It's an ill wind that brings no good. Studies on odour annoyance and the dispersion of odorant concentrations from industries.

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SUMMARY

The subject of this thesis is the relation between exposure to odorant concentrations and resulting odour annoyance, and subjective health effects complaints. In the literature there is no evidence for a strong relationship between physical or chemical parameters of the environment and subjective reactions to them. This is partly due to the lack of accurate exposure measures and the high individual variability in subjective reactions. Normally, a major part of the variance in annoyance reactions remains unexplained.

The principal aim of this series of studies - explained in THE INTRODUCTORY CHAPTER - is to clarify the relation between exposure to odorant concentrations and odour annoyance which may result from this exposure. An attempt is made to improve the estimation of exposure by employing a dispersion model of malodour, which predicts odorant concentrations from emissions and meteorological conditions. Furthermore, the influence is investigated of a number of psychosocial factors - such as appraisal of exposure in terms of health threat, and coping with odour annoyance - on the relation between odour annoyance and exposure. Exposure to odorant concentrations is conceived as an ambient stressor with which individuals have to cope. The way this is done might explain more of the supposedly poor relation between objective exposure and subjective reactions to this exposure. Moreover, the influence of a number of personality characteristics upon this relation is studied, such as neuroticism and the extent to which control over the environment is perceived. Finally, the effect of a number of demographic and additional variables which have found to be related to odour annoyance, is investigated. In order to study these relationships several field studies around odour emitting industries have been conducted.

In THE OLFACTORY CHAPTER a brief outline of the physiology of the nose and the olfactory system is presented. Some problems in olfactory research are discussed. The main problem is that there exists no truly objective measure of odour. The literature on odour perception and odour annoyance is reviewed.

In THE STRESS-THEORETICAL CHAPTER the stress concept is discussed, and an overview of some of the major approaches in stress research is presented. The transactional approach of stress and coping with environmental stress - the psychosocial stress theory developed by Lazarus and coworkers - receives special attention. This theory states that two processes mediate the person-environment relationship: cognitive appraisal and coping. Cognitive appraisal is the process that determines why and to what extent a transaction between person and environment is stressful. Coping is the process through which a person manages the demands of the person-environment relationship, which are appraised as stressful. Coping efforts fall into two main categories: they can be directed towards managing or changing the problem that causes distress (problem-focused coping), and towards the regulation of the emotional response caused by the problem (emotion-focused coping).

Different sources of stress are briefly discussed. One of the sources - ambient stressors - is particularly relevant for the present study. Ambient stressors are chronic, negatively valued, intractable, non-urgent and perceptible (although often unnoticed).

This chapter is ended with a discussion about the way in which annoyance might relate to coping with ambient stressors. Since a crucial characteristic of ambient stressors is their intractability, individual problem-oriented coping strategies do not seem to be effective in the short run. Coping efforts directed towards the impact of ambient stressors with regard to annoyance only seem to be effective when directed towards regulating emotions which these stressors generate. In other words, it is easier to neglect malodour and think it is not that bad, than to prevent the production of industrial malodour.

In THE HYPOTHETICAL CHAPTER the aim of the study is elaborated. Moreover, a model about exposure, annoyance, coping with malodour, and health effects is presented.

Firstly, the exposure to odorant concentrations is determined by means of a dispersion model. Exposure to long-term averaged odorant concentrations is calculated by means of a long-term dispersion model. Moreover, exposure to short-term averaged (momentary) odorant concentrations is calculated by means of the short-term version of the dispersion model.

The second topic concerns to what extent exposure has an effect upon specific malodour-related health complaints and general subjective health status. The third issue is whether or not the supposedly poor relationship between objective exposure to odorant concentrations and the resulting odour annoyance can be enhanced by inclusion of psychosocial factors like appraisal of exposure and coping with both exposure and odour annoyance. The effect upon odour annoyance is investigated of a number of demographic and additional variables of which it is assumed they are related to odour annoyance. The last issue concerns the influence of a number of personality characteristics upon the relation between odorant concentrations and odour annoyance.

