SUMMARY

Chapter 1 Introduction.

The thesis is constructed around three themes, each of which is dealt with in a separate part of the thesis:

- Effects of noise on mental efficiency.
- Effects of noise on the blood pressure regulation system.
- Noise and coping strategies.

Review of the literature up to 1985 shows contradictory effects of noise: sometimes, not always, detrimental effects of noise on performance are found. The same holds for physiological variables: for example blood pressure and heart rate not always increase as a consequence of noise.

On the basis of this review, the case is made for studying the effects of noise at three levels simultaneously, i.e. at a behavioural level, a subjective level and a physiological level. The laboratory study, described here, was part of the Environment Noise and Health study (using a subsidy granted by the Dutch Ministry of Housing, Physical Planning and Environment, abbreviated in Dutch: VROM). A central issue in this study was the question whether there was a relation between effects of noise and cardiovascular diseases. In view of the general research question of this study, the physiological level in the laboratory study is restricted to variables which have a part to play in the blood pressure regulation system.

This chapter also makes a distinction between mental load (measured in the laboratory) and stress, together with potential consequences for the occurrence of cardiovascular disease.

Part 1. Effects of noise on mental efficiency

Chapter 2 Mental effort and mental efficiency.

Two aspects of effort are described in this chapter. The first aspect is linked with computational mechanisms and task demands. The second aspect of effort is related to energetical mechanisms (effects of a stressor; i.e. noise in our experiment). A model is presented which describes both concepts of effort: a control model of state regulation.

Concepts such as mental state and cardiovascular state are operationalised. If a certain alteration in physiological state which has arisen as a consequence of task performance is seen as an indication of greater mental effort, then a change in mental efficiency might have occurred. An index of this efficiency gives us better insight into the nature of regulation processes: does the performance of mental tasks under noisy conditions deteriorate during noise or is it associated with more cardiovascular costs? Chapter 2 presents the operationalisation of such an index.
Chapter 3 Method.

This chapter describes the methodology employed in the experiment. It explains, among other things, the type of tasks which were presented: six short tasks lasting five minutes - four varying in respect of the degree of mental load (divided attention tasks) and two varying in respect of selective attention aspects (selective attention tasks); and a task lasting 45 minutes (the sustained attention task) by way of contrast with the short tasks. All dependent variables are operationalised in this chapter, at behavioural, subjective and physiological levels. Beside mean heart rate as well as systolic and diastolic blood pressure, variability of these signals is calculated by means of spectral analysis.

Finally the statistical design used in this study will be presented.

Chapter 4 Results related to performance and mental state.

Results related to behaviour are described. As a consequence of an increase in degree of mental load, performance deteriorates (divided attention tasks: reaction times become slower and more errors are made). The two selective attention tasks also differ from each other, mainly in respect of the number of errors made.

No effects of noise on performance are evident.

Chapter 5 Results related to cardiovascular indices.

Mean heart rate and blood pressure increase during task performance in comparison with a preceding rest period.

The tasks which vary in terms of mental load (divided attention tasks) differ from each other in respect of mean heart rate, systolic and diastolic pressure. The same applies for the selective attention tasks. When these tasks are performed under noise, however, heart rate and blood pressure do increase.

Chapter 6 Results related to subjective measures.

When asked, our subjects are capable of deducing how taxing the tasks were: where the task load increases, so does the degree of subjective experience. Performance of the tasks under noisy conditions does not cost subjective effort, but it is notable that heart rate and blood pressure do increase during noise.

Chapter 6 concludes that one may speak of a dissociation between belief and subjective experience on the one hand, and physiological costs during performance of mental tasks under noisy conditions on the other hand.

Chapter 7 Sustained attention task.

Results from the extended task are described at two levels: on average over 45 minutes and as a function of time. Over 45 minutes there is almost no evident noise effect (only in heart rate), but in the first ten minutes of the task there are very clear effects: more errors are made during noise and systolic blood pressure shows particular increases in this period.
Chapter 8 Discussion: mental efficiency and noise.

The results related to behaviour and cardiovascular state are summarised once again and related to each other in an index for mental efficiency. Mental efficiency decreases as a consequence of mental load under noisy conditions in all of the short tasks. The same applies for the sustained attention task lasting 45 minutes, in which the effects are particularly strong in the beginning of the task.

Part 2. Effects of noise on blood pressure regulation

Chapter 9 Cardiovascular regulation.

This part of the thesis starts on a theoretical basis: a blood pressure regulation model is presented and a distinction is made between short, medium and long-term regulation. The autonomous nervous system plays an important role in short-term blood pressure regulation. The function and role of the sympathetic and parasympathetic systems are described.

The relation between mental load and variability in heart rate and blood pressure are discussed. This variability is calculated by means of spectral analysis. Advantages of this method are: 1) the possibility to distinguish differential effects of mental load on variability measures, 2) distinction to some extend of the influences of sympathetic and vagal regulation and 3) the possibility to devise a method to determine baroreflex sensitivity.

The last part of chapter 9 draws a link between mental load and blood pressure regulation; results from the literature show that mental load can have an influence on blood pressure and its regulation (changes in mean values and variability, baroreflex sensitivity and hormones).

Chapter 10 Results.

This chapter describes the findings of the experiment:

- In comparison with a rest period, mean heart rate as well as systolic and diastolic blood pressure increase during task performance. Variability in the three frequency bands (low, mid and high) becomes less and baroreflex sensitivity decreases.
- No differences are found as a consequence of a varying task load (divided attention tasks). The selective attention tasks do differ from the divided attention tasks in respect of mean heart rate and variability in all three bands of heart rate and in respect of baroreflex sensitivity.
- Mean heart rate and blood pressure increase as a consequence of performing mental tasks under noisy conditions. Variability in the frequency high band of heart rate (potential index for vagal activation) and variability in the low frequency band of blood pressure (potential index for sympathetic activation) decreases. Baroreflex sensitivity also decreases.
- As a consequence of performing mental tasks, variability in heart rate and blood pressure increases in a rest period following completion of the tasks. Mean heart
rate and blood pressure have already returned to their baseline level. Baroreflex sensitivity has not yet returned to its baseline level.

