Human Response to Aircraft Noise

Maarten Kroesen

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Human Response to Aircraft Noise

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Preface

How can it be that one person is extremely annoyed by the sounds of aircrafts, while his neighbour, living next door and exposed to the exact same acoustic environment, claims not to be bothered at all? Explaining this observation was the purpose of my Ph.D. research, but more importantly, because I found it such a fascinating observation, it also acted as a personal motivator during my years of research. Over these years I tried to answer the question by applying a range of quantitative methods which the social scientist has at his disposal. While I do believe the results of these efforts have led to new insights in how people experience aircraft noise, I cannot claim to have found any definitive answer. Admittedly, in the beginning I did expect to find one (or more) definitive answers, which, with hindsight, was naïve to assume. Providing definitive answers, off course, is not the aim of any science, let alone the social sciences. Still, only in striving to find definitive answers (and no less than just that) do we make new discoveries and become amazed by the world around us. Here the paradoxical nature of science (and perhaps even life) is revealed: while a definitive purpose should be pursued, one can and *should not* hope to ever attain it. This insight comforted me when I experienced the limits of the social scientist's explanatory powers.

Eric Molin, thank you for your years of supervision. Even in the final stages of an article you would relentlessly draw attention to any remaining imperfections. I have greatly appreciated your accuracy to find these flaws! Bert van Wee, thank you also for your useful comments and suggestions. I especially enjoyed the many drawings and conceptualisations you would make during our conservations in order to make sense of it all. Or, as you would say before taking a blank sheet: 'hoe kunnen we hier chocola van maken?' Pieter Jan Stallen and Christian Bröer, I have put your theories to the test and I can inform you that they have passed! I can honestly say that both of you shaped me professionally and I thank you for that. Dirk Schreckenberg, thank you for supporting the 'general construct' conceptualisation. Sabine Janssen, Henk Miedema and Henk Vos, we may not have agreed on how annoyance should be conceptualized but your willingness to share data is still rare these days and very well appreciated! Ron, Menno, Jan Willem and Randy, thank you for the many interesting (and sometimes absurd) conversations I had with you. No need to go into those! Caspar, thank

you for convincing me to stay in academia. To all TLO colleagues, thank you for providing such a great working atmosphere. And finally, to you Renate, thank you for being with me despite the fact that I think too much.

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1. Introduction

1.1 Background

Currently it is estimated that 23.6 million people around the world are exposed to aircraft noise levels of 55 dB(A) L_{dn} or more, which, based on existing exposure-response curves, can be considered a threshold for the onset of significant annoyance in the population. While taking into account traffic growth, the changing composition of aircraft fleets and demographic developments Fleming et al. (2008) estimate that this number will increase to over 30 million in 2025. Even though the current financial crisis has led to a sharp decline in the demand for air travel, the largest aircraft manufacturers still adopt annual growth rates in passenger kilometres of around 5%, which amounts to a doubling of the total amount of air traffic every 15 years (Airbus, 2009; Boeing, 2010).

Aviation has grown tremendously since the 1970s. Yet, due to the introduction of new aircraft technologies noise exposure patterns surrounding airports in the world have greatly shrunk. In the future, however, less is expected from new technology, which is why the number of exposed people is expected to grow. As a result, aircraft noise is regarded as a prominent issue facing capacity expansion efforts. Indeed, noise considerations have played a significant role in recent decisions not to expand airports and in supporting costly relocations (Girvin, 2010). In Europe, it is expected that environmentally driven capacity constraints will effectively determine air transport's development (Graham and Guyer, 1999).

Exposure to aircraft noise can negatively impact health. These effects range from subjective and behavioural effects, like annoyance or sleep disturbance (Miedema, 2007), to physical effects, such as high blood pressure (Babisch, 2006). While the attributable burden of cardiovascular disease due to community noise exposure (including aircraft noise) has been estimated at 0.1% of the total national disease burden (in the Netherlands), a burden expressed in 'severe annoyance' adjusted life-years may amount to 2% of the total disease burden (De

Hollander, 2004).[1] Although little is still known about the mechanisms of causation between exposure, subjective reaction and objective (biological) outcomes, empirically evidence suggests that psychological variables like annoyance play a mediating role (Job, 1996). Annoyance is therefore an important outcome indicator of policy since it, in itself, can be regarded as a negative health factor defined broadly as the absence of social well-being and second, since it likely plays a mediating role in the relationship between noise and the 'hard' medical outcomes like hypertension (Job et al., 2001). In the Netherlands approximately 12% of the population is severely annoyed by aircraft noise (Franssen et al., 2004).