A number of hypotheses is derived from this model. The *exposure* hypothesis: higher odorant concentrations will result in higher levels of odour annoyance. The *long-term versus short-term exposure* hypothesis: the prediction of odour annoyance from odorant concentrations will be improved by using actual short-term averaged odorant concentrations instead of long-term averaged concentrations. The *health complaints* hypothesis: odour annoyance is positively related to both general and malodour-specific health complaints. The *appraisal* hypothesis: individuals who judge that malodour affects their health status in an adverse manner, will be more annoyed than individuals who consider malodour as less of a threat to their health. The *coping* hypothesis: both scores on general and specific problem-focused coping scales will be positively related to odour annoyance. On the other hand, scores on general and specific emotion-focused coping scales will be negatively related to annoyance. The *economic dependency* hypothesis: individuals, who are employed by a malodour emitting industry, will be less annoyed by malodour than individuals, who are not employed by this industry. And finally, the *personality* hypothesis: locus of control and neuroticism will be positively related to odour annoyance.

The methodological aspects of the study are presented in THE METHODOLOGICAL CHAPTER. From this chapter onwards the study is divided into two parts. In PART 1 long-term averaged odorant concentrations, estimated by means of a dispersion model, are used as exposure measure. The dispersion model is described

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and briefly explained, and meteorological conditions which influence the dispersion of agents in the atmosphere, are discussed. In this part subjective data are collected by means of mail questionnaires. During three consecutive autumns the effects of emissions of sugar refineries upon odour annoyance and health complaints are investigated. Refining sugar is a campaign-bound activity: refineries are productive 24 hours a day from September till December. In addition to these temporary malodour sources, the effects of permanent emissions are studied: one study around a tobacco factory, and another study around a mushroom manure factory and a cattle fodder plant.

In PART 2 short-term averaged odorant concentrations, estimated with the short-term version of the dispersion model, are used as measure of momentary exposition. Subjective data are gathered by interviewers who made house calls to interview people about momentary odour annoyance and possible short-term and long-term health complaints. Since the exact time and place of the interview are known, the actual exposure level during this period can be determined by using emissions and meteorological conditions as input for the dispersion model. Two separate investigations were performed, in which momentary odorant concentra-tions emitted by the sugar refineries, are related to momentary odour annoyance. Hence, the most important difference between PART 1 and PART 2 is the time scale on which the exposure level and the subjective reactions have been measured. Additionally, in PART 2 the validity of the short-term dispersion model is tested.

The results are presented in THE EMPIRICAL CHAPTER. Data of PART 1 demonstrate that the five separate studies differ on the exposure measure. The exposure in the three studies around the sugar refineries is highly similar, whereas the exposure in the two studies around permanently emitting sources is much lower than in the sugar studies. Less clear differences are observed in odour annoyance and other effect variables between the sugar studies and the two other studies. The highest level of odour annoyance is found in the study around the mushroom manure and the cattle fodder factory. There are no differences between the studies with regard to general health complaints, appraisal of and coping with malodour.

Regardless of the absolute exposure differences, higher odorant concentrations result in higher levels of odour annoyance in each study, which indicates confirmation of the *exposure* hypothesis. Quite systematically, a correlation around .30 is found between concentration and annoyance.

The *health complaints* hypothesis also is confirmed. Odour annoyance is positively related to health complaints. No direct relation between exposure and health complaints is found. With regard to general health complaints, it is observed that when exposed to odorant concentrations some people are annoyed and, of these people, only some report general health complaints. Exposure in itself does not directly cause general health complaints. Annoyance is the intervening variable between exposure and general health complaints.

Furthermore, the *appraisal* hypothesis is confirmed. Overall a positive relation is demonstrated between odour annoyance and the extent to which it is believed that malodour is bad for one's health and well-being. This relation turns out to be stronger when exposure is higher. When all the relevant variables are involved in regression analyses, it appears that appraisal is a strong predictor of odour annoyance, and of both malodour-specific and general health complaints.

For the *coping* hypothesis a distinction between general and specific coping behaviour is made, since coping is at least partly dependent upon situational factors. Overall, there is no confirmation for the general part of the hypothesis. Only around the mushroom manure factory support is found for the malodour-specific part of this hypothesis.

Employees of the sugar refinery are less annoyed by malodour than non-employees, which means support for the *economic dependency* hypothesis. In the residential environment the exposure is lower for the employees, whereas exposure at the work place is much higher than for the non-employees.

