.e. a higher value for the risk factor corresponded with a higher blood pressure. Alcohol use and noise as well, however, had an insignificant negative relation with systolic blood pressure in areas exposed to traffic noise. The explained variance ($r^2$) of blood pressure by risk factors and noise amounted to 16-17% in traffic noise areas and to 21-23% in aircraft noise areas.

We conclude that a positive relationship between aircraft noise and systolic blood pressure was found in our population sample without correction for confounding factors. This result corresponds with that of Knipschild (1977). After correcting for confounding factors, however, no positive correlation remained. In areas with traffic noise we found, as have previous studies, no positive correlation between noise and either diastolic or systolic blood pressure (Knipschild 1979, 1984).

Table 7.43 Beta and p values and explained variance $(r^2)$ in multiple regression analysis of the relationship between risk factors and noise, and diastolic and systolic blood pressure(n = 271 in traffic noise; n = 339 in aircraft noise)

| Risk factor | DBP | | | | SBP | | |
|---|---|---|---|---|---|---|---|
| Traffic noise | p | beta | $r^2$ | | p | beta | $r^2$ |
| age | .000* | .24 | .08 | sex | .000* | .29 | .08 |
| sex | .003* | .18 | .06 | age | .006* | .16 | .10 |
| hyp. siblings | .005* | .17 | .11 | hyp. siblings | .002* | .18 | .13 |
| hyp. parents | - | - | - | hyp. parents | .48 | .05 | .13 |
| quetelet index | .000* | .25 | .16 | quetelet index | .000* | .24 | .18 |
| alcohol use | .81 | .01 | .16 | alcohol use | .82 | -.01 | .17 |
| noise | .81 | .01 | .16 | noise | .74 | -.02 | .17 |
| Aircraft noise | | | | | | | |
| age | .000* | .30 | .09 | age | .000* | .25 | .06 |
| sex | .029* | .30 | .10 | sex | .004* | .15 | .08 |
| hyp. parents | .000* | .19 | .14 | hyp. parents | .000* | .19 | .11 |
| hyp. siblings | .021* | .12 | .15 | hyp. siblings | .18 | .07 | .12 |
| quetelet index | .000* | .31 | .23 | quetelet index | .000* | .32 | .20 |
| alcohol use | .83 | .01 | .23 | alcohol use | - | - | - |
| noise | .48 | .03 | .23 | noise | .19 | .07 | .21 |

* denotes significance at $p < 0.05$. In some cases the contribution of the risk factor to the explanation of blood pressure was so low that the analysis produced no beta or p value.

2. Relationship between environmental noise and IHD

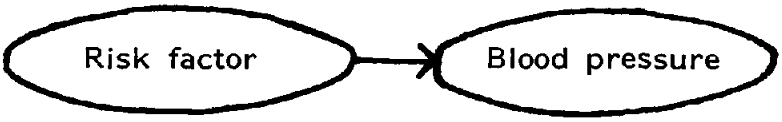
   After the correcting for risk factors, we found no significant relationship between aircraft noise and IHD in an analysis of covariance (p = 0.32); the relationship between traffic noise and IHD was almost significant (p = 0.06). In this case, the explained variance is only 2%.

### 7.5.5 The influence of psychological variables on the relationship between environmental noise and blood pressure

The inclusion of psychological variables into our survey was considered worthwile in improving our understanding of the relationship between exposure to environmental noise and detrimental health effects. Here we analyse the effects on blood pressure of three of these variables: primary appraisal, perceived control and coping behaviour.

1. Primary appraisal

As a first step we analyzed the relationship between primary appraisal and blood pressure.



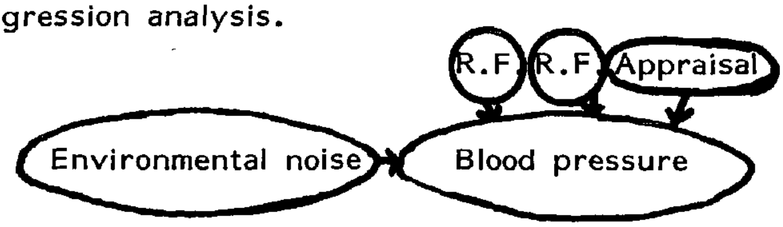
In Table 7.44 the p values for the regression analysis of primary appraisal and of each of the five components of primary appraisal with blood pressure are given. Neither primary appraisal nor any of its five components had a significant positive correlation with blood pressure; indeed in most cases the relationship was even negative.

Table 7.44 Beta and p values and explained variance ($r^2$) in regression analysis of the relationship between primary appraisal, and each of its five components, with blood pressure

| | DBP | | | SBP | | | n |
|---|---|---|---|---|---|---|---|
| Traffic noise | p | beta | $r^2$ | p | beta | $r^2$ | |
| Primary appraisal | .75 | -.02 | .00 | .82 | .02 | .00 | 211 |
| Perceived loudness | .40 | .05 | .00 | .056 | .11 | .01 | 304 |
| Bitter scale | .62 | -.03 | .00 | .98 | -.00 | .00 | 360 |
| Mokken scale | .63 | -.03 | .00 | .89 | .01 | .00 | 219 |
| Stress feelings | .89 | -.01 | .00 | .48 | -.04 | .00 | 304 |
| Non-specific annoyance | .82 | -.01 | .00 | .76 | .02 | .00 | 303 |
| Aircraft noise | | | | | | | |
| Primary appraisal | .24 | -.26 | .00 | .34 | -.05 | .00 | 352 |
| Perceived loudness | .13 | -.01 | .01 | .40 | -.04 | .00 | 408 |
| Bitter scale | .83 | -.01 | .00 | .54 | .03 | .00 | 414 |
| Mokken scale | .57 | -.03 | .00 | .59 | -.03 | .00 | 361 |
| Stress feelings | .26 | -.06 | .00 | .09 | -.08 | .01 | 409 |
| Non-specific annoyance | .52 | -.03 | .00 | .49 | -.03 | .00 | 409 |

* denotes significance at $p < 0.05$.

Appraisal was then incorporated as an extra risk factor in multiple regression analysis.



If appraisal together with noise is added as a fourth category in multiple regression analysis (as described in par. 7.5.4 and Table 7.43), primary appraisal made no significant contribution to predicting levels of blood pressure (Table 7.45).

Table 7.45. Beta and p values and explained variance ($r^2$) in multiple regression analysis of the relationship of risk factors, noise and primary appraisal with blood pressure (n = 143 for traffic noise; n = 149 for aircraft noise)

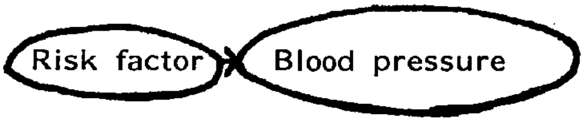
| Risk factor | DBP | | | SBP | | | |
|---|---|---|---|---|---|---|---|
| Traffic noise | p | beta | $r^2$ | | p | beta | $r^2$ |
| age | .001* | .27 | .13 | sex | .000* | .40 | .17 |
| sex | .020* | .18 | .16 | age | .21 | .10 | .20 |
| hyp.parents | .89 | -.01 | .16 | hyp.siblings | .13 | .12 | .22 |
| hyp.siblings | .99 | .00 | .15 | hyp.parents | .40 | .07 | .21 |
| quetelet index | .012* | .22 | .18 | quetelet index | .056 | .16 | .23 |
| alcohol use | .49 | .05 | .18 | alcohol use | .61 | .04 | .23 |
| noise | .45 | -.06 | .18 | primary appr. | .77 | -.02 | .22 |
| primary app. | .89 | -.01 | .17 | noise | .99 | -.00 | .22 |
| Aircraft noise | | | | | | | |
| age | .049* | .16 | .09 | age | .53 | .05 | .04 |
| sex | .19 | .10 | .09 | sex | .06 | .14 | .06 |
| hyp.parents | .008* | .21 | .14 | hyp.parents | .002* | .24 | .12 |
| hyp.siblings | .60 | .04 | .14 | hyp.siblings | .27 | -.09 | .11 |
| quetelet index | .000* | .33 | .23 | quetelet index | .000* | .35 | .22 |
| alcohol use | .66 | .03 | .23 | alcohol use | .25 | .09 | .23 |
| primary app. | .19 | .10 | .23 | noise | .86 | .01 | .22 |
| noise | .83 | .02 | .23 | primary app. | .94 | .00 | .22 |

* denotes significance at $p < 0.05$

Similarly, when each of the five components of primary appraisal was included in the multiple regression analysis, again no significant contribution was made to predicting levels of blood pressure (Brederode, 1988).

2. Perceived control

As a first step we analyzed the relationship between perceived control and blood pressure.



There was no significant correlation in the regression analysis of the relationship between perceived control and blood pressure (Table 7.46).

Table 7.46 Beta and p values and explained variance ($r^2$) in regression analysis of the relationship between perceived control and blood pressure.

|  | DBP |  |  | SBP |  |  | n |
|---|---|---|---|---|---|---|---|
| Traffic noise | p | beta | $r^2$ | p | beta | $r^2$ |  |
| Perceived control | .34 | -.06 | .00 | .37 | -.05 | .00 | 303 |
| Aircraft noise |  |  |  |  |  |  |  |
| Perceived control | .54 | -.03 | .00 | .38 | -.04 | .00 | 407 |

* denotes significance at $p < 0.05$

The regression analysis was than repeated in a modified version. The sample was divided according to the value of the perceived control variable: people with high scores for perceived control were compared with people having low scores for perceived control. The results were calculated using the formula made by Neter (1974) and are shown in Table 7.47. The regression lines of the relationships between noise and blood presssure were not significantly different for people with high or low scores for perceived control.

Table 7.47 F values for the difference in regression lines of relationship between noise and blood pressure for people with a high score for perceived control (5 or 6) compared to people with a low score for perceived control (3 or 4). (n = 303 for traffic noise; n = 407 for aircraft noise)

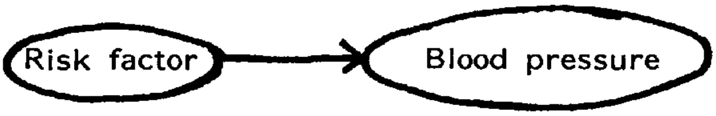
| | Traffic noise | Aircraft noise |
|---|---|---|
| Diastolic blood pressure | 0.5 | 0.6 |
| Systolic blood pressure | 1.4 | 0.6 |

* F is significant if > 3.0

Because of the common difficulty people had in answering questions about their reaction to noise to which they were not regularly exposed, we also calculated F values for people who on the scale for perceived loudness scored 15 or more (maximum 25). There was still, however, no significant difference between the regression lines, the highest F value being only 1.4 (n = 176 for traffic noise; n = 355 for aircraft noise).

3. Coping

As a first step we analyzed the relationship between each of the general and specific coping factors and blood pressure.



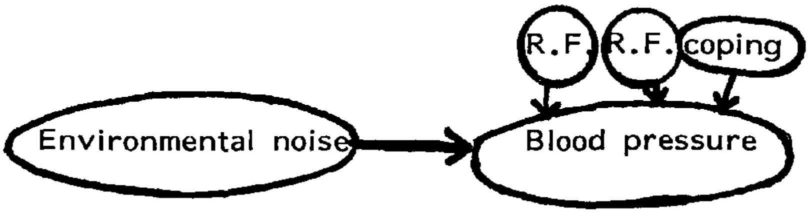
In only two out of the 24 cases was there a significant relationship between the coping variable and blood pressure; the explained variance was only 1% (Table 7.48).

Table 7.48 Beta and p values and explained variance ($r^2$) in regression analysis of the relationship between each of the coping variables and blood pressure

| Coping variables | DBP | | | SBP | | | n |
|---|---|---|---|---|---|---|---|
| Traffic noise | p | beta | $r^2$ | p | beta | $r^2$ | |
| noise - problem orientated | .81 | -.01 | .00 | .03* | -.11 | .01 | 394 |
| noise - comforting | .28 | -.05 | .00 | .04* | -.10 | .01 | 395 |
| noise - avoidance | .56 | .03 | .00 | .81 | -.01 | .00 | 394 |
| general - problem orientated | .50 | -.03 | .00 | .50 | .03 | .00 | 395 |
| general - comforting | .86 | -.01 | .00 | .76 | -.02 | .00 | 395 |
| general - avoidance | .81 | .01 | .00 | .42 | -.04 | .00 | 395 |
| Aircraft noise | | | | | | | |
| noise - problem orientated | .95 | .00 | .00 | .94 | .00 | .00 | 426 |
| noise - comforting | .88 | -.01 | .00 | .19 | -.06 | .00 | 427 |
| noise - avoidance | .65 | .02 | .00 | .66 | -.02 | .00 | 427 |
| general - problem orientated | .80 | -.01 | .00 | .62 | .02 | .00 | 431 |
| general - comforting | .28 | -.05 | .00 | .14 | -.07 | .01 | 430 |
| general - avoidance | .45 | .04 | .00 | .28 | .05 | .00 | 431 |

* denotes significance at $p < 0.05$.

The multiple regression analysis as described in para 7.5.4 and Table 7.4.3 was then repeated with each of the six coping variables in turn added, together with noise, as a fourth category. None of the six coping variables significantly contributed towards predicting levels of blood pressure (Brederode, 1988).



A further regression analysis between noise and blood pressure was done, in which people with high scores for a coping variable were compared with those people with a low score. The results, calculated following the formula of Neter (1974) are shown in Table 7.49. The regression lines were not significantly different.

Table 7.49 F values for differences in the regression lines of the relationship between noise and blood pressure for people with a high score for noise-problem orientated behaviour ( > 20), noise-comforting ( > 18), noise-avoidance ( > 18) and general items ( > 10), compared with people with a lower score for these variables

| Coping variables | | Traffic noise | n | Aircraft noise | n |
|---|---|---|---|---|---|
| noise - problem orientated | DBP | 0.1 | 394 | 0.5 | 426 |
| | SBP | 0.9 | 394 | 1.0 | 426 |
| noise - comforting | DBP | 0.1 | 395 | 0.1 | 427 |
| | SBP | 0.3 | 395 | 0.8 | 427 |
| noise - avoidance | DBP | 2.0 | 394 | 1.2 | 426 |
| | SBP | 0.1 | 394 | 2.2 | 426 |
| general - problem orientated | DBP | 0.0 | 395 | 0.6 | 431 |
| | SBP | 1.5 | 395 | 0.9 | 431 |
| general - comforting | DBP | 0.6 | 395 | 0.4 | 430 |
| | SBP | 0.5 | 395 | 0.5 | 430 |
| general - avoidance | DBP | 1.9 | 395 | 0.3 | 431 |
| | SBP | 0.8 | 395 | 0.3 | 431 |

* denotes significance at F > 3.0

Because of the common difficulty people had in answering questions concerning their reaction to noise to which they were not regularly exposed, we also calculated the F values for the coping variables related to noise for people who on the scale for perceived loudness scored 15 or more (maximum 25). There was still no significant difference between the regression lines, the highest F value being 2.8 (n = 175 for traffic noise; n = 351 for aircraft noise).

We conclude that none of the psychological variables seems to be of much importance in enabling prediction of blood pressure levels to be made.

## 7.6 Discussion

### 1. Methods

### Characteristics of participants in survey

The epidemiological survey comprised a field survey, including a medical questionnaire, and a medical survey. The questionnaire was titled 'Residence and living situation' and therefore no bias was expected on the specific subjects of noise, blood pressure and ischaemic heart disease at the start of the survey. Of the 2024 people interviewed almost 900 were actually examined. This reduction in number was partly caused by the voluntariness of participation and partly by exclusion of participants for medical reasons. This did lead to differences in the samples of people in each of the surveys: people in the survey who had IHD were significantly more willing to take part in the medical survey, but since we found no significant relationship between environmental noise and IHD, this was not relevant. The two samples did not differ from each other, however, in percentage of people who were or who were not under control for hypertension or in percentage of participants and non-participants in the six different noise levels.

## Blood pressure measurement

Blood pressure was measured according to rule. It was measured twice, with a ten minute interval, of which we used the lowest one in the analyses. The difference between each of the two measurements for diastolic and systolic blood pressure respectively, which we expected to a certain extend because of the influence of tension before or during the examination, was rather large. The squared correlation between the two measurements was only 0.60-0.65 for diastolic blood pressure and 0.70-0.75 for systolic blood pressure. A third measurement could well be different again. A point measurement of blood pressure in an epidemiological survey may therfore not be representative.

## Risk factors

Although we corrected for six of the most important risk factors of blood pressure the explained variance was only 16-23%. It is possible that salt intake can explain some of the resulting variance. It is difficult, however, to measure salt intake in an epidemiological survey.