To reduce the negative effects of aircraft noise exposure, the Federal Aviation Administration has primarily focused on the source with successively stringent certification standards for new aircrafts. Later, policies also addressed other means to reduce exposure to aircraft noise. Illustrative is ICAO's[2] balanced approach, which (in addition to source reductions) focuses on land-use planning, noise abatement operational procedures and aircraft operating restrictions (ICAO, 2004).[3] In line with this approach a growing trend can be observed in the number of airport noise restrictions, such as operational curfews, noise abatement procedures and noise limits at airports worldwide (Girvin, 2010).

Even though noise policy is mainly concerned with reducing noise (exposure) levels, noise annoyance is only partially determined by acoustic factors. While there is a clear relationship between noise exposure and community reaction at the aggregate level (Figure 1A), there is much remaining variation at the level of neighbourhoods (Figure 1B) and individuals (Figure 1C). At best[4], aircraft noise exposure can only explain 25-40% of the observed variance in individual noise reactions (Job, 1988). A third of the total variance has been attributed to so-called non-acoustic factors (Guski, 1999). The most important non-acoustic determinants of noise reaction are social-psychological in nature compromising factors such as trust in the noise source authorities and the perceived control over the noise exposure. The effects of relevant non-acoustic factors have been established in community surveys as well as laboratory experiments, providing firm evidence for their influence on people's reaction to noise.

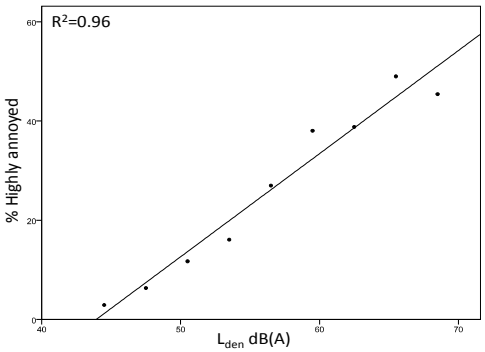

Figure 1A. Exposure response curve based on aggregate data (3 dB(A) intervals)

[1] This figure also depends on the attached severity weight.
[2] International Civil Aviation Organization.
[3] ICAO's guidelines are supported by both the European Commission and the Federal Aviation Authority.
[4] With the full range of exposure covered and very accurate noise and reaction measurements.

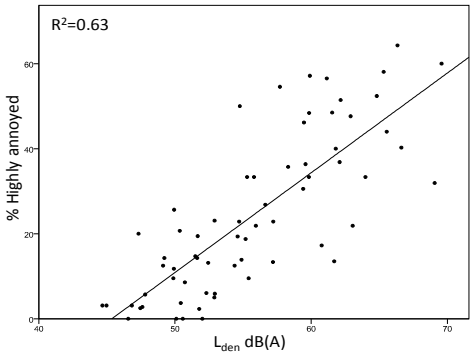

Figure 1B. Exposure-response curve based on aggregate data (neighbourhood level)

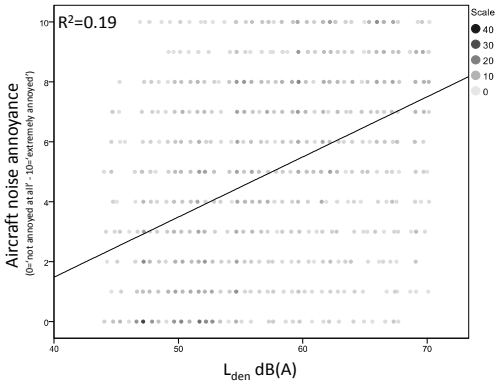

Figure 1C. Exposure-response curve based on disaggregate data (individual level)
Note: Based on data from the Frankfurt noise study (N = 2,312) (see Schreckenberg and Meis, 2006; Schreckenberg et al., 2010)