When the complete research model is regressed, it appears that in most cases the demographic variables are not very relevant in explaining variance in the effect variables. Age is an exception: this variable is negatively related to both odour annoyance and malodour-specific health effects. The relations that were demonstrated in the previous sections, do not change after control for demographic influences. The general coping scales are not very relevant in explaining differences in odour annoyance or in specific health variables. General problem-focused coping goes together with fewer general health complaints, but this result is independent of annoyance and odorant concentration. Appraisal of malodour and odour annoyance are powerful predictors of the general health complaints. Some additional variables which are assumed to be related to odour annoyance, are only of minor importance. Furthermore, noise annoyance surprisingly is a strong predictor of odour annoyance. It seems that industrial malodour and noise often come together.

In the sugar studies a habituation effect is supposed, since odour annoyance is decreasing with increasing number of exposure years. However, this effect turns out to be completely determined by age. Around the permanent sources there is no reason to suppose habituation, as the correlations between duration of residence and annoyance are not significant.

Additionally, in the sugar studies there is a difference in odour annoyance between townspeople and villagers under conditions of equal exposure. This difference is explained by a number of covariates: villagers are older, had a higher duration of residence, a more positive attitude towards industry in general. Moreover, they are less annoyed by noise, and appraise malodour less negatively than the townspeople. Furthermore, the townspeople report outside the period of the sugar-beet campaign less annoyance than during the campaign. The difference is most evident in the high exposure area.

In PART 2 short-term averaged odorant concentrations serve as measure of exposure instead of long-term averaged. The main object is to improve the estimation of the exposure by the emissions of the sugar refineries by employing actual meteorological data. However, there is no confirmation for the *long-term versus short-term* exposure hypothesis. The first interview study shows a low correlation between momentary odour annoyance and momentary odorant concentration, due to the fixed research day in the week. Winds were not always blowing from the west: a necessity for malodour periods to occur in the research area. In the second study interviews were only taken on days with western winds, which results in a better distribution of odorant concentrations. The correlation between momentary annoyance and momentary concentrations is similar to the correlations between averaged annoyance and long-term averaged concentrations.

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The *health complaints* hypothesis is confirmed in both studies. Moreover, there is no systematic indication that the relation between odour annoyance and general health complaints is explained by neuroticism.

With regard to the *appraisal* hypothesis, both interview studies produce similar results. Individuals who consider malodour as more of a threat to their health and well-being, are at similar exposure more annoyed than those who do not conceive malodour as such.

In the second interview study the results do not contradict the malodour-specific part of the *coping* hypothesis. Individuals who cope with malodour by attempting to change (the impact of) the malodour source, are more annoyed than individuals who do not so. On the other hand, people who regulate their emotional state, when confronted with malodour, are less annoyed. Both effects are more obvious with higher exposure.

Furthermore, no overall support for the *personality* hypothesis is acquired. Locus of control appears to be unrelated to momentary odour annoyance and the other effect variables. Only in the second study, neuroticism positively is related to annoyance.

When the complete research model is regressed, it again emerges that the demographic variables are only of minor importance in explaining variance in the effect variables, except in general health complaints. Age is an exception, as in most cases it is observed that this variable is negatively related to both odour annoyance and malodour-specific health effects. Appraisal of malodour is a strong predictor of momentary odour annoyance and health complaints. Again it can be concluded that both general and malodour-specific coping strategies are of little substance in explaining odour annoyance or specific health variables. Independent of exposure general emotion-focused coping is observed to be positively associated with general health complaints. Appraisal of malodour and odour annoyance are strong predictors of these complaints. Odour annoyance is a powerful predictor of malodour-specific health effects. Again, the additional variables are of minor importance, except residential satisfaction: the less satisfied with dwelling and residential area, the more annoyed by malodour.

In the validation of the short-term dispersion model it appeares that, despite the considerable interindividual variation in the correlation between smelling the sugar refinery and the momentary odorant concentration, there is no big difference between the moderately positive annoyance-concentration correlation in the second interview study and the overall correlation in the smell panel. The short-term dispersion model is probably not sufficiently specific.

In THE CONCLUDING CHAPTER the results and conclusions are discussed with reference to the research model. Moreover, the findings are viewed against the background of other research on malodour and some suggestions with regard to malodour policy are made.