## Minnesota Code

The Minnesota Code is especially developed to standardise results of E.C.G. readings of men in epidemiological surveys in the general population. It has, however, several disadvantages if used to assess cardiovascular disease. The Minnesota Code (code 5) had to be adapted for women, because backward turning of the T-axis which is common in this group can result in a non-pathological negative T-wave and therefore in code 5. In our survey this would have resulted in a false positive code in women compared to men. The sensitivity of Minnesota Code 1 for myocardial infarction was 33% (prevalence of myocardial infarction was 1%). This can only partly be explained because signs of myocardial infarction can disappear from the E.C.G.. The sensitivity of Minnesota Code 1,4 and 5 for ischaemic heart disease was low (9%, prevalence of IHD was 12%). This was largely due to the large number of participants who, although with a positive history of IHD, had no signs of it on the ECG. These false negative results we expected since signs of myocardial infarction can disappear from the E.C.G. and because diagnoses of IHD were partly made from medical records of the participants. This did not influence the results because we combined the results from the medical records with those from the Minnesota Code. If we would have corrected for the supposed false positive results of the Minnesota Code for IHD, ten people had code 1 or 5 while clinically they had no signs of IHD, the prevalence of IHD would have gone from 12 to 11%. The supposed false positive results from the Minnesota Code therefore did not influence the results considerably.

## 2. Results

Like Knipschild (1979, 1984) we did not find a significant relationship between traffic noise and cardiovascular disease. Knipschild gave the following possible reasons: firstly, differences in noise exposure may have been too small to give rise to differences in health effects; secondly, by keeping windows closed and by sleeping more often at the back of their houses, occupants of houses in noisy streets managed to reduce their exposure to noise. A third possible reason could have been the noise level. Knipschild (1984) found that aircraft noise levels of 35-40 KE annoy one in three people, whereas the same amount of people are annoyed by traffic noise levels of 70-74 dB(A). Since there was a positive relationship between the occurrence of cardiovascular diseases and aircraft noise levels 35-40 KE, he only expected traffic noise levels of 70-74 dB(A) to have a similar effect. Very few people in his study, however, were exposed to such levels.

We found a significant positive relationship between aircraft noise and systolic blood pressure in the dose-effect model. Unlike Knipschild (1977), however, we did not find more hypertension (SBP 175 mmHg or DBP 100 mmHg) among either men or women in strata 3-6 compared to those in strata 1 and 2. In areas of aircraft noise the significant positive relationship between noise and systolic blood pressure disappeared when risk factors were accounted for.

We did not find any significant relationship between environmental noise and IHD. This is probably caused by the low prevalence of IHD and is not surprising since Thompson (1981) already stated that evidence on effects of noise on cardiovascular parameters other than blood pressure is weak and fragmentary.

## 7.7 Conclusions

The most important conclusions regarding the methods and results of our study on the relationship between environmental noise and cardiovascular diseases are as follows:

### 1. Methods

Our research strategy of following a field survey involving more than 2000 people with a medical survey involving almost 900 people had no effect on the numbers of people in the six strata nor on the numbers of people with hypertension, who participated in the survey.

The occurence of hypertension, as revealed by the questionnaire, had a very low correlation with measured diastolic hypertension (.24) and systolic hypertension (.19). The sensitivity of the questions about hypertension for measured hypertension was also very low. Our decision to use only measured blood pressure reduced the number of participants in the analyses from 2024 to less than 900.

In our survey the Minnesota Code caused several problems. We wanted a standard method of recording ischaemic heart disease by ECG; although the Minnesota Code did standardise results, it was not always associated, however, with pathological indications of IHD.

## 2. Results

Environmental noise exerted no indirect influence on the occurrence of cardiovascular diseases by way of their risk factors e.i. weight, alcohol consumption, smoking, cholesterol level and HDL-cholesterol level.

We found a significant interaction between level of aircraft noise, strata 1 and 2 compared to strata 5 and 6, and the relationship of systolic blood pressure with age. In high noise areas systolic blood pressure of older people rose more than that of younger people. This interaction was almost significant for alcohol consumption and relative weight. When all strata were included there was no significant linear relationship between blood pressure and age, alcohol consumption or relative weight.

It may be of interest to look more closely at the interaction between noise levels and the relationship between blood pressure and its risk factors.

In the dose-effect model, age, sex, hypertension in the family, relative weight and alcohol use all had a significant positive relationship with blood pressure. When other risk factors were accounted for alcohol use had no significant positive effect on blood pressure.

Like Knipschild (1979;1984), we found no significant positive relationship between traffic noise and blood pressure. In the dose-effect model there was a significant positive relationship between military aircraft noise and systolic blood pressure. Knipschild (1977) had a similar result concerning civil aircraft noise. When blood pressure risk factors were accounted for, however, noise was found to have no significant positive effect. We found no significant relationship between environmental noise and ischaemic heart disease, probably because of the rarity of IHD.

Introduction of psychological variables into our analysis did not improve our understanding of the relationship between environmental noise and blood pressure.

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# 8. ENVIRONMENTAL NOISE AND ELECTROLYTE CONCENTRATIONS (preliminary results)

T.R. Knottnerus, K. Altena and R. Stewart

# 8. ENVIRONMENTAL NOISE AND ELECTROLYTE CONCENTRATIONS*

## 8.1 Introduction

Recently the influence of noise on intra- and extracellular electrolyte concentrations related to the development of cardiovascular disease has been recognized (Ising et al., 1980, 1981, 1985). Especially the effects of an alteration in the erythrocyte magnesium concentration as resulting from noise exposure and mental load are investigated.
In this study we analyse the possible relationship between level of road traffic and military aircraft noise and the concentrations of erythrocyte and serum magnesium, calcium, sodium and potassium. The scope of the results presented in this chapter is limited because some known influences on electrolyte concentrations, like dietary habits and consumption of medicaments could not be fully taken into account. The data collected in our survey were not aimed at deducing the individual electrolyte intake.

The analyses presented are intended to answer the following questions:
is the level of exposure to environmental noise associated with the intra- and extracellular electrolyte concentrations, and
are psychological constructs explanatory elements in the relationship: environmental noise - electrolyte concentration?
In order to answer these questions we first give a short review of relevant literature in section 8.2. In section 8.3 we describe the research problem. In section 8.4 a description is given of method and materials. Section 8.5 describes the results. In section 8.6 the results are discussed and in section 8.7 the conclusions are drawn.

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* The authors thank dr. W. Babisch and prof.dr. H. Ising for their contributions to the accuracy of measurement and cautiousness in interpreting results.

## 8.2 The relationship between noise, electrolyte concentration and cardiovascular risks

The association between the magnesium metabolism and cardiovascular morbidity and mortality have been discussed by several authors (for recent reviews see Altura, 1981; Ebel, 1983; Günther, 1981). Last decade the effects of noise exposure and other stressors on the magnesium metabolism have gained greater attention.

Ising et al. (1980) have conducted a laboratory experiment into non-auditory physiological effects of traffic noise. Fifty-seven male test persons aged between 18 and 34 worked one day (7 hours) without traffic noise ($L_{Aeq}$ lower than 50 dB(A)) and one day with traffic noise alternately at a constant equivalent noise level of 85 dB(A). Several significant reactions to noise were found: decrease of working quality, increase of psychical tension, increase of blood pressure (systolic and diastolic), increase of pulse frequency, increase of epinephrine, cAMP, urine and serum Mg, protein, cholesterol and a decrease of erythrocyte Na and renin. An analysis of the relationship between these variables, including age and sensitivity to noise and an analysis of the interactive effects of noise and stress of learning, resulted in the suggestion of the hypothetical mechanism as presented in Fig. 8.1.

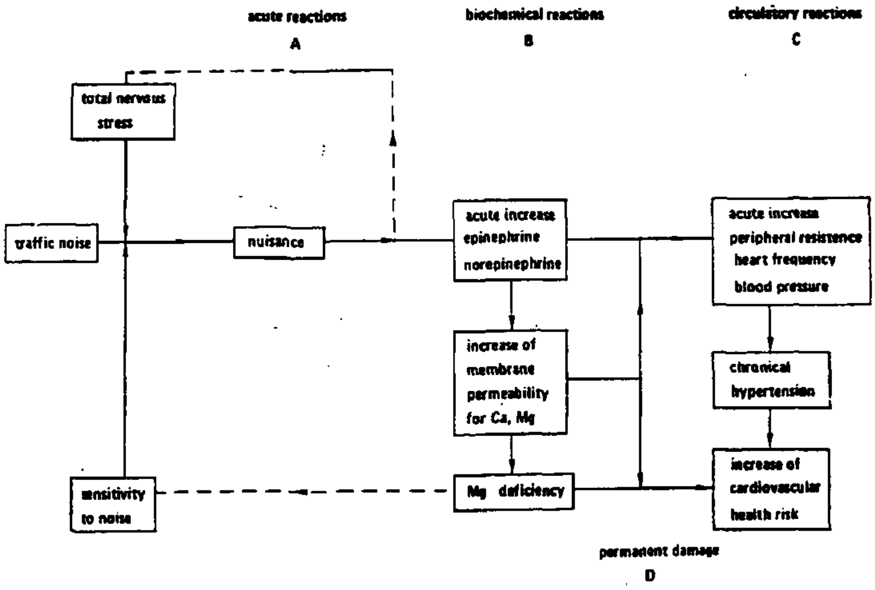


Figure 8.1 Hypothetical mechanism of the action of traffic noise, incorporating electrolytes in blood (Ising et al. 1980)

The general structure of this model implies that traffic noise causes an increase of bloodpressure and this in turn is a risk factor for cardiovascular diseases. On the other hand, the decrease of intracellular Mg due to traffic noise, also increases cardiovascular health risk. Magnesium deficiency also increases sensitivity to noise which in turn reinforces the effect of traffic noise.

Ising et al. (1980) attribute an important role to the magnesium metabolism in the etiology of cardiovascular diseases. Catecholamines released under stress may result in an increase of membrane permeability for calcium and magnesium. Intracellular Mg decreases and intracellular Ca increases. In the studies of Ising et al. (1980), an increased noise sensivity due to a decrease of erythrocyte Mg concentration was found.

The associations found between type A behaviour and predisposition to cardiac disease and hypertension (Friedman, 1969) made Altura (1981) develop the hypotheses that type A subjects are more or less permanently stressed, which is accompanied by higher catecholamine levels. This in turn gives rise to higher levels of free acids (FFA) and lower levels of erythrocyte magnesium. This situation heightens the risk for the development of cardiovascular disease among type A subjects. Following this idea, Henrotte conducted an experimental study in which two groups of male students performed a vigilance task with and without noise exposure (LAeq: 85 dB(A) (Henrotte, 1984). The two groups were selected on basis of their score on the Jenkins Activity Survey (Jenkins, 1975). One group was classified as type A, the other as type B. Results showed a significant decrease of erythrocyte magnesium (MgE) and a significant increase in serum magnesium (MgP). The increase in serum FFA (AGL.S) and uninary catecholamines was more pronounced and significant among the type A compared to the type B subjects (see fig. 8.2).

|  |  | Mg E | Mg P | Ca P | Zn E | Protéines P | AGL S | Catéch. U |
|---|---|---|---|---|---|---|---|---|
| Type A ■ | m | 2.148 | 0.797 | 2.472 | 0.206* | 77.79 | 0.202 | 79.9 |
|  | σ | 0.202 | 0.056 | 0.079 | 0.029 | 3.49 | 0.095 | 46.3 |
| Type B ▨ | m | 2.193 | 0.823 | 2.475 | 0.189* | 78.51 | 0.271 | 104.3 |
|  | σ | 0.268 | 0.056 | 0.114 | 0.022 | 3.45 | 0.163 | 44.6 |

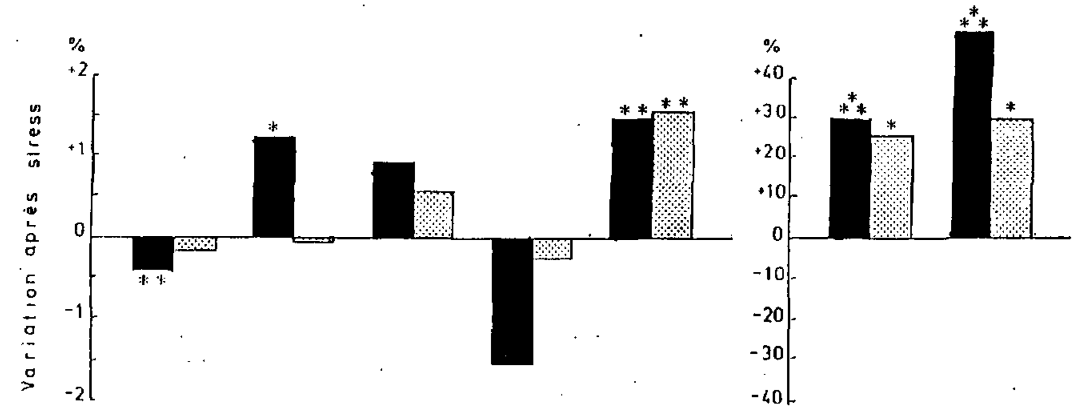


Figure 8.2 Mean and standard deviation of biochemical variable before exposition to noise (upper part) and mean differences after exposition, as percentage of the values before exposition (*p .05, ** p .02, p .001). (Henrotte, 1984)

These findings are in accordance with the ideas developed by Ising (1981). It is hypothesized by Ising et al. (1980) and Ising et al. (1981), that noise alone is not a sufficient condition for cardiovascular risks. A study of Knipschild (1977) and the results of their own study (Ising et al, 1980) provide evidence for the hypothesis that prolonged noise exposure together with stress of another kind (mental stress, stress of every day life) will increase cardiovascular risks.

The results of animal experiments indicate that phonotrauma, i.e. the damage to the inner ear caused by noise, is intensified by magnesium deficiency (Ising et al., 1981; Joachims et al, 1983). Furthermore, Ising et al.(1981) suppose that general cultural conditions influence the magnesium deficiency: changing work conditions increase stress, while at the same time magnesium input via nutrition decreases. Especially the increase of information processing as a component of changing work conditions is seen as an stress condition of increasing importance. But Ising et al. (1981) hypothesize, on the basis of human and animal experiments that only a high noise exposure level (levels above 85 dB(A), or levels above 50 dB(A) in combination with other stressors), will adversely effect cardiovascular parameters.

The increase of membrane permeability for Mg and Ca is controlled by the synaptic release of catecholamine under exposure to habitual noise, i.e. working noise. The norepinephrine is released into the innervated organs, i.e. the myocardium or vascular walls as a result of the activation of the sympathetic nervous system. This results in an increase of peripheral resistance, heart frequency, and blood pressure. At the same time however, the increase of catecholamines (epinephrine and norepinephrine) impedes the Mg input in the cells but reinforces the Ca input. (Ising et al., 1980). A chronic exposure to noise and resulting activation thus causes a decrease in intracellular Mg and eventually a Mg deficiency, this in turn increases cardiovascular risk.

Up to now, the mechanisms postulated are for the greater part investigated in experimental studies. In the greater part of these studies the duration of the noise exposure is relatively short.

Long term effects of noise exposure can be investigated in epidemiological studies. Recently the first results from two prospective studies became available. The preliminary cross-sectional results from the Cearphilly heart disease study do not reveal a significant association between noise level (road traffic noise) and erythrocyte magnesium (Babisch, 1986). In the 'Bonn traffic noise study' (Von Eiff et al., 1985) no systematic association between the noise exposure and the erythrocyte magnesium concentration was found. In the male part of the sample a decrease of erythrocyte magnesium was found after one and a half year. This decrease was associated with an increase in systolic (sbp) and diastolic bloodpressure (dbp). ( eMg/sbp: r= -.32, p .05; eMg/ dbp: r= -.41, p .01) (Von Eiff et al., 1985; Ising et al., 1985). The authors recommend further research with this subsample to investigate the relation with noise exposure.

## 8.3 Research problem

In this chapter we evaluate the hypothesis that level of environmental noise is associated with intra- and extracellular electrolyte concentrations of magnesium, calcium, sodium and potassium, and that the way subjects cope with the noise exposure influences this association.

Following Ising et al. (1980, 1981) we also evaluate the hypothesis that level of noise is associated with a decrease of eMg concentration.

## 8.4 Materials and method

From the subjects who participated in the medical survey (see chapter 4 and 7) blood samples were taken in order to analyse erythrocyte and serum electrolyte concentration. The preparation and storage of the samples was performed following precise description (M.R.C., 1985, von Eiff et al., 1985). The concentration of erythrocyte and serum magnesium, calcium, sodium and potassium (eMg, eCa, eNa, eK, sMg, sCa, sNa, sK) were determined by means of atomic spectroscopy by the laboratory of dr. H. Ising (Institute of Water, Soil and Air Hygiene, Federal Health Office, Berlin).

Although the processing of the blood samples was performed with care, a number of samples, collected in Amsterdam, had to be excluded from the statistical analyses of eNa and eCa concentrations. As a result of "bad ery washing" (indicated by the laboratory) the concentrations of eNa and eCa were unreliable. In Table 8.1 the numbers of 'samples' excluded on these grounds are quantified. For Ca and Na the ery-washing is most important, since the extra-cellular concentrations are much higher than the intracellular concentrations. Contaminations of ery-concentrations (e.g., with serum concentrations) therefore result in highly biased estimates. For this reason, an ery-concentration higher than 0.5 mmol/kg dry weight for Ca and at the same time higher than 30 mmol/kg dry weight for Na, are interpreted as an indication of bad ery-washing (see also fig. 8.2). This problem does not apply to eMg and eK because ery-concentrations for Mg and K are higher than serum concentrations. Generally serum-concentrations are regarded more reliable. Ery-washing was performed shortly after the medical examination of the subjects. Any series of samples in which at least on bad eCa-eNa washing was found was completely excluded from statistical analysis in order to exclude the possibility of bad ery-washing in succession (e.g., due to contaminated materials). A series of samples consisted of maximally 24 samples taken in succession.