1.2 Research focus

Although the body of literature concerning non-acoustic factors has been steadily growing previous research is characterized by an important shortcoming; quantitative models which attempt to explain subjective noise reaction are not informed by theory. Over the past decades several researchers have commented on this limitation:

"In the absence of a well-defined theory of noise annoyance, researchers have depended on statistical analyses to generate as well as test hypotheses. With few exceptions, studies have not been designed on the basis of explicit hypotheses." (Taylor, 1984: p. 243)

Several years later Fidell (cited in Stallen, 1999) observes that:

"The view that the fundamental problems in predicting the effects of noise on individuals and communities are problems of theory, not of measurement, has slowly gained recognition." (Fidell, 1990: p. 19)

A decade later Stallen (1999) comments on this observation:

"However, recognition does not yet seem to have gained much speed. For, example, in the perhaps largest environmental annoyance survey ever (TNO and RIVM, 1998), the data about potential determinants of annoyance were analysed only by step-wise regression with order of inclusion determined by ad-hoc interrelationships between potential determinants and annoyance (Stallen, 1999: p. 72)"

It can be concluded that research related to non-acoustic factors does not follow the deductive model in which theoretical expectations are formulated and subsequently verified with empirical data. So far only experiments on the effect of noise on humans followed this model. The analysis of field data, however, is generally not informed by a theoretical model.

While research related to non-acoustic factors cannot be characterized as deductive, neither can it be viewed as truly inductive. As noted by Bröer (2006), both the acoustic model (see Figure 1) and models that include non-acoustic factors (see e.g. Taylor, 1984) suppose that people passively react to noise. Assuming a static stimulus-response model, which supposedly holds for all people, the influence of non-acoustic factors is modeled in a similar fashion as the influence of acoustic factors. This model fails to appreciate an important quality of human beings in being able to actively attribute meanings to the world around them. Instead, meanings are fixed in advance by the researcher. The question whether the categories used by the researcher or the relationships he draws indeed overlap with those used and drawn by subjects in the field to give meaning to reality thereby remains unanswered.

To summarize, so far neither a deductive nor an inductive theory has been formalized in a quantitative model of subjective reaction to aircraft noise.

The lack of theory in explanatory models of noise reaction has five negative consequences. In the first place, causal claims stand on weak grounds. The description of the underlying theoretical mechanism is usually regarded as a criterion for establishing a causal effect. Second, without theory we can never really understand noise annoyance. What is actually expressed by a person who indicates that he/she is highly annoyed? Third, without theory non-acoustic factors and aircraft noise annoyance cannot be integrated within in an encompassing conceptual model. In effect, the underlying (causal) structure of aircraft noise annoyance will remain obscured. Fourthly, without theory progress in empirical research related to non-acoustic factors will be slow. Without reflection on the question why certain non-acoustic factors influence annoyance response, it will likely reveal the significance of a similar set of factors over and over again. Finally, if annoyance is not properly understood, neither can it be properly dealt with. Theory is therefore also important from a practical and policy-related perspective.

While explanatory models of noise reaction generally lack a theoretical basis, two theories of (aircraft) noise annoyance have been previously developed. The main aim of the present thesis is to operationalize and test these theories *quantitatively*. The first is the psychological stress theory, which has been translated to the concept of annoyance by Stallen (1999). This theory will be tested following the conventional hypothetico-deductive approach. In contrast to previous models of noise reaction, model specification will be informed by theoretical considerations. The second theory is the discourse resonance theory, which has been developed and qualitatively verified by Bröer (2006). In contrast to the psychological stress theory, which aims to provide an universal explanation for aircraft noise, the discourse resonance theory is contextual; it is responsive to the meanings which people in their everyday lives attribute to aircraft noise. Unlike previous explorative models, the discourse resonance theory can therefore be characterized as truly inductive.

The overall outline of the thesis is as follows. After the psychological stress theory is tested in the first study two explorative studies follow. These explorative studies attempt to address a short-coming of the model in the first study. The (surprising) findings of these explorative studies can be accounted for by the discourse resonance theory. This theory is quantitatively tested in study four and five. The sixth study tests several additional hypotheses that follow from the discourse resonance theory. The seventh study is again explorative in nature and indirectly tests an idea derived from the discourse resonance theory. The eighth study focuses on policy actors' response to present insights in non-acoustic factors. In the next section the studies and their related research questions are described in further detail.