-- More magnesium (risk factor for cardiovascular disorders) and sodium is secreted as a consequence of noise.

Chapter 11 Discussion.

First our results are compared with results from the literature. If noise of a sufficient intensity is presented or the duration of noise presentation is long enough, heart rate and blood pressure increase during rest periods. If mental tasks have to be performed under noise, then less intensive noise during short periods already suffices to produce these effects. The noise effects detected in the variability measures are related to blood pressure regulation mechanisms. Baroreflex sensitivity as well as vagal activity (high frequency band of heart rate) decreases during task performance under noise. In the course of an extended task there is evidence of a counter-regulation in blood pressure: at the point that systolic blood pressure decreases strongly, variability in the low frequency band of blood pressure (a possible index of sympathetic activity) can similarly be seen to increase less rapidly compared to the control condition.

Questions of what cardiovascular mechanisms are responsible for these effects are discussed, possible alternative hypotheses are presented to explain these changes in cardiovascular regulation under noise: three different explanations from literature are discussed: the afferent feedback hypothesis, the defense reaction and the possible role of frontal cortex. The defense reaction fits best our cardiovascular data.

Further, rebound effects are found during rest periods after task performance. Mean heart rate and blood pressure have already returned to their baseline levels in the rest period following completion of the short tasks. In this period the effects are strongest in variability of heart rate and blood pressure: variability in heart rate and blood pressure during this rest period increases compared to the rest period preceding task performance. The conclusion drawn is that spectral measures give additional information of changes in the regulation of blood pressure.

Part 3 Noise effects and coping strategies

Chapter 12 Individual differences and coping strategies.

Our laboratory study was part of the Environmental Noise and Health study (using a subsidy granted by the Dutch Ministry of Housing, Physical Planning and Environment, in Dutch: VROM). A central issue in this study was whether psychological concepts such as 'coping with noise' and 'perceived noise control' (appraisal) could provide a better explanation of the relationship between noise and health. The study consisted of a field survey, medical research and a laboratory study. These both concepts were chosen with a view to linking these three areas of research.
The selection of the experimental subjects who participated in the experiment is also looked at: the participants were healthy, young women who do not complain and who only differ from each other in respect of the degree of avoidance under noisy conditions (a coping strategy) and perceived noise control. Selection was based on data from the field survey and medical research. The laboratory experiment was carried out one and a half year later.

Results from questionnaires which were completed before and during this experiment only show a difference on avoidance: the non-coping has higher scores on these items than the coping group. The factor 'appraisal' does not show any other differences for the behavioural and physiological variables.

Chapter 13 Noise effects and coping strategies.

The two coping groups' results show that they do not differ in respect of performance while carrying out mental tasks under noisy conditions. The same is true of mean heart rate and blood pressure.

They do differ in respect of the variability measures. The non-coping group shows more spectral power in the low frequency band of blood pressure (possible index for sympathetic activity) in the extended task and also in the selective attention tasks. During task performance of both the extended task and the short tasks under noise, this group reacts with a stronger decrease in spectral power in the high frequency band of heart rate (index for vagal activity), compared with the coping group. The non-coping group also secretes more sodium.

No differences are found between subjects who differ in respect of their degree of perceived control or type of noise (exposition of air traffic noise or road traffic noise in daily life).

Chapter 14 Discussion.

The coping group reacts to noise with a reduction in mental efficiency, while the non-coping group maintains a comparable rate of mental efficiency. Connected with this is the fact that the coping group becomes increasingly reactive as a consequence of noise, while precisely the opposite applies for the non-coping group: the increases in blood pressure initially experienced by the non-copers during performance of the extended task under noise disappear completely during task performance of the short tasks under noise.

Results from the perspective of blood pressure regulation indicate that the two groups do not differ in respect of mean heart rate or blood pressure during the whole experiment. The absence of a priori differences in blood pressure in the medical survey was in fact one of the selection criteria for participation in the experiment. The groups do differ from each other in respect of a number of regulation parameters. During the short tasks under noise the coping group shows a increased sympathetic reactivity, a possible risk factor for hypertension. During the extended task the non-coping group reacts with a decrease in parasympathetic activity. During task performance of the short tasks under noise this group reacts with a further, stronger vagal withdrawal, a possible risk factor for cardiac disorders (i.e. congestive heart failure, coronary artery disease, 'sudden death'). The non-
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coping group also secretes more sodium as a consequence of noise. They secrete more norepinephrine during task performance (an increased sympathetic reaction). This, however, applies for both experimental conditions. This latter group shows also more health complaints and does more frequently consult physicians.

It is concluded that no effects of noise on performance and subjective effects are found in our study. However, blood pressure and heart rate increase, baroreceptor sensitivity decreases as a consequence of task performance under noise. One speaks of a dissociation between performance and subjective experience on the one hand, and physiological costs during performance of mental tasks under noise on the other hand. These are hidden effects of noise. At the same time both groups are differently vulnerable to noise, expressed in indices of the autonomic nervous system, both indicating different risk factors for cardiovascular health: the coping group (people showing active problem oriented behaviour in daily life) for hypertension and the non-coping group (people showing active avoidance behaviour in daily life) for cardiac disorders, like congestive heart failure, coronary artery disease and 'sudden death'.