Table 8.1 Number of 'bad samples' eCa and eNa and remaining number suitable for analyses (road-traffic noise)

| Noise level | Number of samples | | |
|---|---|---|---|
| | Total | 'Bad' | Remaining |
| 1 | 76 | 24 | 52 |
| 2 | 77 | 31 | 46 |
| 3 | 56 | 6 | 50 |
| 4 | 76 | 10 | 66 |
| 5 | 90 | 27 | 63 |
| 6 | 43 | 40 | 3 |
| Total | 418 | 138 | 280 |

This large number of missing cases forced us to omit all subjects from noise level 6 in the road traffic noise sample for the analyses in which eCa and eNa are involved. Indications of 'bad washing' were only found in the road traffic sample.

In this study erythrocyte Mg, Ca, Na and K concentration, are expressed in mmol/kg dry weight; serum Mg, Ca, Na and K are expressed in mmol/l. A clear comparison of serum and erythrocyte values from various studies is often hampered by the different ways of determination and expression of the concentrations (see for instance Ebel and Günther, 1983). In table 8.2 ranges of normal values obtained in blood serum are presented (see also values presented in section 8.2). No such values are available for erythrocyte concentrations.

Table 8.2 Normal range of serum electrolyte concentrations

| | |
|---|---|
| sMg | 0.7 - 1.0 mmol/l[1] |
| sCa | 2.2 - 2.6 mmol/l[1] |
| sNa | 135 - 143 mmol/l[1,2] |
| sK | 3.4 - 4.5 mmol/l[1,2] |

1) source Eastham (1985)
2) plasma concentrations

Results presented in Table 8.3 and section 8.5 relate to the subjects who took part in the medical examination. No subjects were excluded on the basis of medical status.

Figure 8.3 presents frequency distributions of the electrolyte concentrations over both samples used in this chapter.

Results of T-test for differences between electrolyte concentrations (road traffic vs. military aircraft) are presented in Table 8.3.

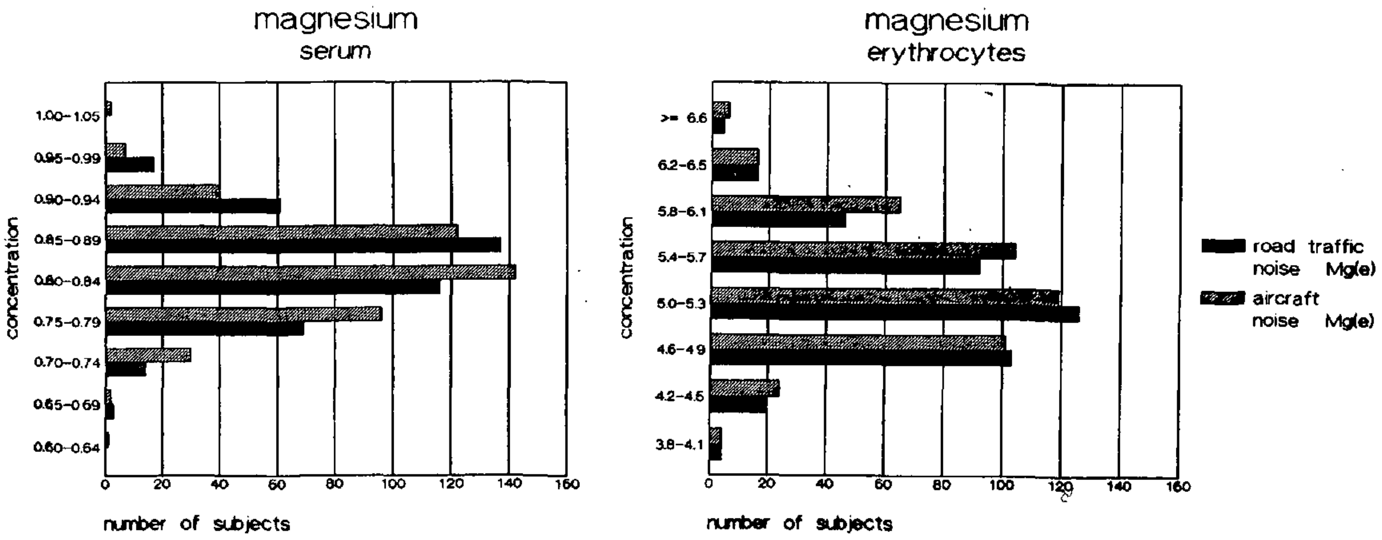
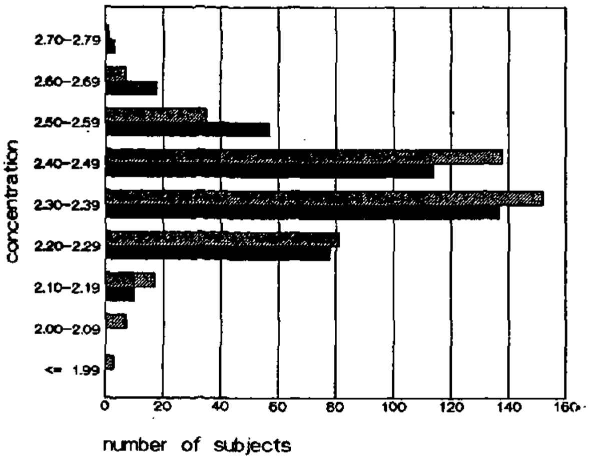
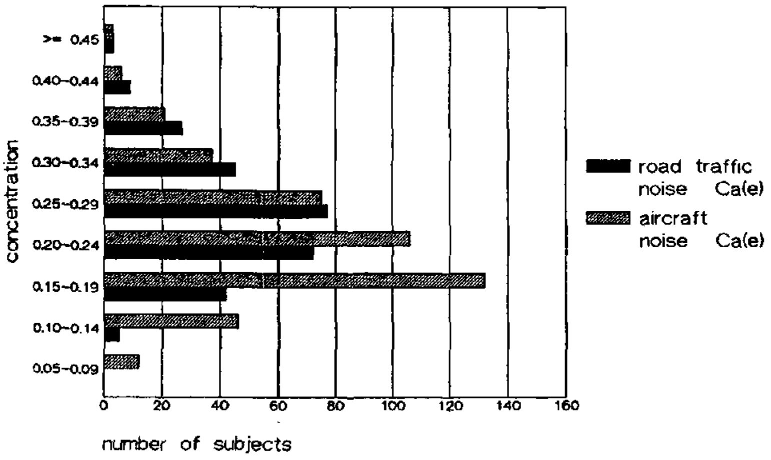


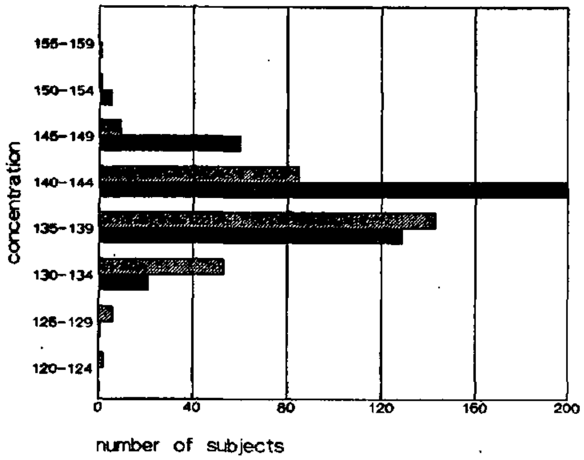
Figure 8.3 Frequency distributions of erythrocyte (right) and serum (left) electrocyte concentrations in road traffic and aircraft noise samples - continued on the next page.



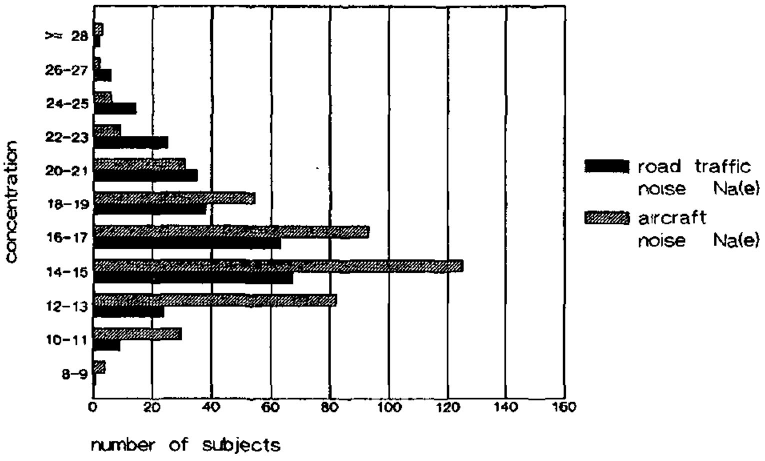
calcium
serum



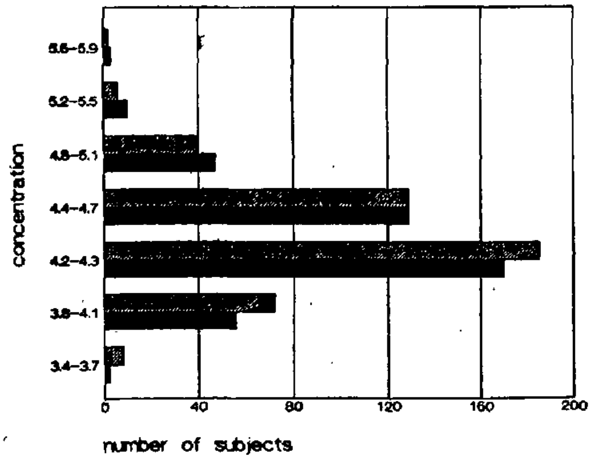
calcium
erythrocytes



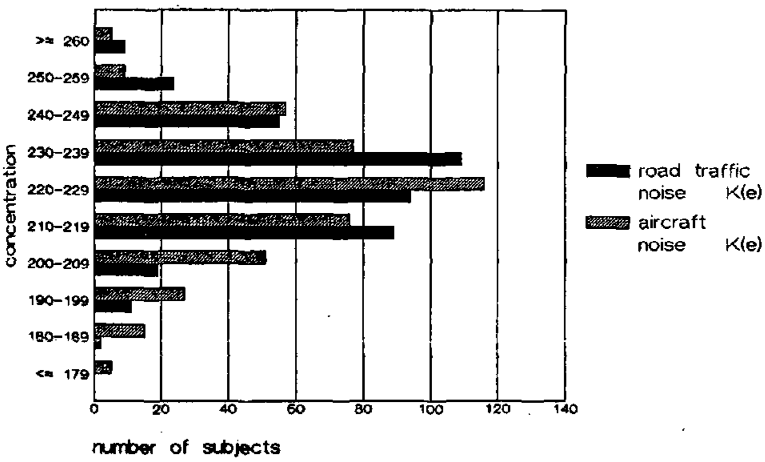
sodium
serum



sodium
erythrocytes



potassium
serum



potassium
erythrocytes

Table 8.3 Noise source and electrolyte concentrations

| | Road traffic noise | | | Militairy aircraft noise | | | | |
|---|---|---|---|---|---|---|---|---|
| | mean | s.d.* | n | mean | s.d. | n | T-value of difference | p (two-sided) |
| eMg | 5.19 | (.50) | 411 | 5.22 | (.52) | 439 | 1.11 | .268 |
| eCa | .25 | (.17) | 282 | .20 | (.10) | 439 | 4.24 | .000 |
| eNa | 17.41 | (3.78) | 284 | 15.47 | (3.33) | 439 | 7.05 | .000 |
| eK | 223.55 | (15.09) | 412 | 217.03 | (17.58) | 438 | 5.81 | .000 |
| sMg | .82 | (.06) | 417 | .81 | (.06) | 442 | 4.26 | .000 |
| sCa | 2.37 | (.12) | 417 | 2.34 | (.17) | 442 | 2.44 | .015 |
| sNa | 138.69 | (4.00) | 417 | 138.11 | (5.12) | 445 | 1.85 | .065 |
| sK | 4.49 | (.38) | 417 | 4.42 | (.38) | 444 | 2.51 | .012 |

* s.d. = standard deviation

Except for eMg and sNa there is a significant difference (p .05) between the electrolyte concentrations with respect to noise source (aircraft vs. road traffic). As has been shown in Chapter 4, significant differences between the aircraft and road traffic noise samples are present in almost every variable in this study.

## 8.5 Results

First we present univariate results with respect to noise stratum and electrolyte concentrations in 8.5.1. In section 8.5.2 we eliminate, as far as possible, (see 8.1) the influence of confounding variables. In section 8.5.3 we present analyses concerning the influence of psychological constructs.

### 8.5.1 Noise level and electrolyte concentrations

By means of analysis of variance and regression analysis we evaluate the relationship between noise level and electrolyte concentrations. First univariate results are presented. From Table 8.4 on basis of the F-tests performed, we conclude that for road traffic, the level of noise has a significant effect on eNa, eK, sCa and sK, which means that at least in one of the six strata the mean and standard deviation of the concentrations differs from the values of the other strata.

For military aircraft noise the stratum has a significant effect on eCa, eK, sNa and sK concentrations (Table 8.5). These tests provide no information on the general shape of the relationship (e.g., linear or non-linear).

Table 8.4 Level of road traffic noise and electrolyte concentrations: F-tests

| | | Erythrocytes(mmol/kg d.w.) | | | | Serum(mmol/l) | | | |
|---|---|---|---|---|---|---|---|---|---|
| noise level | n | eMg | eCa** | eNa** | eK | sMg | sCa | sNa | sK |
| 1 | 75 | 5.17 | .238 | 17.60 | 220.57 | .83 | 2.36 | 138.81 | 4.46 |
| | | (.52) | (.06) | (4.15) | (14.13) | (.05) | (.12) | (4.09) | (.37) |
| 2 | 76 | 5.20 | .240 | 17.25 | 222.43 | .82 | 2.37 | 138.67 | 4.37 |
| | | (.46) | (.07) | (3.45) | (16.79) | (.59) | (0.10) | (3.98) | (.37) |
| 3 | 54 | 5.11 | .253 | 17.97 | 229.27 | .83 | 2.37 | 139.66 | 4.46 |
| | | (.47) | (.07) | (3.70) | (14.11) | (.05) | (.09) | (3.55) | (.37) |
| 4 | 75 | 5.24 | .240 | 18.18 | 229.83 | .82 | 2.41 | 137.93 | 4.62 |
| | | (.55) | (.08) | (3.59) | (14.99) | (.06) | (.13) | (3.78) | (.41) |
| 5 | 87 | 5.20 | .245 | 15.84 | 226.00 | .82 | 2.39 | 138.98 | 4.54 |
| | | (.47) | (.07) | (3.41) | (11.20) | (.06) | (.12) | (3.86) | (.35) |
| 6 | 43 | 5.19 | * | * | 220.28 | .82 | 2.29 | 137.88 | 4.46 |
| | | (.56) | | | (16.99) | (.06) | (.08) | (4.84) | (.38) |
| Mean | | 5.19 | .25 | 17.41 | 223.55 | .82 | 2.37 | 138.69 | 4.49 |
| (s.d.) | | (.50) | (.07) | (3.78) | (15.10) | (.06) | (.12) | (4.00) | (.38) |
| sign. of F-test (univ) | | .472 | .730 | .001 | .000 | .77 | .00 | .124 | .001 |

Note: Figures are mean concentrations; standard deviations are given between brackets.

* Due to missing data (see Table 8.1) the number of samples is three

** See Table 8.1 for number of non-contaminated samples

Table 8.5 Comparison of distributions of electrolyte concentrations in the different noise strata in the aircraft noise sample by means of F-tests

| noise level | n | Erythrocytes(mmol/kg.d.w) | | | | Serum(mmol/l) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | eMg | eCa | eNa | eK | sMg | sCa | sNa | sK |
| 1 | 101 | 5.23 | .23 | 15.50 | 221.58 | .81 | 2.33 | 140.15 | 4.54 |
| | | (.50) | (.16) | (3.41) | (17.58) | (.06) | (.11) | (4.57) | (.38) |
| 2 | 107 | 5.30 | .23 | 15.75 | 215.92 | .79 | 2.35 | 136.12 | 4.39 |
| | | (.51) | (.06) | (3.38) | (17.46) | (.05) | (.09) | (5.29) | (.31) |
| 3 | 88 | 5.16 | .21 | 15.59 | 217.79 | .81 | 2.37 | 137.42 | 4.45 |
| | | (.56) | (.07) | (3.38) | (17.48) | (.06) | (.30) | (4.47) | (.37) |
| 4 | 72 | 5.13 | .17 | 15.53 | 213.84 | .82 | 2.35 | 139.40 | 4.31 |
| | | (.54) | (.06) | (3.50) | (19.12) | (.06) | (.13) | (5.39) | (.41) |
| 5 | 60 | 5.31 | .15 | 14.90 | 214.05 | .82 | 2.35 | 137.78 | 4.36 |
| | | (.50) | (.08) | (3.08) | (15.6) | (.05 | (.14) | (5.01) | (.42) |
| 6 | 15 | 5.25 | .17 | 14.64 | 216.47 | .81 | 2.49 | 137.87 | 4.50 |
| | | (.47) | (.09) | (2.58) | (14.57) | (.04) | (.08) | (4.17) | (.34) |
| Mean | | 5.22 | .20 | 15.47 | 217.03 | .81 | 2.34 | 138.11 | 4.42 |
| (s.d) | | (.52) | (.10) | (3.33) | (17.58) | (.06) | (.17) | (5.13) | (.38) |
| F-test sign.of (univ) | | .80 | .000 | .608 | .040 | .151 | .470 | .000 | .001 |

Note: Figures are mean concentrations; standard deviations are given between brackets.

By means of linear regression analysis the linear component of the relationship between noise level and electrolyte concentrations is analyzed. The correlations between noise level and electrolyte concentrations are given in Table 8.6. In the sample exposed to road traffic noise only serum potassium is significantly (p .05) correlated with the noise level. In the aircraft noise sample noise level is correlated with serum magnesium (p .05). In this sample noise level is negatively correlated (p .05) with erythrocyte calcium and potassium, and with serum potassium. We observe opposite effects of noise level upon the serum potassium concentrations in both samples.

Table 8.6 Level of noise and electrolyte concentrations: linear regression analysis

| Road traffic noise (n=418) | | | Aircraft noise (n=441) | | |
|---|---|---|---|---|---|
| | r | p | | r | p |
| eMg | .025 | .305 | eMg | -.008 | .434 |
| eCa | -.064 | .141 | eCa | -.283 | .000 |
| eNa | -.079 | .092 | eNa | -.064 | .089 |
| eK | -.011 | .416 | eK | -.125 | .005 |
| sMg | -.022 | .328 | sMg | .080 | .046 |
| sCa | -.036 | .235 | sCa | .061 | .100 |
| sNa | -.046 | .177 | sNa | -.047 | .162 |
| sK | .113 | .011 | sK | -.132 | .003 |

* n=280

### 8.5.2 Noise level, electrolyte concentrations and confounding variables

In this section we investigate the relationship between noise level and electrolyte concentrations taking account of confounding factors.

Possible confounding factors are: age, sex, weight, time of day, dietary habits, alcohol consumption, use of medicaments. The influence of these factors are especially documented in research on electrolyte concentrations in relation with cardiac failures and renal diseases (for a review see Ebel and Günther, 1983; Johansson, 1981).

Quantitative information on confounding factors in the relationship noise-electrolyte concentrations is partly based on animal experiments. Quantitative information on confounding factors with respect to human samples and populations is scarce and often restricted to but a few confounders. In this analysis we have controlled for: age, relative weight (Quetelet index), sex, hypertension parents, hypertension siblings, smoking and alcohol consumption. The last four variables are dichotomized as follows: hypertension parents: 1. (yes), 2. (no, don't know); hypertension siblings: 1. (yes), 2. (no, don't know); smoking: 1. (yes), 2. (no) ; alcohol consumption: 1. (yes), 2. (no) See chapter 7 for a more elaborate treatment of these factors.

The variance explained by noise level, after accounting for influences mentioned above, is shown in the tables 8.8 and 8.9. The T-value and the level of the significance for the hypothesis that there is no linear relationship between noise level and electrolyte concentrations are presented in the last two columns of these tables. In the first three steps the contributions of the following variables are given:

(a) age, sex, relative weight;
(b) smoking, alcohol use;
(c) hypertension parents, hypertension siblings;
In the fourth step:
(d) noise level is included.

For road traffic noise (Table 8.7) we see that noise level still has a significant, but small influence on sK. In the population exposed to military aircraft noise eCa, eK and sK concentrations are influenced by noise level.

From the many epidemiological surveys performed, and previous research into the health effects of environmental noise we know that the physiological 'base line value' and the reactions to noise are age and sex specific. (see for instance Von Eiff et al., 1985). Rehm (1983), for instance, put forward that Knipschild in his traffic noise study (Knipschild, 1979) could not find medical effects because of the typical characteristics of the populationsample: housewives, age: 40-49. "The risk of suffering from cardiovascular disease is still very low in women at that age due to the protective effects of their female hormones; so that influences of environmental factors may be masked" (Rehm, 1983).

In the following analyses we, evaluate the influence of noise level on the electrolyte concentrations separately for men and women. First the results for the road traffic noise sample are documented in table 8.9 and 8.10.

Table 8.7 Level of road traffic noise and electrolyte concentrations: stepwise regression with confounding variables.

| | | $R^2$ | $R^2$ change | sign.F | T | sign. |
|---|---|---|---|---|---|---|
| e Mg | a | .013 | | .154 | | |
| | b | .024 | | .089 | | |
| | c | .027 | | .151 | | |
| | d | .028 | | .199 | -.572 | .568 |
| e Ca*) | a | .005 | | .734 | | |
| | b | .005 | | .925 | | |
| | c | .014 | | .806 | | |
| | d. | .015 | | .856 | .495 | .621 |
| e Na*) | a | .151 | | .000 | | |
| | b | .159 | | .000 | | |
| | c | .175 | | .000 | | |
| | d | .182 | | .000 | -1.486 | .138 |
| e K | a | .044 | | .001 | | |
| | b | .046 | | .003 | | |
| | c | .055 | | .003 | | |
| | d | .059 | | .005 | .004 | .997 |
| s Mg | a | .016 | | .093 | | |
| | b | .030 | | .038 | | |
| | c | .031 | | .093 | | |
| | d | .032 | | .127 | -.598 | .55 |
| s Ca | a | .027 | | .012 | | |
| | b | .035 | | .016 | | |
| | c | .040 | | .025 | | |
| | d | .041 | | .036 | -.703 | .483 |
| s Na | a | .003 | | .743 | | |
| | b | .009 | | .617 | | |
| | c | .010 | | .786 | | |
| | d | .013 | | .742 | -1.091 | .276 |
| s K | a | .010 | | .257 | | |
| | b | .018 | | .200 | | |
| | c | .027 | | .146 | | |
| | d | .038 | .011 | .049 | 2.171 | .031 |

Note: Successive groups of variables introduced in the equation are: a. age, sex, relative weight; b. smoking, use of alcohol; c. hypertension parents, hypertension siblings; d. noise level (n = 418, * n = 280 due to missing values).

Table 8.8 Level of aircraft noise and electrolyte concentrations: stepwise regression with confounding variables

| | | $R^2$ | $R^2$ change | sign.F | T | sign. |
|---|---|---|---|---|---|---|
| e Mg | a | .074 | | .000 | | |
| | b | .098 | | .000 | | |
| | c | .104 | | .000 | | |
| | d | .105 | | .000 | -.772 | .440 |
| e Ca | a | .010 | | .213 | | |
| | b | .012 | | .414 | | |
| | c | .015 | | .507 | | |
| | d | .098 | .073 | .000 | -6.237 | .000 |
| e Na | a | .085 | | .000 | | |
| | b | .104 | | .000 | | |
| | c | .108 | | .000 | | |
| | d | .114 | | .000 | -1.518 | .129 |
| e K | a | .036 | | .001 | | |
| | b | .040 | | .004 | | |
| | c | .042 | | .010 | | |
| | d | .055 | .013 | .002 | -2.419 | .016 |
| s Mg | a | .056 | | .000 | | |
| | b | .061 | | .000 | | |
| | c | .062 | | .000 | | |
| | d | .067 | | .000 | 1.510 | .132 |
| s Ca | a | .014 | | .115 | | |
| | b | .019 | | .134 | | |
| | c | .024 | | .173 | | |
| | d | .272 | | .159 | 1.247 | .213 |
| s Na | a | .048 | | .000 | | |
| | b | .052 | | .000 | | |
| | c | .052 | | .002 | | |
| | d | .054 | | .003 | -.860 | .390 |
| s K | a | .019 | | .039 | | |
| | b | .034 | | .012 | | |
| | c | .042 | | .011 | | |
| | d | .058 | .016 | .001 | -2.718 | .006 |

Note: Successive groups of variables introduced in the equation are: a. age, sex, relative weight; b. smoking, use of alcohol; c. hypertension parents, hypertension siblings; d. noise level (n = 441).

Table 8.9 Level of road traffic noise and electrolyte concentrations: stepwise regression with confounding variables (male subsample)

| | | $R^2$ | $R^2$ change | sign.F | T | sign.T |
|---|---|---|---|---|---|---|
| eMg | a | .011 | | .528 | | |
| | b | .019 | | .694 | | |
| | c | .020 | | .887 | | |
| | d | .047 | | .601 | 1.773 | .079 |
| eCa*) | a | .029 | | .362 | | |
| | b | .046 | | .534 | | |
| | c | .064 | | .632 | | |
| | d | .066 | | .721 | -.440 | .661 |
| eNa*) | a | .000 | | .992 | | |
| | b | .008 | | .968 | | |
| | c | .020 | | .969 | | |
| | d | .052 | | .827 | -1.480 | .144 |
| eK | a | .001 | | .942 | | |
| | b | .020 | | .674 | | |
| | c | .043 | | .541 | | |
| | d | .051 | | .553 | .935 | .352 |
| sMg | a | .073 | | .012 | | |
| | b | .081 | | .045 | | |
| | c | .126 | | .017 | | |
| | d | .127 | | .031 | -.088 | .930 |
| sCa | a | .050 | | .051 | | |
| | b | .070 | | .079 | | |
| | c | .073 | | .199 | | |
| | d | .077 | | .250 | -.692 | .491 |
| sNa | a | .003 | | .847 | | |
| | b | .009 | | .908 | | |
| | c | .033 | | .696 | | |
| | d | .034 | | .790 | -.226 | .791 |
| sK | a | .008 | | .598 | | |
| | b | .025 | | .567 | | |
| | c | .089 | | .103 | | |
| | d | .089 | | .161 | -.030 | .976 |

Note: Successive groups of variables introduced in the equation are: a. age, relative weight; b. smoking, use of alcohol; c. hypertension parents, hypertension siblings; d. noise level (n = 124, * n = 74).

Table 8.10 Level of road traffic noise and electrolyte concentrations: stepwise regression with confounding variables (female subsample)

| | | $R^2$ | $R^2$ change | sign.F | T | sign.T |
|---|---|---|---|---|---|---|
| eMg | a | .015 | | .139 | | |
| | b | .035 | | .146 | | |
| | c | .036 | | .203 | -.501 | .617 |
| eCa*) | a | .043 | | .660 | | |
| | b | .017 | | .774 | | |
| | c | .026 | | .651 | -1.340 | .182 |
| eNa*) | a | .033 | | .040 | | |
| | b | .044 | | .201 | | |
| | c | .046 | | .246 | -.751 | .454 |
| eK | a | .009 | | .280 | | |
| | b | .027 | | .293 | | |
| | c | .028 | | .364 | -.598 | .550 |
| sMg | a | .002 | | .800 | | |
| | b | .017 | | .599 | | |
| | c | .019 | | .646 | -.732 | .465 |
| sCa | a | .011 | | .214 | | |
| | b | .016 | | .608 | | |
| | c | .017 | | .717 | -.178 | .859 |
| sNa | a | .000 | | .939 | | |
| | b | .013 | | .746 | | |
| | c | .019 | | .649 | -1.263 | .208 |
| sK | a | .016 | | .233 | | |
| | b | .027 | | .281 | | |
| | c | .053 | .026 | .041 | 2.693 | .008 |

Note: Successive groups of variables introduced in the equation are: a. age, relative weight; b. smoking, use of alcohol, hypertension parents, hypertension siblings; c. noise level (n = 124, * n= 209).

Results for the sample exposed to military aircraft noise are given in table 8.11 and 8.12.

Table 8.11 Level of aircraft noise and electrolyte concentrations: stepwise regression with confounding variables (male subsample)

| | | $R^2$ | $R^2$ change | sign.F | T | sign.T |
|---|---|---|---|---|---|---|
| e Mg | a | .046 | | .094 | | |
| | b | .132 | | .007 | | |
| | c | .242 | | .000 | | |
| | d | .273 | .031 | .000 | -2.012 | .047 |
| e Ca | a | .008 | | .665 | | |
| | b | .030 | | .547 | | |
| | c | .058 | | .444 | | |
| | d | .339 | .281 | .000 | -6.359 | .000 |
| e Na | a | .021 | | .341 | | |
| | b | .032 | | .520 | | |
| | c | .047 | | .580 | | |
| | d | .080 | | .321 | -1.847 | .068 |
| e K | a | .013 | | .525 | | |
| | b | .024 | | .668 | | |
| | c | .024 | | .880 | | |
| | d | .048 | | .683 | -1.546 | .126 |
| s Mg | a | .014 | | .499 | | |
| | b | .044 | | .341 | | |
| | c | .075 | | .261 | | |
| | d | .086 | | .262 | -1.091 | .278 |
| s Ca | a | .015 | | .463 | | |
| | b | .070 | | .125 | | |
| | c | .071 | | .290 | | |
| | d | .073 | | .379 | .419 | .676 |
| s Na | a | .051 | | .071 | | |
| | b | .061 | | .178 | | |
| | c | .113 | | .064 | | |
| | d | .124 | | .071 | -1.083 | .282 |
| s K | a | .048 | | .081 | | |
| | b | .144 | | .004 | | |
| | c | .167 | | .006 | | |
| | d | .189 | | .005 | -1.615 | .110 |

Note: Successive groups of variables introduced in the equation are: a. age, relative weight; b. smoking, use of alcohol; c. hypertension parents, hypertension siblings; d. noise level (n = 286, * n= 209).

Table 8.12 Level of aircraft noise and electrolyte concentrations: stepwise regression with confounding variables (female subsample)

| | | $R^2$ | $R^2$ change | sign.F | T | sign.T |
|---|---|---|---|---|---|---|
| e Mg | a | .082 | | .000 | | |
| | b | .097 | | .000 | | |
| | c | .098 | | .000 | | |
| | d | .098 | | .000 | -.108 | .914 |
| e Ca | a | .012 | | .133 | | |
| | b | .016 | | .278 | | |
| | c | .018 | | .445 | | |
| | d | .077 | .059 | .001 | -4.530 | .000 |
| e Na | a | .039 | | .002 | | |
| | b | .066 | | .000 | | |
| | c | .069 | | .000 | | |
| | d | .070 | | .002 | -.449 | .654 |
| e K | a | .000 | | .927 | | |
| | b | .010 | | .507 | | |
| | c | .014 | | .622 | | |
| | d | .024 | | .347 | -1.853 | .0649 |
| s Mg | a | .022 | | .026 | | |
| | b | .026 | | .089 | | |
| | c | .028 | | .171 | | |
| | d | .043 | .015 | .049 | 2.262 | .025 |
| s Ca | a | .003 | | .654 | | |
| | b | .014 | | .343 | | |
| | c | .019 | | .403 | | |
| | d | .022 | | .389 | 1.106 | .270 |
| s Na | a | .048 | | .000 | | |
| | b | .052 | | .002 | | |
| | c | .058 | | .004 | | |
| | d | .059 | | .007 | -.586 | .558 |
| s K | a | .011 | | .173 | | |
| | b | .015 | | .310 | | |
| | c | .022 | | .317 | | |
| | d | .035 | .013 | .114 | -2.138 | .033 |

Note: Successive groups of variables introduced in the equation are: a. age, relative weight; b. smoking, use of alcohol; c. hypertension parents, hypertension siblings; d. noise level (n = 327).

By a break-down of the sample exposed to military aircraft noise in males and females we observe the following phenomena: (see table 8.11 and 8.12). The effect of noise level on eMg is significant in the male sample.

In the female sample the sMg concentration is influenced by noise level. The effect on erythrocyte potassium disappears after the break-down. Comparing Table 8.8 and 8.11 we observe an increase in the effect of noise level on eCa. For men, the noise level explaines 27.4% of the eCa concentration.

A break-down of the sample exposed to road traffic noise shows that the effects of noise level on serum potassium is restricted to the female population.

### 8.5.3 Psychological variables

In these analyses we document some possible associations between noise level, psychological variables and electrolyte concentrations. Here we present the first results of the influences of coping with noise. Three coping strategies are distinguished developing a comforting attitude and perspective with respect to the noise situation ("comforting cognitions"), to negate or avoid annoying aspects of the situation ("palliative behaviour"), and goal-directed behaviour in order to solve the problem ("problem oriented behaviour") (see Chapter 6 for an elaborate treatment of coping strategies). The three coping styles are incorporated as a third step in the analysis (c).

Results for road traffic noise (Table 8.13) show an influence of coping (comforting cognitions) on the concentration eK. Other ery- and serum concentrations are not significantly affected by any of the coping strategies.

For the sample exposed to military aircraft noise an increase in variance explained in sK results from coping (palliatives) (table 8.14).

Table 8.13 Level of road traffic noise and electrolyte concentrations: stepwise regression with confounding variables and coping style

| | | $R^2$ | $R^2$ change | sign.F | T | sign.T |
|---|---|---|---|---|---|---|
| eMg | a | .013 | | .154 | | |
| | b | .027 | | .151 | | |
| | c | .029 | | .345 | | |
| | d | .029 | | .406 | | |
| eCa | a | .005 | | .734 | | |
| | b | .014 | | .806 | | |
| | c | .025 | | .765 | | |
| | d | .026 | | .807 | | |
| eNa | a | .151 | | .000 | | |
| | b | .175 | | .000 | | |
| | c | .185 | | .000 | | |
| | d | .191 | | .000 | | |
| eK | a | .044 | | .000 | | |
| | b | .055 | | .003 | | |
| | c | .074 | .019 | .002 | 2.643 | .009 |
| | d | .074 | | .002 | | |
| sMg | a | .016 | | .094 | | |
| | b | .031 | | .095 | | |
| | c | .031 | | .274 | | |
| | d | .032 | | .325 | | |
| sCa | a | .027 | | .013 | | |
| | b | .040 | | .026 | | |
| | c | .045 | | .054 | | |
| | d | .046 | | .073 | | |
| sNa | a | .003 | | .745 | | |
| | b | .010 | | .788 | | |
| | c | .017 | | .751 | | |
| | d | .019 | | .761 | | |
| sK | a | .010 | | .259 | | |
| | b | .027 | | .149 | | |
| | c | .029 | | .332 | | |
| | d | .040 | | .149 | | |

Note: Successive groups of variables introduced in the equation are: a. age, sex, relative weight; b. smoking, use of alcohol, hypertension parents, hypertension siblings; c. coping styles; d. noise level. The T-value and significance for the hypothesis that there is no linear relation between coping style and electrolyte concentrations are also presented (n = 418).

Table 8.14 Level of aircraft noise and electrolyte concentrations: stepwise regression with confounding variables and coping style

| | | $R^2$ | $R^2$ change | sign.F | T | sign.T |
|---|---|---|---|---|---|---|
| eMg | a | .074 | | .000 | | |
| | b | .104 | | .000 | | |
| | c | .114 | | .000 | | |
| | d | .115 | | .000 | | |
| eCa | a | .010 | | .213 | | |
| | b | .015 | | .507 | | |
| | c | .022 | | .481 | | |
| | d | .104 | .082 | .000 | | |
| eNa | a | .085 | | .000 | | |
| | b | .109 | | .000 | | |
| | c | .110 | | .000 | | |
| | d | .115 | | .000 | | |
| eK | a | .036 | | .001 | | |
| | b | .042 | | .010 | | |
| | c | .046 | | .030 | | |
| | d | .059 | | .007 | | |
| sMg | a | .056 | | .000 | | |
| | b | .062 | | .000 | | |
| | c | .068 | | .000 | | |
| | d | .074 | | .000 | | |
| sCa | a | .014 | | .117 | | |
| | b | .024 | | .177 | | |
| | c | .025 | | .369 | | |
| | d | .028 | | .353 | | |
| sNa | a | .048 | | .000 | | |
| | b | .052 | | .002 | | |
| | c | .055 | | .008 | | |
| | d | .057 | | .010 | | |
| sK | a | .019 | | .040 | | |
| | b | .042 | | .012 | | |
| | c | .055 | .013 | .008 | -2.709 | .007 |
| | d | .073 | | .007 | | |

Note: Successive groups of variables introduced in the equation are: a. age, sex, relative weight; b. smoking, use of alcohol, hypertension parents, hypertension siblings; c. coping styles; d. noise level. The T-value and significance for the hypothesis that there is no linear relation between coping style and electrolyte concentrations are also presented (n = 441).

## 8.6 Discussion

The scope of the results presented is restricted. The association between noise level and electrolyte concentrations is obtained after elimination of a limited number of confounding variables (age, sex, relative weight, smoking, use of alcohol, hypertension parents, hypertension siblings). Influences of factors like secundary hypertension, dietary habits and intake of medicaments can not or only to a limited extent be quantified on the basis of the present data set. Also the interrelationship between electrolyte concentrations and the associations with biochemical parameters, like for instance creatinine (as indicator of kidney functioning), needs further investigation. It should also be noted here that during the analysis no information on mineral intake via nutrition was available. Nutritional habits may cause considerable variation in electrolyte concentrations. If nutritional habits covary with level or kind of noise, this may cause a confounded relationship between noise and electrolyte concentrations. The differences between the aircraft and road traffic sample is also a difference in rural versus urban population. This difference might well covary with nutritional patterns.
With these restrictions in mind the results suggest an influence of noise level on some electrolyte concentrations in blood.

The relationship between level of noise and eMg concentration, as hypothesized by Ising et al. (1981) is not confirmed in our analyses for both aircraft and road traffic noise. For men exposed to aircraft noise we observe a significant relationship between level of aircraft noise and eMg concentration, an increasing level of aircraft noise being associated with a decreasing level of eMg concentration. According to Ising et al. (1981) this may imply a higher cardiovascular risk for men exposed to higher levels of aircraft noise.

The relationship between level of noise and concentrations of eCa is strong in the sample exposed to military aircraft noise. The explained variance in the eryconcentration is about 8 %. The effects on eCa concentrations are usually contrary to effects on eMg concentrations. In this study the

reverse is the case. This casts some more doubts on the reliability of eCa measurements (see section 8.4).
The relationship between noise level and sK is complex. For aircraft noise this relationship is negative, for road traffic noise it is positive. For aircraft noise the relationship between eK and noise level is also negative. On closer inspection it appears that a decrease of eK and sK is associated with an increase in aircraft noise level for women only. Men show the same but insignificant relationship. These results may be due to confounders like indicated above.

## 8.7 Conclusions

Preliminary results are reported on the correlations between level of aircraft noise and electrolyte concentrations in blood of magnesium, calcium and potassium.
The results partially support Ising's hypothesis that level of noise is associated with a decrease of erythrocyte magnesium concentration. This is seen as a risk factor for cardiovascular diseases.
The remarkably strong effects of aircraft noise on erythrocyte calcium concentrations in blood might be due to an artifact but should be investigated further.

These results are obtained after elimination of the influence of riskfactors for cardiovascular diseases (age, sex, weight, height, smoking, use of alcohol, hypertension parents and hypertension siblings) and should be interpreted with care as a number of other confounding factors are not considered.

No clear evidence is available on the role of coping styles in relation to electrolyte concentrations.

Overall we conclude that:

- the analyses should be continued in order to quantify the associations found thus far in more detail; and to quantify the associations with somatic and psychosomatic health effects.

- if the results found thus far, are confirmed, a set of variables should be defined which enable future investigations to establish the relationship between environmental noise and electrolyte concentrations, and the associated health effects.

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# 9. EVALUATION

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# 9 EVALUATION

## 9.1 Introduction

In chapter 1 we have formulated two general research purposes. One purpose is to clarify some methodological issues by designing a research strategy based on a combination of different methods (epidemiological survey on psychosocial and medical effects followed by elaborating experiments on a subsample) and the effort to eliminate biases and confounding factors. The other purpose of this investigation is to shed some light on the role of psychological constructs in the noise-health relationship. Do we better understand the relationship between environmental noise and health if we introduce psychological constructs referring to appraisal of noise and coping with noise or its negative consequences?

With these questions in mind we evaluate in this chapter the results described in the previous chapters. In section 9.2 and 9.3 methodological issues are considered. Section 9.2 is devoted to the problems connected with noise sources (type of environmental noise, accuracy of the metrics used) and the samples as chosen. Section 9.3 deals with the advantages we encountered in the combination of the research methods used.

Section 9.4 evaluates the use of successively more complex models in the analyses. Special attention is paid to the introduction of psychological variables into the models.

Section 9.5 finally is devoted to the possible generalization of our results, including the question: "Are there any results indicating that we can identify groups that incur health risks more than other groups?".

## 9.2 Noise sources and sample problems

### 9.2.1 *Homogeneity and representativety of the sample*

In chapter 4 the samples used in this research were described in detail. Almost every variable showed significant differences between the road traffic sample and the aircraft sample. Within the two samples, however, the distribution of the biographical variables is independent of stratum number. Generalization of our results is not intended (and not possible) beyond the theoretical population as defined in chapter 4. The samples used in this report should be regarded as typical examples of a population (20-55 years old) exposed to (different levels of) environmental noise (military aircraft noise or road traffic noise).

### 9.2.2 Differences between aircraft noise and road traffic noise

In all analyses of this study we see consequently more effects or indications of possible effects (annoyance, subjective health, blood pressure, electrolyte concentrations in blood) of environmental noise in the aircraft noise sample than in the road traffic noise sample. The only exception is residential satisfaction, but this exception can be explained by the different characteristics of noise sources, homes and inhabitants in both samples. With respect to the noise sources, the different time structures of them may in part be the cause of these findings. Since different noise intensity metrics were used in both samples, direct comparison of both types of noise is not possible.

### 9.2.3 Accuracy of noise levels used

Only recently, information regarding measurements of aircraft noise levels in one of the regions we studied, became available. In chapter 4 the results of these measurements, as compared to the calculated levels used in this project were presented. We conclude that differences up to about 5 KE occur. This may be due to differences between the flight paths used in the calculations, and the actual ones. No simple translation is possible in order to convert the calculated into measured levels; for a great number of dwellings a new assignment to noise strata should be made.The consequences of these differences are not yet evaluated on this short notice. As the differences are relatively small, no changes of prime importance in our conclusions should be expected to result from a recalculation. Nevertheless, it is clear that the results of a re-analysis can modify the strength of the relations found.

### 9.2.4 Physical versus subjective noise metrics

Measurement of environmental noise levels in either dB(A) or KE correlates only weakly with the effects obtained (including the different annoyance variables). We may deduce from that observation, that probably noise levels expressed in dB(A) and KE are not adequate estimators of the noise level people perceive. Parts of the questionnaire used can be interpreted as measuring the perceived annoyance and/or as measuring the perceived loudness. When interpreted in the latter fashion a more subjective noise intensity scale improves in some cases (to a limited extent) the amount of explained variance.

## 9.3 Methodological issues: the combination of research methods

The research strategy chosen forms the subject of this section. As we stated in chapter 1, a combination of psychosocial and medical survey techniques is used to overcome a number of methodological shortcomings of earlier research. We have indeed been able to integrate psychological constructs into the analyses of demographic, psychosocial and medical effects. Introduction of noise appraisal, coping strategies and perceived control is demonstrated to increase the understanding of the relation between environmental noise and health effects as far as the subjective health effects are concerned. We cannot exclude the possibility that this is an artefact induced by the statistical methods used. No improvements of the introduction of psychosocial constructs is found in the medical survey where objective health effects are considered.

Together with the epidemiological surveys laboratory experiments were performed. The results of these experiments are not available yet, but will be published seperately (Veldman, 1988). The subjects used in the experiments are selected from the samples used in the surveys. Subjects are selected on the basis of their coping and control strategies. Integration of the results of the laboratory experiments with the results reported here is not possible yet.

The data collected in this project enable further research on many points (see e.g. chapter 10). It is outside the time limits set by the permission of the research grant and the scope of this report to fully extract all possible insights contained in the dataset collected. In chapter 10 we indicate several areas where future research is regarded fruitful.

## 9.4 Theoretical issues

We have tested three classes of models (see chapter 3). The first and most simple class of models is of the dose-effect type. A more complex model not only relates the effect to the dose, but includes also possible confounding variables and individual differences. The third class of models includes psychological constructs as relevant elements in the relationship between dose and effect, in an attempt to enhance our understanding of the relationship between environmental noise and health effects.

The results of this study have shown, that the direct effects of noise on a variety of effect variables are in most cases rather weak when analysed in terms of simple dose-respons models. This is in agreement with results reported in literature regarding comparable dose ranges and comparable selection criteria for the samples. Introduction of individual differences into the models improves the amount of explained variance in the effect variables, but does not increase the amount of variance which may be attributed to the level of environmental noise. This is not suprising, because as has been shown in chapter 4, the individual differences are in most cases homogenously distributed over the noise strata.

We have observed a rather low correlation between physical noise metrics and observed effects. However, a fairly strong correlation between the appraisal of noise and a number of effects is demonstrated. The correlation between physical noise metrics and appraisal is again rather low.

We conclude, that the introduction of psychological variables into the relation between environmental noise and health effects essentially improves the understanding of these relations as far as subjective health effects are considered. There are no indications in this study, that individual differences other than psychosocial modify the noise health relation, although in some cases strong noise-independent effects of these variables are demonstrated.

## 9.5 Groups at risk

By design the samples used in this study consist of people in relatively good health (e.g. as a consequence of the age limits set on 20-55). Also, in the medical survey subjects with possibly confounding health complaints or illnesses have been excluded. However, the environmental noise levels they are exposed to pose a problem for the subjects (e.g. interference with activities). The seriousness of this problem depends on the influence of other stressors, on the type of noise involved, on the individual perception of the exposure, and on the strategies the subject has available. This complex situation implies that no simple definition of groups at risk can be given. However, the following can be inferred from our results:

a. Older women in the lower socio-economic strata with relatively low levels of perceived control show high levels of subjective health complaints. No direct relation with level of exposure to environmental noise could be established.
b. Higher levels of subjective health complaints are found in correlation with other stressors (daily hassles), with low residential satisfaction, with irritation caused by noise exposure, and with passive coping strategies.
c. In an integral definition of health (including subjective health criteria) exposure to environmental noise produces adverse effects

(especially annoyance). The negative health effects are stronger when analysed in combination with other stressors (that are in general of greater explanatory power compared to environmental noise).

d. Exposure to aircraft noise possibly changes the relation between age and blood pressure, in such a way that a higher exposition implies a steeper regression line between the items mentioned. The data allow, however, equivocal interpretations.

e. Combinations of variables (e.g. noise stratum and blood pressure) can be used as prediction for other health effects.

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# 10. CONCLUSIONS AND RECOMMENDATIONS

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# 10. CONCLUSIONS AND RECOMMENDATIONS

## 10.1 Introduction

This chapter presents an overview of the conclusions derived in the preceding chapters (section 10.2). From these conclusions recommendations for further research are deduced.

## 10.2 Conclusions

The conclusions given in this chapter are in fact summaries of the earlier chapters. The conclusions are organized according to the different parts of this project.

### 10.2.1 Residential satisfaction and sample bias

In chapter 5 the following conclusions are obtained regarding the influence of environmental noise upon residential satisfaction and wish to move:

a) People, who indicate that they wish to move out of their present home have, as expected, a lower residential satisfaction. They also perceive significantly higher noise levels. No significant difference is observed in noise level expressed in more or less physical dimensions (dB(A) or KE).

b) In our sample around military airfields (about 1000 subjects) almost no effect of environmental noise on the residential satisfaction, and hence the wish to move, is detected. Only a very weak effect of perceived loudness upon residential satisfaction is observed (about 1 % or less of the variance of residential satisfaction).

c) In our population around more or less noisy roads (also about 1000 subjects), the perceived loudness is shown to affect the residential satisfaction to some extend. The importance of the perceived loudness is about equal to the total importance of all other explaining variables together. Depending upon the variable used the total amount of explained variance in residential satisfaction is 10 to 20 %. The noise levels as expressed in more or less physical dimensions (dB(A) or KE) do not show an effect.

d) The differences between road traffic noise and aircraft noise samples may be due to the fact that in the latter a much higher part of the houses is owned by the inhabitant. Also the distribution of homes over different types is different in both samples. Ownership of the home and type of dwelling are amongst the most important explaining variables in residential satisfaction.

e) There are no indications that selective migration has induced a bias in the population exposed to aircraft noise, used in this study.
f) A relatively small selection effect in the sample exposed to road traffic noise can not be excluded. This implies that some people (most sensitive to environmental noise?) move out of the noisiest areas, yielding a "survivor" population in the higher levels of perceived noise. Since the correlations between noise stratum number (a more or less physical estimate of noise level) and the perceived loudness are weak, we can not quantify the probable effect of this finding upon the reported results. We conclude that this result may cause minor underestimation of the real effects of environmental noise as described in this report.

### 10.2.2 Psychosocial aspects of the noise health relationship (chapter 6)

In Chapter 6 the results of the psychosocial survey on 2000 subjects are summarized as:

a) Using the dose-effect approach a weak direct relation between noise exposure level and different annoyance variables is obtained ($r^2$ varied between 0.02 and 0.16).
b) No significant direct effect of noise exposure level upon subjective health has been found.
c) In the individual differences approach a significant contribution of residential satisfaction and daily hassles upon subjective health variables is detected ($r^2$ in the range from 0.05 through 0.19).
d) Psychological variables from stress theories (appraisal, coping strategies, perceived control) have a significant influence on the subjective health variables.
e) Individuals who score differently on the three coping strategies show differences in subjective health variables: an active problem oriented coping strategy lowers the score on subjective health complaints.
People who cope with stressful situation by avoiding and denial reactions show higher scores on subjective health complaints.
f) Multivariate analysis results in a total amount of explained variance in subjective health complaints of 20 to 35%. Environmental noise can be associated with 3 to 4% of this variance.
g) Subjects living in insulated dwellings show a lower score on perceived loudness and frequency of activity interference. Stress feelings due to noise and sleep complaints however are not decreased in insulated houses.

### 10.2.3 Environmental noise and cardiovascular diseases

From the medical survey, involving 800 subjects, the following conclusions are obtained:

a) A number of factors known to affect blood pressure, are shown to have similar effects in the sample used in this project. These include age, sex, hypertension in the family, relative weight (quetelet index) and alcohol use of the respondent.

b) In the sample exposed to aircraft noise, a weak interaction between the level of noise exposure and the relation between blood pressure and age of the subject is present. A significant positive correlation in this sample between noise level and blood pressure in a monovariate regression analysis is due to confounding by risk factors as mentioned under a).

c) In the sample exposed to road traffic noise, no direct effects on blood pressure or ischaemic heart diseases, induced by this noise, are observed. These results are in agreement with earlier results, reported by Knipschild et al.(1984).

e) Introduction of psychological variables does not improve our understanding of the relationship between environmental noise and measured blood pressure.

### 10.2.4 Environmental noise and electrolyte concentrations in blood (chapter 8)

In a late phase of the study data became available regarding concentrations of $K^+$, $Na^+$, $Mg^{++}$ and $Ca^{++}$ in blood erythocytes and in blood serum. The analyses, presented in Chapter 8, give first results of the correlations of these concentrations with environmental noise.

Furthermore the results described in chapter 8 and hence the conclusions summarized below, must be regarded with care, because a number of possible confounders (electrolyte intakes per individual for instance) were not measured in this project.

The preliminary results of the analysis are obtained after elimination of possible confounders as far as they were measured in the project: age, relative weight, smoking, use of alcohol, hypertension parents and hypertension siblings. Under the above formulated restriction we conclude:

a) The analyses seem to demonstrate a significant influence of noise level and sex on some electrolyte concentrations. The results for aircraft noise and road traffic noise differ, both in magnitude and, in the case of potassium concentrations in blood serum, also in direction of the effect. This effects might be artifacts, due to confounding by variables we did not measure.

b) For aircraft noise the following results are obtained: In the sample of males an increasing level of noise seems to be associated with a decreasing concentration of erythrocyte magnesium and calcium. For the sample of females an increase in noise level seems to be associated with an decreasing concentration of erythrocyrte calcium and potassium and serum potassium, and an increase in serum magnesium.

c) For road traffic noise an increase in noise level seems to be associated with an increase in serum potassium concentration.

### 10.2.5 Overall conclusions

In chapter 9, we have evaluated the overall results of the research project in terms of effectivity and efficiency of the combined application of different types of research strategies and theories into the present study of the relationship between environmental noise an health effects. The following conclusions are drawn:

a) The attempt to eliminate biases and confounding factors has proven to be successful. An at first sight significant relation between noise level and blood pressure was eliminated by the introduction of risk factors. Also in subjected health variables a significant contribution of confounders has been observed.
b) Results obtained in analysis using the dose effects approach and the individual differences models are in agreement with results reported in literature.
c) The attempt to integrate elements of biological and psychological stress-theories (yielding constructs used in the models of the type as depicted in section 3.4) has resulted in a better understanding of the noise-health relationship, especially in the analyses of migration effects and subjective health effects.

## 10.3 Recommendations for further research

The results and conclusions of this study reveal a number of relationships, that are relevant to the induction of health effects by environmental noise. A number of open questions however remained or are induced by the results obtained. This section summarizes the recommendations for future research as derived from these items, organized analogous to the previous section.

### 10.3.1 Residential satisfaction and sample bias (chapter 5)

We have shown that the perceived level of environmental noise reduces residential satisfaction especially in areas with a high level of road traffic noise. The weak relation in the aircraft noise population, used in this study, may be due to different characteristics of the homes in both samples. This assumption should be tested. The data collected in this study are not sufficient for this purpose. They are confounded by specific characteristics of the homes and the people who live in these homes. Therefore we recommend:

a) A survey, aimed to reveal the relations between environmental noise and migration variables, should be conducted, in which careful precautions are taken to prevent (or to correct for) confounding by dwelling characteristics and individual differences. On the basis of our results in the road traffic sample, the sample size needed is estimated to be in the order of several hundreds of subjects.

In this project no measurements have been made of actual migration. Although we report evidence that residential satisfaction is lowered by environmental noise, effects on actual migration are not proven. Lako (1987) has found a higher migration rate out of noisier streets in a large sample in Amsterdam (N=3000), especially in streets having a lower socioeconomic status. Combining the results of Lako (1987) with the results reported here, we recommend:

b) A longitudinal study, measuring residential satisfaction and actual migration as a function of noise exposure, should be conducted. A first estimate can be obtained by reapproaching (a subsample of) the subjects who participated in this study. Actual migration of the samples used in this report may be recorded in this way.

As we have shown, a selection effect in a population exposed to different levels of environmental noise can not be excluded, although a direct proof still lacks. Therefore we recommend:

c) In conducting field surveys on the effects of environmental noise, one should be prepared to expect a selection effect, giving rise to a bias of the population under study. One might find a population which is enriched in 'survivors'. Therefore such surveys should be planned in such a way that confounding, induced by this selection effect, can be corrected for.

### 10.3.2 Psychosocial aspects of the noise health relationship (chapter 6)

In chapter 6 it was concluded that the combination of different stressors may induce increased (subjective) health effects. Also a dependence from different coping strategies upon the effects observed was shown. We recommend to perform research to investigate these points further.

a) Additional analyses on the data collected in this project should be performed aimed at the detection of possible interaction of different stressors in inducing subjective health effects. The effects of different stressors (environmental stressors, daily hassles, residential dissatisfaction) may induce effects only when they come together.

b) The influence of coping strategies and coping behaviour should be investigated further.

### 10.3.3 Environmental noise and cardiovascular diseases (chapter 7)

In the epidemiological survey as conducted in this project (N=about 800, aged between 18 and 55), no relation has been observed between the level of environmental noise (as measured by more or less physical dimensions) and blood pressure as an indicator of health. Introduction of risk factors into the analyses has not revealed effects that were hitherto hidden. On the contrary, it removed effects, which were apparently caused by confounding by these risk factors. There are two possible explanations for this result:

either there are no health effects of environmental noise large enough to be detected in our survey;

and/or the estimators of noise level are poor measurements of the real noise levels people are exposed to; the detection of subjective health effects in our samples however (chapter 6) makes this possibillity less probable;

and/or the measurement of blood pressure in a medical survey may be a bad indicator of possible long term health effects, at least partly because of the poor representativity of a point measurement of blood pressure, obtained in this survey (the two measurements per individual, about 10 to 15 minutes apart, have no higher covariance than about 50 to 70 %).

Due to the sample size (about 400 respondents per noise source), effects of the order of 1 % explained variance would have been significant in our analyses. Since no such effects have been observed we recommend:

> The measurement of blood pressures in large surveys aimed at the *identification of noise induced health effects, is not an efficient way of* studying the long term health effects of noise.

*The conclusions given here only holds for a relatively healthy population.* The population used in this study consisted of people between 18 and 55 years of age. Cardiovascular diseases are known to become apparent at ages above 50 years. Furthermore people suffering from a number of diseases which are supposed to influence blood pressure, were excluded from the medical survey of this project.

### 10.3.4 Environmental noise and electrolyte concentrations in blood (chapter 8)

On the basis of the preliminary results reported in Chapter 8, we recommend:

a) Further analyses in which the relation between noise level, electrolyte concentrations, blood pressure and related somatic and psychosomatic health problems are evaluated are needed. Attention should be paid to possible confounding factors.

When these analyses conform the effect after correction for confounding variables, the relevance of the observed effect can be investigated by:

b) A follow-up study among subjects from the samples used in this study, in which the predictive power of electrolyte concentrations in relation with noise level, cardiovascular- and psychosomatic health problems is evaluated might be of importance.

### 10.3.5 Integrated recommendations (chapter 9)

Measurements of aircraft noise levels showed a discrepancy with the calculated ones as used in this report.

a) Analyses therefore should be performed using the measured values of aircraft noise to characterize the noise dose.

Apart from this methodological point we also recommend:

b) In this report only an extensive but tentative attempt has been made to analyze results obtained from the different surveys together. The data collected, however, enable more detailed analyses of the interrelationships.
c) Integration of the results of the psychosocial survey and of the laboratory experiments is of prime importance
d) In this report we have studied a number of health effects separately. They may, however, be seen as complementary expressions of damage to health. This hypothesis should be elaborated and tested in the data of this project.

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RIJKSUNIVERSITEIT GRONINGEN

# ENQUETE
# WOON- EN LEEFSITUATIE
februari, maart 1985

## INSTRUKTIE

De vragen, die ik u ga stellen zijn verdeeld naar drie onderwerpen:
A - Vragen over uw woonsituatie;
B - Vragen over uw gezondheid;
C - Vragen over de rust in uw omgeving;
D - Personalia

Terwijl ik de vragen voorlees, kunt u meelezen. De antwoorden waaruit u kunt kiezen staan steeds onder de vraag en zijn genummerd. In de meeste gevallen is slechts één antwoord mogelijk.

Als u iets niet duidelijk is, of als u twijfelt over uw antwoord, laat dat dan gerust weten.

## A. WOONSITUATIE.

Allereerst wil ik u een aantal vragen stellen over uw woonsituatie.

1. Sinds wanneer woont u in dit huis ?
   19..

2. Sinds wanneer woont u in deze buurt ?
   19..

3. Wat voor een woning is dit ?
   1. Koopwoning
   2. Huurwoning

---

4\. Wat voor een type huis is dit ?

1. Flat (galerijwoning)
2. Flat (portiekwoning)
3. Etagewoning (beneden)
4. Etagewoning (boven)
5. Eengezinswoning (rij)
6. Eengezinswoning (2 onder één kap)
7. Vrijstaande woning

---

5\. Met hoeveel mensen deelt u dit huis ?

5a. Aantal:......volwassenen

5b. Aantal:...... kinderen

---

6\. Kunt u de belangrijkste reden aangeven waarom u juist in dit huis bent komen wonen ?

1. Dit was de eerste mogelijkheid (niet verder gezocht);
2. Dit was de enige mogelijkheid (wel verder gezocht);
3. Dit is een goedkope woning;
4. Om de kwaliteit van het huis;
5. Omdat deze buurt ons (mij) beviel;
6. Anders..........................

---

7\. Beschikt u over een balkon ?

1. Ja
2. Nee ga door naar vraag 8

---

7a. Hoevaak verblijft u zomers voor uw plezier op uw balkon ?

1. Nooit
2. Soms
3. Vaak

---

8\. Beschikt u over een tuin ?

1. Ja
2. Nee ga door naar vraag 9

---

8a. Hoevaak verblijft u zomers voor uw plezier in uw tuin ?

1. Nooit
2. Soms
3. Vaak

---

---

9. Als u alles in aanmerking neemt, hoe tevreden bent u dan met dit huis?

   1. Helemaal niet tevreden
   2. Nauwelijks tevreden
   3. Noch tevreden, noch ontevreden
   4. Tevreden
   5. Helemaal tevreden

---

10. En als u alles bij elkaar optelt, hoe tevreden bent u dan met deze buurt?

    1. Helemaal niet tevreden
    2. Nauwelijks tevreden
    3. Noch tevreden, noch ontevreden
    4. Tevreden
    5. Helemaal tevreden

---

11. Kunt u met een paar woorden aangeven wat u de plezierige dan wel onplezierige kanten van dit huis en deze buurt vindt ?

---

---

12. Wilt u hier voorlopig blijven wonen of denkt u er serieus over om te verhuizen, als de gelegenheid zich voordoet?

    1. Ik wil hier blijven wonen          ga door naar 14
    2. Ik wil verhuizen
    3. Ik wil verhuizen, maar zie geen mogelijkheden

---

13. Als u wilt verhuizen, kunt u dan aangeven wat de <u>belangrijkste</u> reden daarvoor is ?

    1. In verband met de grootte van het huis (te groot/te klein)
    2. In verband met de kwaliteit van het huis
    3. In verband met het gebrek aan stilte in deze buurt
    4. In verband met gezondheid van zelf of één van de gezinsleden
    5. In verband met werk van zelf of één van de gezinsleden
    6. Anders......................

---

---

14. Hieronder ziet u een aantal uitspraken, die betrekking hebben op uw woonsituatie. Kunt u voor elk hiervan aangeven in hoeverre u het met deze uitspraak eens bent? Er zijn steeds vijf antwoordmogelijkheden:

| helemaal oneens | oneens | eens, noch oneens | eens | helemaal eens |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

1. Deze woning is groot genoeg (voor ons gezin).
2. Deze woning heeft een praktische indeling.
3. Je kunt deze woning goed ventileren/luchten.
4. Deze woning verkeert in goede staat.
5. Dit is een prettig huis om in te wonen.
6. Er is hier te weinig groen in de buurt.
7. De lucht is hier nog zuiver.
8. Het uitzicht is hier plezierig.
9. Deze buurt doet prettig aan als je er doorheen wandelt.
10. Dit is een prettige buurt om in te wonen.

---

15. Zijn er in uw woning isolatie-voorzieningen aangebracht tegen geluid ?

1. Ja
2. Nee

---

16. Kunt u aangeven hoeveel uur u gemiddeld NIET thuis bent ?

Door de week:

a.Overdag gemiddeld......uur niet thuis (van 7-18.00 uur)

b.'s Avonds/Nachts gemiddeld....uur niet thuis (van 18.00-7 uur)

In het weekeinde:

c.Overdag gemiddeld......uur niet thuis

d.'s Avonds/Nachts gemiddeld.....uur niet thuis

---

17. Ik wil u nu aantal uitspraken voorleggen die betrekking hebben op de manier waarop u op dit moment uw situatie ervaart. In het eerste gedeelte gaat het om algemene uitspraken. U kunt kiezen uit vijf antwoorden:

| helemaal oneens | oneens | eens, noch oneens | eens | helemaal eens |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

1. Vaak heb ik het gevoel, dat men mij niet tot rust laat komen

2. Ik ervaar mijn leven van dit moment als erg plezierig

3. Ik kom voldoende aan ontspanning toe

4. Vaak zou ik onder de druk van de alledaagse zorgen uit willen komen

En nu volgen een aantal uitspraken over specifieke aspekten van uw huidige situatie.

5. Mijn werksituatie (huishouding) vind ik
zeer plezierig 1 2 3 4 5 zeer belastend

6. Mijn gezins- dan wel leefsituatie vind ik
zeer plezierig 1 2 3 4 5 zeer belastend

7. Kontakten met anderen (familie, vrienden, kennissen) vind ik
zeer plezierig 1 2 3 4 5 zeer belastend

8. Mijn financiële situatie van dit moment vind ik
zeer plezierig 1 2 3 4 5 zeer belastend

9. De dingen die ik de laatste tijd heb meegemaakt vind ik
zeer plezierig 1 2 3 4 5 zeer belastend

18. U hebt hierboven aangegeven hoe u uw situatie van dit moment ervaart Kunt u aan de hand van onderstaande uitspraken aangeven hoe u doorgaans op lastige situaties reageert. U kunt hiertoe het beste één lastige situatie in gedachten nemen. U kunt alsvolgt antwoorden:

| nooit | soms | vaak | heel vaak |
|---|---|---|---|
| 1 | 2 | 3 | 4 |

1. Ik zie het probleem als een uitdaging
2. Ik probeer de spanning te verminderen door meer te roken, drinken eten of beweging te nemen.
3. Ik zoek afleiding.
4. Ik ga doelgericht te werk om het probleem op te lossen.
5. Ik ga moeilijke situaties zoveel mogelijk uit de weg.
6. Ik blijf optimistisch over de toekomst.
7. Ik probeer altijd kalm te blijven in moeilijke situaties.
8. Ik bedenk verschillende mogelijkheden om een probleem op te lossen.
9. Ik maak me niet druk; alles komt op zijn pootjes terecht.
10. Ik zet eerst de zaken op een rij.
11. Ik ga er van uit dat problemen zich vanzelf weer oplossen.
12. Ik bedenk me dat anderen het ook moeilijk hebben.
13. Ik praat er met vrienden en familie over.
14. Ik probeer me aan de situatie te onttrekken.
15. Ik probeer aan andere dingen te denken.

## B. GEZONDHEID.

We zijn net uitvoerig ingegaan op uw woonsituatie. In dit gedeelte wil ik overgaan op een ander onderwerp. Er zullen vragen worden gesteld over uw rook-drink en eetgewoonten en eventuele klachten, die u op dit moment hebt. Daarnaast zijn er een aantal vragen over uw nachtrust.

19. Wat is uw gewicht?
.......kg.

20. Wat uw is uw lengte?
.....m........cm.

21. Rookt u ?
1. Ja
2. Nee, ik ben minder dan een jaar geleden gestopt
3. Nee, ik ben meer dan een jaar geleden gestopt
4. Nee ik heb nooit gerookt ga door naar vraag 27

22. Rookt(e) u sigaretten en/of shag ?
1. Ja:....sigaretten per dag (1 pakje shag = 40 sigaretten)
2. Nee

23. Rookt(e) u sigaren ?
1. Ja:....grote sigaren per dag
2. Ja:....kleine sigaren per dag
3. Nee

24. Rookt(e) u pijp ?
1. Ja:....per dag
2. Nee

25. *Inhaleert(de) u of rookt(e) u over de longen ?*
   1. Ja, altijd
   2. Ja, meestal
   3. Ja, af en toe
   4. Nee

26. Indien u nu geen sigaretten, maar wel sigaren en/of pijp rookt, hebt u vroeger wel sigaretten gerookt ?
   1. Ja
   2. Nee

27. *Is er ooit een verhoogde bloeddruk bij u gekonstateerd?*
   1. Ja
   2. Nee ga door naar vraag 34
   3. Weet niet ga door naar vraag 34

28. Bent u daarvoor nu nog onder controle bij een arts?
   1. Ja
   2. Nee ga door naar vraag 34

29. Hoe lang woonde u hier toen de verhoogde bloeddruk geconstateerd werd ?

   ....jaar

   Indien minder dan een jaar, hoeveel maanden ?

   ....maand (afronden op hele getallen)

30. Moet u hiervoor nu een zoutloos/zoutarm dieet gebruiken ?
   1. Ja
   2. Nee

31. Moet u hiervoor nu medicijnen gebruiken ?
   1. Ja
   2. Nee

32. Is er een oorzaak bekend voor uw verhoogde bloeddruk en is deze niet uw gewicht, pilgebruik, emoties en spanningen ?
   1. Ja
   2. Nee ga door naar vraag 34

33. Wat is/was de oorzaak van uw verhoogde bloeddruk ?
    a. Nierziekte
    b. Anders

34. Heeft u een of meerdere van de volgende ziektes (gehad) ?
    a. Nierziekte
    b. Aangeboren hartafwijking
    c. Hartklepafwijking

35. Heeft u ooit pijn of een onaangenaam gevoel in de borstkas gehad?
    (dus bij vrouwen niet in de borsten zelf)
    1. Ja ga door naar vraag 37
    2. Nee

36. Heeft u ooit een drukkend of zwaar gevoel in de borstkas gehad?
    1. Ja
    2. Nee Indien bij 35 en 36 nee ga door naar vraag 53

37. Hangen of hingen deze klachten samen met klachten van asthma, bronchitis, een zware verkoudheid, hyperventilatie, kortademigheid, klaplong, gekneusde of gebroken ribben of een gekneusd, gebroken borstbeen ?
    1. Ja ga door naar vraag 53
    2. Nee
    3. Weet niet

38. Bent u voor deze pijn of dit gevoel naar de dokter geweest?
    1. Ja
    2. Nee ga door naar vraag 40

39. Wat zei deze dat het was?
    1. Hartinfarct in 19..(jaar) ga door naar vraag 59
    2. Angina Pectoris ga door naar vraag 52
    3. Vernauwing van de kransslagaders (= vaten van het hart zelf) ga door naar vraag 52
    4. Afwijking van een hartklep
    5. Onbekend
    6. Anders

40. Krijgt/kreeg u deze klachten als u extra lichamelijke inspanning verricht(te) ?

1. Ja
2. Nee

41. Krijgt/kreeg u deze klachten als u tegen de wind inloopt of fietst(e)?

1. Ja
2. Nee

42. Krijgt/kreeg u deze klachten als u de trap oploopt(opliep) ?

1. Ja
2. Nee

43. Krijgt/kreeg u deze klachten als u zich voorthaast(e) ?

1. Ja
2. Nee

44. Krijgt/kreeg u deze klachten als u gewoon loopt (liep) ?

1. Ja
2. Nee

Indien 40 t/m 44 steeds nee, ga door naar vraag 48

45. Wat doet of deed u als u pijn of een drukkend gevoel in de borstkas voelt of voelde?

1. Ophouden of langzamer aan doen
2. Tablet onder de tong nemen en eventueel langzamer aandoen
3. Gewoon doorgaan

46. Wat gebeurt of gebeurde er dan met het gevoel of de pijn ?

1. Het gevoel verdwijnt/verdween
2. Het gevoel verdwijnt niet/verdween niet

47. Hoe snel verdwijnt/verdween het gevoel of de pijn ?

1. In tien minuten of minder
2. In meer dan tien minuten

48. Krijgt/kreeg u de klachten als u in de kou komt(kwam) ?

1. Ja
2. Nee

---

49. Gewoonlijk wanneer u opgewonden of overstuur bent(was) ?
1. Ja
2. Nee

---

50. Binnen tien minuten na het eten ?
1. Ja
2. Nee

---

51. Kunt u aangeven waar de pijn zat?
1. Borstbeen boven of midden
2. Borstbeen onder
3. Links voor in de borst
4. Linker arm
5. Elders, nl..............

---

52a. Hoe lang geleden kreeg u deze klachten voor het eerst ?
In 19..

52b. Hebt u deze klachten gedurende het laatste half jaar (nog) gehad ?
1. Ja
2. Nee

---

53. Heeft u ooit een ernstige pijn in het voorste gedeelte van uw borstkas gehad, die een half uur of langer duurde en die niet het gevolg was van een ongeval ?
1. Ja
2. Nee ga door naar vraag 57
3. Weet niet

---

54. Werd deze pijn veroorzaakt door asthma, bronchitis, een ernstige verkoudheid, hyperventilatie, klaplong, gekneusde of gebroken ribben, een gekneusd of gebroken borstbeen of een hartzakontsteking ?
1. Ja ga door naar vraag 57
2. Nee

---

55. Bent u hiervoor naar de dokter geweest ?
1. Ja
2. Nee ga door naar vraag 57

---

56. Hebt u toen bloedverdunnende middelen (sintrom, marcoumar) gekregen of bent u bij de trombose-dienst geweest ?
1. Ja in 19..
2. Nee

57. Heeft u ooit een hartinfarct gehad ?
1. Ja in 19..
2. Nee
3. Weet niet

58. Heeft u ooit een operatie aan een kransslagader van uw hart gehad?
1. Ja in 19..
2. Nee

Nu volgen een aantal vragen naar de gezondheidstoestand van uw familieleden.

59. Lijdt of heeft uw vader en/of moeder geleden aan hoge bloeddruk ?
1. Ja
2. Nee
3. Weet niet

60. Lijdt of heeft (hebben) één of meer van uw broers of zusters geleden aan hoge bloeddruk ?
1. Ja
2. Nee
3. Weet niet

61. Heeft uw vader en/of moeder voor zijn/haar 60e jaar een hartinfarct gehad ?
1. Ja
2. Nee
3. Weet niet

62. Heeft (hebben) één of meer van uw broers/zusters voor hun 60e een hartinfarct gehad ?
1. Ja
2. Nee
3. Weet niet

63. Is uw vader en/of uw moeder voor zijn/haar 60e jaar onverwacht en plotseling overleden (binnen 1 uur) en was dit niet ten gevolge van een hersenbloeding, ongeval of kanker ?

1. Ja
2. Nee
3. Weet niet

64. Is (zijn) één of meer van uw broers en of zusters voor zijn/haar 60e jaar onverwacht en plotseling (binnen een uur) overleden en was dit niet ten gevolge van een hersenbloeding, een ongeval of kanker ?

1. Ja
2. Nee
3. Weet niet

65. Heeft u suikerziekte?

1. Ja
2. Nee ga door naar vraag 68

66. Moet u hiervoor nu een dieet gebruiken ?

1. Ja
2. Nee

67. Moet u hiervoor nu geneesmiddelen gebruiken (tabletten of injecties) ?

1. Ja
2. Nee

68. Gebruikt u alcoholische dranken?

1. Ja
2. Nee ga door naar vraag 72

69. Hoe vaak drinkt u alcoholische dranken?

1. Eén tot een paar maal per jaar
2. Eén maal per maand
3. Eén maal per week
4. Een paar maal per week
5. Dagelijks

70. Wat drinkt u en hoeveel per dag (ook als dit één maal per jaar is)

.... aantal glazen bier per dag en/of

.... aantal glazen wijn (sherry, port) per dag en/of

.... aantal glazen sterk alcoholische dranken

71. Als u drinkt, drinkt u dus gemiddeld:

.......glazen per dag

De volgende vraag is alleen bestemd voor vrouwen Mannen door naar 74

72. Gebruikt u nu de pil (niet de prikpil) ?

1. Ja
2. Nee ga door naar vraag 74

73. Welk merk pil (zie onderstaande lijst)

nummer....

1. Binordiol
2. Conova 30
3. Cyclocur
4. Diane
5. Fisioquens
6. Gynovlar 21
7. Lyndiol
8. Marvelon
9. Microgynon 30
10. Microgynon 50
11. Minipregnon
12. Ministat
13. Modicon
14. Neogynon 21
15. Neogynon 28
16. Neocon
17. Neostederil
18. Orlest
19. Orthonovum 1/50
20. Orthonovum 1/80
21. Ovanon
22. Ovidol
23. Ovostat
24. Ovulen 1
25. Ovulen 50
26. Pregnon 28
27. Sequilar
28. Stederil d
29. Stederil d 150/30
30. Trigynon
31. Trinordiol

---

Nu volgen nog enkele korte vragen over uw gezondheid, waarop u eenvoudig met ja of nee kunt antwoorden en niet diep behoeft in te gaan.

---

74. Bent u doof of dovig aan één van beide oren ?
1. Ja
2. Nee ga door naar vraag 76

---

75. Gebruikt u een gehoorapparaat of een ander hulpmiddel(hoorn) om mensen te verstaan ?
1. Ja
2. Nee

---

76. Bent u wel eens opgenomen geweest op een psychiatrische afdeling of in verband met psychische problemen ?
1. Ja
2. Nee ga door naar vraag 79

---

77. Heeft dit plaatsgevonden toen u hier al woonde ?
1. Ja
2. Nee

---

78. Was dit de eerste keer ?
1. Ja
2. Nee

---

79. Bent u onder behandeling van een psycholoog of psychiater ?
1. Ja
2. Nee ga door naar vraag 81

---

80. Is de behandeling begonnen toen u hier woonde ?
1. Ja
2. Nee

---

---

81. Lijdt u aan asthma (aanvallen van benauwdheid bij de ademhaling) ?
1. Ja
2. Nee ga door naar vraag 83

---

82. Hoe vaak per jaar hebt u hier last van ?
....maal per jaar

---

83. Hebt u in de periode dat u hier woont een zweer aan maag of twaalfvingerige darm gehad ?
1. Ja
2. Nee ga door naar vraag 85

---

84. Was dit de eerste keer ?
1. Ja
2. Nee

---

85. Hebt u in de periode, dat u hier woont problemen met uw stem gehad of bent u hees geweest (niet ten gevolge van een verkoudheid) ?
1. Ja
2. Nee ga door naar vraag 87

---

86. Bent u hiervoor naar een KNO arts, een logopedist of een afdeling foniatrie geweest ?
1. Ja
2. Nee

---

87. Hoeveel dagen gedurende het laatste jaar hebt ten gevolge van ziekte u uw dagelijks werk (betaald, onbetaald en huishoudelijk werk) niet kunnen doen ?
.......dagen

---

88. Hoeveel dagen was dit ten gevolge van verkoudheid of griep ?
.......dagen

---

89. Hoe vaak hebt u dit laatste jaar uw huisarts bezocht ?
......maal indien 1 maal ga door naar 92

---

90. Was dit steeds voor één of meer dezelfde problemen ?
1. Ja ga door naar vraag 92
2. Nee

91. Hoeveel keer bent u voor een nieuwe klacht/probleem naar uw huisarts geweest ?
......maal

De volgende vragen zijn alleen voor vrouwen bestemd.
Mannen door naar 97

92. Hebt u in de tijd, dat u hier woont één of meerdere miskramen gehad ?
1. Ja......maal
2. Nee

93. Hebt u in de tijd dat u hier woont één of meerdere kinderen gekregen (niet gedopteerd) ?
1. Ja
2. Nee ga door naar vraag 97

94. Werden deze kinderen op tijd geboren ?
1. Ja op tijd geboren aantal.....
2. Nee te laat geboren aantal....
3. Nee te vroeg geboren aantal

95. Indien op tijd geboren, waren ze normaal van gewicht ?
1. Ja, normaal van gewicht aantal....
2. Nee, te zwaar aantal....
3. Nee, te licht aantal....

96. Indien te licht, rookte u tijdens de zwangerschap(pen) ?
1. Ja, de gehele zwangerschap aantal...(zwangerschappen)
2. Ja, maar alleen in het begin aantal...(zwangerschappen)
3. Ja, maar alleen aan het eind aantal...(zwangerschappen)
4. Nee

Ik ga u nu enkele vragen stellen over wat u zelf gemiddeld per week eet. Ook het weekend is van belang. Wanneer u in het weekend anders eet, dan door de week, dan moet u daarmee rekening houden bij het beantwoorden van de vragen. Voordat u de vragen beantwoordt wil ik u vragen om nu eerst te bedenken wat u meestal eet en drinkt bij het ontbijt (brood, soort beleg, muesli, melk, karnemelk, yoghurt etc), de lunch en het avondeten (aardappels, rijst, vlees, kip, lever, niertjes, groenten, melk, yoghurt, karnemelk etc). Bedenk hierbij ook hoe vaak u één of meerdere van deze maaltijden overslaat. Zou u bovendien willen nagaan wat en hoeveel u 's ochtends, 's middags en 's avonds tussen de maaltijden door eet en drinkt (zoals koek, gebak, chips,pinda's, patat frites, kroketten etc) ?

97. Kunt u van de volgende producten aangeven hoeveel dagen in de week u deze gemiddeld eet ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.Gewone of volle yoghurt | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 2.Magere yoghurt | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 3.Magere kaas (20+) | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 4.Gewone kaas (volvet of 40+) | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 5.Vla of pudding | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 6.Kant en klare toetjes of vruchtenyoghurt | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 7.Vruchten op sap | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8.Bruin brood of volkoren brood | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 9.Witbrood | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 10.Roomboter | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 11.Halvarine | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 12.Dieetmargarine (zie lijst onder) | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 13.Dieethalvarine (zie lijst onder) | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 14.Gewone margarine | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

dieetmargarine (60-65% m.o.v)

Bebo dieetmargarine
Becel dieetmargarine
Cis Cis dieetmargarine
Dieetmargarine(Albert Heyn)
Suncos

dieethalvarine (minimum 40% m.o.v)

Bebo halvarine
Era halvarine
Euro zonnebloemolie
Gouda's Glorie halvarine
Halvarine Albert Heyn
Leeuwenzegel halvarine
Remia halvarine
Santee
Weight Watchers halvarine
Wida zonnebloemhalvarine

Bij de volgende vragen hebt u de volgende antwoordmogelijkheden:

| Nooit | 1xper maand | 2xper maand | 1x | 2x | 3x | 4x | 5x | 6x | 7x per week |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

98. Hoevaak eet u de volgende producten ?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.zoutjes of chips | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 2.Pinda's of andere noten | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 3.Gehakt bij warme maaltijd | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 4.Rookworst of verse worst | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 5.Speklappen | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 6.Carbonade | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 7.Kroketten, frikadellen, sauzijzenbroodjes | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 8.Patat frites | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 9.Lever of niertjes | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10.Grote koeken (gevuld, Rondo's) | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 11.Gebak of cake | nooit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 99. Hoeveel (zichtbare) eieren eet u gemiddeld <u>per week</u> ? | 0 | 1 | 2 | 3 | 4 | 5 | meer | |
| 100. Hoeveel koppen koffie drinkt u <u>per dag</u> ? | 0 | 1 | 2 | 3 | 4 | 5 | meer | |
| 101. Hoeveel koppen thee drinkt u <u>per dag</u> ? | 0 | 1 | 2 | 3 | 4 | 5 | meer | |
| 102. Hoeveel scheppen suiker gebruikt u in de koffie ? (per kopje) | 0 | ½ | 1 | 1½ | 2 | 2½ | 3 | .. |
| 103. Hoeveel scheppen suiker gebruikt u in de thee ? (per kopje) | 0 | ½ | 1 | 1½ | 2 | 2½ | 3 | .. |

---

Kunt u aangeven hoeveel u van de volgende producten gemiddeld <u>per dag</u> <u>eet/drinkt</u> ?

104.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.Stuks fruit | 0 | 1 | 1 | 2 | 3 | meer |
| 2.Glazen volle melk | 0 | 1 | 1 | 2 | 3 | meer |
| 3.Glazen halfvolle melk | 0 | 1 | 1 | 2 | 3 | meer |
| 4.Glazen magere melk | 0 | | 1 | 2 | 3 | meer |
| 5.Glazen frisdrank (cola, sinas, 7up of cassis) of vruchtensap | 0 | | 1 | 2 | 3 | meer |

---

105. Wat voor braadvet of-olie gebruikt u bij het bakken of braden ?

1. Altijd gewone margarine of boter of een olie die <u>niet</u> op onderstaande lijst voorkomt
2. Dieetmargarine of een olie die <u>wel</u> op onderstaande lijst voorkomt
3. Beide

---

| | |
|---|---|
| Becel dieetolie | (Van den Bergh en Jurgens) |
| Benedictus druivenpittenolie | (Mayolande) |
| Benedictus zonnebloemolie | (Mayolande) |
| Delftse slaolie | (Calvé) |
| Diedesol | (Sigg) |
| Diedoja | (Sigg) |
| Fondueolie | (Natura V) |
| Huile diététique ditavitol | (Sigg) |
| Kaucher's lijnolie | (Kaucher) |
| Lunisit öl lijnolie | (Fink) |
| Maisolie | (Natura V) |
| Mazola Knorr | (C.P.C.) |
| Reddy zonnebloemolie | (VAndemoortele) |
| Saffloerolie | (Zonnatura) |
| Saatvital zonnebloemolie | (Neköllner) |
| Sandial slaolie | (Vandemoortele) |
| Slaolie | (Gouda's Glorie) |
| Sojaolie | (Zonnatura) |
| Tarwekiemolie | (Zonnatura) |
| Vitelma dieetolie | (Vandemoortele) |
| Weight Watchers druivenpitolie | (Boas) |
| Zonnebloemolie | (Calvé) |
| Zonnebloemolie | (Natura V) |
| Zonnebloemolie | (Zonnatura) |

---

106. Hieronder worden een aantal vragen gesteld, die te maken hebben met uw nachtrust. Het gaat erom hoe u doorgaans slaapt. U kunt antwoorden met ja of nee.

1. Ik doe vaak 's nachts geen oog dicht.
2. Ik sta 's nachts vaak op.
3. Ik lig 's nachts meestal erg te woelen.
4. Ik word 's nachts vaak meerdere malen wakker.
5. Ik vind dat ik meestal heel slecht slaap.
6. Ik slaap naar mijn gevoel vaak maar een paar uur.
7. Ik slaap niet langer dan vijf uur.
8. Ik vind dat ik 's nachts meestal goed slaap.
9. Ik slaap meestal makkelijk in.
10. Ik kom naar mijn gevoel meestal slaap tekort.
11. Ik lig vaak langer dan een half uur wakker in bed, voordat ik inslaap.
12. Als ik 's nachts wakker word kan ik moeilijk weer inslapen.
13. Ik heb 's ochtends nadat ik ben opgestaan vaak een moe gevoel.
14. Ik voel mij 's ochtends nadat ik ben opgestaan meestal goed uitgerust.

107. Gebruikt u slaapmiddelen ?

1. Iedere nacht
2. Regelmatig
3. Zo nu en dan
4. Nooit

---

108. Draagt u wel eens oordoppen(-watten) bij het slapen gaan ?

1. Iedere nacht
2. Regelmatig
3. Zo nu en dan
4. Nooit

---

109. Bent u wel eens van slaapkamer gewisseld om beter te kunnen slapen ?

1. Ja
2. Nee

110. Bestaat de mogelijkheid in dit huis om aan de andere kant van het huis te gaan slapen ?

1. Ja
2. Nee

111. Als u aangegeven hebt, dat u vaak slecht slaapt, hoe komt dat volgens u ?

-
-
-

## C. GELUID.

Ik wil nu overstappen op een ander onderdeel van de vragenlijst. In dit gedeelte willen we nog wat nader ingaan op uw woonsituatie en dan met name op de geluiden, die u in en om uw huis hoort, de mate van hinder, die u daarvan ondervindt en de manier waarop u hiermee omgaat.

Allereerst een aantal vragen over de soorten van geluid, die u rond uw woning hoort.

112. Hoe vaak hoort u geluiden van uw buren, zoals stemmen, muziek, boren ?
    1. Vrijwel nooit ga door naar 118
    2. Soms
    3. Vaak

113. Kunt u aan de hand van onderstaande woorden omschrijven hoe de geluiden van de buren voor u klinken ?

| | | | | | | |
|---|---|---|---|---|---|---|
| hard | 1 | 2 | 3 | 4 | 5 | zacht |
| hoog | 1 | 2 | 3 | 4 | 5 | laag |
| sterk | 1 | 2 | 3 | 4 | 5 | zwak |
| monotoon | 1 | 2 | 3 | 4 | 5 | afwisselend |
| indringend | 1 | 2 | 3 | 4 | 5 | gedempt |
| langdurig | 1 | 2 | 3 | 4 | 5 | kortdurend (over de dag) |
| plotseling | 1 | 2 | 3 | 4 | 5 | konstant |
| vertrouwd | 1 | 2 | 3 | 4 | 5 | onbekend |

114. Kunt u aan de hand van onderstaande woorden aangeven welke gevoelens deze geluiden bij u oproepen. U kunt alsvolgt antwoorden:

| helemaal oneens | oneens | eens, noch oneens | eens | helemaal eens |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Geluiden van de buren maken mij

| | | | | | |
|---|---|---|---|---|---|
| ONTSPANNEN | 1 | 2 | 3 | 4 | 5 |
| GESPANNEN | 1 | 2 | 3 | 4 | 5 |
| ANGSTIG | 1 | 2 | 3 | 4 | 5 |
| GEÏRRITEERD | 1 | 2 | 3 | 4 | 5 |
| ZENUWACHTIG | 1 | 2 | 3 | 4 | 5 |
| KWAAD | 1 | 2 | 3 | 4 | 5 |

115. Vindt u geluiden van buren hinderlijk ?

1. Helemaal niet ga door naar 117
2. Een beetje
3. Nogal
4. Tamelijk veel
5. Heel erg

116. Op welke tijdstip van de dag ondervindt u de meeste hinder en op welk tijdstip de minste ? Graag ordenen van 1 t/m 4.

1. 's ochtens (7-12)
2. 's middags (12-18)
3. 's avonds (18-23)
4. 's nachts (23-7)

117. In welke mate bent u het met elk van onderstaande uitspraken eens ? U kunt antwoorden met eens of oneens.

1. Geluiden van buren kun je best accepteren
2. Aan burengerucht kun je wennen
3. Aan geluiden van je buren ben je overgeleverd
4. Tegen geluiden van buren kun je direct aktie ondernemen
5. Tegen geluiden van je buren kun je alleen met veel moeite iets doen

---

118. Hoe vaak hoort u geluiden van wegverkeer, zoals auto's, brommers, bussen etc ?

1. Vrijwel nooit  ga door naar 124
2. Soms
3. Vaak

---

119. Kunt u aan de hand van onderstaande woorden omschrijven hoe verkeersgeluiden voor u klinken ?

| | | | | | | |
|---|---|---|---|---|---|---|
| hard | 1 | 2 | 3 | 4 | 5 | zacht |
| hoog | 1 | 2 | 3 | 4 | 5 | laag |
| sterk | 1 | 2 | 3 | 4 | 5 | zwak |
| monotoon | 1 | 2 | 3 | 4 | 5 | afwisselend |
| indringend | 1 | 2 | 3 | 4 | 5 | gedempt |
| langdurig | 1 | 2 | 3 | 4 | 5 | kortdurend (over de dag) |
| plotseling | 1 | 2 | 3 | 4 | 5 | konstant |
| vertrouwd | 1 | 2 | 3 | 4 | 5 | onbekend |

---

120. Kunt u aan de hand van onderstaande woorden aangeven welke gevoelens verkeersgeluiden bij u oproepen. U kunt alsvolgt antwoorden:

| helemaal oneens | oneens | eens, noch oneens | eens | helemaal eens |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Geluiden van verkeer maken mij:

| | | | | | |
|---|---|---|---|---|---|
| ONTSPANNEN | 1 | 2 | 3 | 4 | 5 |
| GESPANNEN | 1 | 2 | 3 | 4 | 5 |
| ANGSTIG | 1 | 2 | 3 | 4 | 5 |
| GEIRRITEERD | 1 | 2 | 3 | 4 | 5 |
| ZENUWACHTIG | 1 | 2 | 3 | 4 | 5 |
| KWAAD | 1 | 2 | 3 | 4 | 5 |

---

121. Vindt u verkeersgeluiden hinderlijk ?

1. Helemaal niet  ga door naar 123
2. Een beetje
3. Nogal
4. Tamelijk veel
5. Heel erg

---

126. Op welke tijdstip van de dag ondervindt u de meeste hinder en op welk tijdstip de minste ? Graag ordenen van 1 t/m 4.

1. 's ochtens (7-12)
2. 's middags (12-18)
3. 's avonds (18-23)
4. 's nachts (23-7)

---

123. In welke mate bent u het met elk van onderstaande uitspraken eens ? U kunt antwoorden met eens of oneens

1. Verkeersgeluiden kun je best accepteren
2. Aan verkeerslawaai kun je wennen
3. Aan geluiden van verkeer ben je overgeleverd
4. Tegen verkeerslawaai kun je direct aktie ondernemen
5. Tegen geluiden van verkeer kun je alleen met veel moeite iets doen

---

124. Hoe vaak hoort u geluiden van vliegverkeer?

1. Vrijwel nooit ga door naar 130
2. Soms
3. Vaak

---

125. Kunt u aan de hand van onderstaande woorden omschrijven hoe geluiden van vliegtuigen voor u klinken ?

| | | | | | | |
|---|---|---|---|---|---|---|
| hard | 1 | 2 | 3 | 4 | 5 | zacht |
| hoog | 1 | 2 | 3 | 4 | 5 | laag |
| sterk | 1 | 2 | 3 | 4 | 5 | zwak |
| monotoon | 1 | 2 | 3 | 4 | 5 | afwisselend |
| indringend | 1 | 2 | 3 | 4 | 5 | gedempt |
| langdurig | 1 | 2 | 3 | 4 | 5 | kortdurend (over de dag) |
| plotseling | 1 | 2 | 3 | 4 | 5 | konstant |
| vertrouwd | 1 | 2 | 3 | 4 | 5 | onbekend |

---

126. Kunt u aan de hand van onderstaande woorden aangeven welke gevoelens deze geluiden bij u oproepen. U kunt alsvolgt antwoorden:

| helemaal oneens | oneens | eens, noch oneens | eens | helemaal eens |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Geluiden van vliegtuigen maken mij:

| | | | | | |
|---|---|---|---|---|---|
| ONTSPANNEN | 1 | 2 | 3 | 4 | 5 |
| GESPANNEN | 1 | 2 | 3 | 4 | 5 |
| ANGSTIG | 1 | 2 | 3 | 4 | 5 |
| GEïRRITEERD | 1 | 2 | 3 | 4 | 5 |
| ZENUWACHTIG | 1 | 2 | 3 | 4 | 5 |
| KWAAD | 1 | 2 | 3 | 4 | 5 |

127. Vindt u vliegverkeersgeluiden hinderlijk ?

1. Helemaal niet ga door naar 130
2. Een beetje
3. Nogal
4. Tamelijk veel
5. Heel erg

128 Hoe hinderlijk vindt u <u>elk</u> van de volgende aspecten ?
(voor antwoordcategorieën zie vraag 127)

| | | | | | |
|---|---|---|---|---|---|
| 1. Laag overvliegen | 1 | 2 | 3 | 4 | 5 |
| 2. Overvliegen | 1 | 2 | 3 | 4 | 5 |
| 3. Starten | 1 | 2 | 3 | 4 | 5 |
| 4. Landen | 1 | 2 | 3 | 4 | 5 |
| 5. Proefdraaien | 1 | 2 | 3 | 4 | 5 |

129. Op welke tijdstip van de dag ondervindt u de meeste hinder en op wel tijdstip de minste ? Graag ordenen van 1 t/m 4.

1. 's ochtens (7-12)
2. 's middags (12-18)
3. 's avonds (18-23)
4. 's nachts (23-7)

130. In welke mate bent u het met elk van onderstaande uitspraken eens ? U kunt antwoorden met eens of oneens.

1. Vliegverkeersgeluiden kun je het best accepteren
2. Aan het lawaai van vliegtuigen kun je best wennen
3. Aan geluiden van vliegverkeer ben je overgeleverd
4. Tegen vliegverkeerslawaai kun je direct aktie ondernemen
5. Tegen vliegtuiglawaai kun je alleen met veel moeite iets doen

Indien de vragen 118,124 en 130 allen met nooit ga door naar vraag 137

---

131. U heeft in de vorige vragen aangegeven welke geluiden u hoort en van welke geluiden u last heeft. Waar het in de nu volgende vraag om gaat is <u>in welke mate u bij bezigheden in huis u verstoord wordt</u>. U kunt als volgt antwoorden:

| helemaal niet | een beetje | nogal | tamelijk veel | heel erg |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

| door: | A<br>Burengerucht | B<br>Verkeerslawaai | C<br>Vlieglawaai |
|---|---|---|---|
| 1. Middagrust | | | |
| 2. Telefoongesprek voeren | | | |
| 3. Gesprek voeren | | | |
| 4. Lezen voor ontspanning | | | |
| 5. Denkwerk | | | |
| 6. Radio/muziek luisteren | | | |
| 7. T.V. kijken | | | |
| 8. Nietsdoen, ontspannen | | | |
| 9. Slapen | | | |

---

132. Kunt u uit de aktiviteiten, die in de vorige vraag genoemd zijn die aktiviteit kiezen, waarbij u het meest verstoord wordt door geluid.

Aktiviteit nummer.......(keuze uit 0 t/m 9)

138. Hoeveel moeite kost het om u te concentreren op deze aktiviteit, als het lawaaiig om u heen is?

1. Totaal geen moeite
2. Een beetje moeite
3. Tamelijk veel moeite
4. Erg veel moeite
5. Ontzettend veel moeite

134. Wat heeft u in het verleden gedaan aan geluidshinder of wat denkt u te gaan doen als u gehinderd zou worden door geluiden in uw woonomgeving?

| helemaal niet v.toepassing | nauwelijks v.toepassing | evenzeer wel als n.v.t. | gedeeltelijk v.toepassing | helemaal v.toepassing |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

1. Alles over geluidshinder te weten proberen te komen.
2. Proberen te ontspannen.
3. Jezelf vertellen, dat iedere buurt zijn voor- en nadelen heeft.
4. De ramen sluiten.
5. Een klacht indienen.
6. De spanning en hinder verminderen door te eten, drinken en/of roken.
7. Je erop voorbereiden dat het lawaai nog erger kan worden.
8. Iets met de buurtbewoners organiseren.
9. Iemand om hulp vragen.
10. Je ondanks de hinder van geluid proberen te concentreren op wat je aan het doen bent.
11. Medicijnen gebruiken, als de spanning te veel wordt.
12. Jezelf vertellen, dat er toch niets aan te doen is.
13. Kwaad worden.
14. Accepteren, dat het hier nooit stil is.
15. Harder praten, de televisie harder etc. als het geluid stoort.

| helemaal niet v.toepassing | nauwelijks v.toepassing | evenzeer wel als n.v.t. | gedeeltelijk v.toepassing | helemaal v.toepassing |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

16. Afleiding zoeken.

17. Officiële instantie (bv gemeente) inschakelen.

18. Jezelf vertellen, dat je overdrijft.

19. Accepteren, dat je nu eenmaal gevoelig voor geluid bent.

20. Betrokken persoon (bedrijf, instantie) bellen.

21. Veel over het probleem piekeren.

22. Op de geluiden wachten, ook als het stil is.

23. Verschillende mogelijkheden overwegen om iets aan het geluid en/of de hinder te doen.

24. Verhuizen.

25. Het huis isoleren tegen geluid.

26. Oordoppen dragen.

---

## D. PERSONALIA

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Tot slot wil ik u nog een aantal algemene vragen stellen.

---

135. Geslacht

........

---

136. Wat is uw leeftijd?

.... jaar

---

137. Wat is uw laatst genoten opleiding, die u voltooid heeft?
    1. Lagere school
    2. Idem + Vakschool
    3. Mulo/Mavo/Drie jaar Voortbereidend Wetenschappelijk Onderwijs
    4. Idem + Vakopleiding
    5. Havo/HBS/Atheneum/Gymnasium
    6. HBO
    7. Universiteit

---

138. Wat is uw plaats in de huishouding?
    1. Kostwinner
    2. Huisman/huisvrouw
    3. Beide
    4. Anders, nl.........

---

139. Wat is uw beroep?

.................(Indien geen beroep ga door naar vraag 147)

---

140. Oefent u dit beroep op dit moment uit?
    1. Ja ga door naar vraag 142
    2. Nee

---

141. Zo nee, wat is daarvoor de reden?
1. Ziekte
2. Werkloosheid
3. Gestopt met werken
4. Anders

142. Wat voor een soort werk doet/deed u ?
1. Overwegend handwerk
2. Overwegend hoofdwerk

143. Bent/was u in loondienst ?
1. Ja
2. Nee    ga door naar vraag 145

144. Zo ja, heeft/had u leiding over anderen ?
1. Ja
2. Nee
ga door naar 146

145. Als u zelfstandig werkt, hoeveel mensen werken er dan in uw bedrijf ?
..................

146. Heeft/had u wisselende diensten/werkt u in de ploegendienst ?
1. Ja
2. Nee

147. Is/was het waar u werkt(e) lawaaiig?
1. Absoluut niet
2. Een beetje
3. Nogal lawaaiig
4. Tamelijk erg
5. Heel erg

148. Vindt/vond u uw werk inspannend ?
1. Ja, vooral lichamelijk inspannend
2. Ja, vooral geestelijk inspannend
3. Zowel geestelijk als lichamelijk inspannend
4. Nee, niet overmatig inspannend

We zijn nu aan het eind van dit gesprek gekomen. Ter afsluiting wil ik u nog het volgende vragen:

149. Bent u eventueel bereid verder met dit onderzoek mee te werken, door mee te doen aan een medisch onderzoek en/of een betaald experiment ?
1. Ja
2. Nee ga door naar 150

Vindt u het dan goed, dat ik uw naam, adres en telefoonnummer op een apart formulier noteer ?

150. Kunt u in het kort aangeven wat u van de gestelde vragen vond?

151. Wilt u nog andere opmerkingen maken over dit gesprek?

HARTELIJK DANK VOOR UW MEDEWERKING!

Produktie en distributie:
Ministerie van Volkshuisvesting,
Ruimtelijke Ordening en Milieubeheer,
Centrale Directie Voorlichting en
Externe Betrekkingen,
Van Alkemadelaan 85,
2597 AC 's-Gravenhage

VROM 90017/2-89
5526/104

ISBN 90 346 1835 8