1.3 Research questions

1.3.1 Study 1: Testing a theory of aircraft noise annoyance

In line with previous work of Stallen (1999), the first study conceptualizes noise annoyance as a form of psychological stress. Noise annoyance, according to this model, arises when a stressor (like aircraft noise) is perceived as such and when the abilities to cope are perceived to be insufficient. These pathways are termed primary and secondary appraisal respectively. While the first pathway is commonly assumed to exist, also in a-theoretical models (see e.g. Guski, 1999), the addition of the second pathway is theoretically innovative. It means that one may be behaviourally disturbed by sounds, but not annoyed if the coping resources are perceived to be sufficient. Related to aircraft noise, the noise management by the source (e.g. the airport operator) or beliefs about the social and economic impacts of aviation, may significantly increase or decrease coping potential, and therefore indirectly, annoyance response.

Unlike previous correlational studies or explorative models, the model of Stallen (1999) provides the theoretical mechanisms which support the relationships between non-acoustic factors and noise reaction. The study aims to answer the following research question:

Does the conceptualization of annoyance as a form of psychological stress fit with the empirical relationships between acoustic factors, non-acoustic factors and aircraft noise annoyance?

To this purpose a structural equation model is specified and estimated based on data gathered from a survey in April 2006 among residents living near Schiphol.

1.3.2 Study 2: Determining the direction of causality

The first study reveals that the operationalisation of the psychological stress theory can be empirically supported. However, because the study is based on cross-sectional data, the criterion of time-precedence cannot be empirically assessed. The second paper tries to address this limitation via the use of panel data.[5] The second study does not test an explicit theory. Instead, it aims to answer the following explorative research questions:

Which non-acoustic factors can explain changes in aircraft noise annoyance over time?

Can aircraft noise annoyance explain changes in non-acoustic factors over time?

Data were gathered in April 2008 from the same respondents as in study one, using the same questionnaire. These data were used to estimate a structural equation model, specifically a cross-lagged panel model, which could answer the question of causal precedence.

[5] Panel data contain measures of the same variables from the same respondents observed repeatedly through time.

1.3.3 Study 3: Annoyance as a reflection of a general attitude

The findings of the second study show that due to multicollinearity establishing causal effects remains difficult (even with the use of panel data). Temporarily suspending the issue of causality, a relevant question seems to be why the correlations among non-acoustic factors and between non-acoustic factors and aircraft noise annoyance are so strong. The psychological stress theory cannot account for these strong interrelations. But which theory and related model do support such a structure?

Without an explicit theory the model that is suggested by the data is a common factor model. Within this conceptualization both non-acoustic factors and noise annoyance would reflect a more general attitude towards aircraft noise. In this model non-acoustic factors have no direct influence on aircraft noise annoyance, since both represent reflections of an underlying latent factor.

The third study tests the idea that aircraft noise annoyance and non-acoustic factors form reflections of a common underlying factor. Specifically, it attempts to answer the following research questions:

Can a common factor account for the empirical associations between aircraft noise annoyance and non-acoustic factors?

To what extend is aircraft noise annoyance a reflection of this common factor?

To answer these research questions a confirmatory second-order factor model is specified. The model is estimated with data from a survey conducted in 2005 near Frankfurt airport. The analysis is performed in cooperation with Dirk Schreckenberg, the principal investigator of the Frankfurt study.

1.3.4 Study 4: Policy, frames and annoyance

The common factor structure fits the data. The third study does not, however, elaborate on the theoretical argument that can support this structure. The discourse resonance theory developed by Bröer (2006), on the other hand, can account for the common factor structure in the data.

The main argument of this theory is that policy arguments resonate among the public and thereby shape people's evaluative frames of aircraft noise.[6] Bröer (2006) hypothesized that people (actively) interact with policy arguments and that the resultants of these interactions determine how people perceive and appraise aircraft noise. The meanings that subjects attribute to aircraft noise lie at the core of this theory. Bröer (2006) expected that the scope of these meanings would be discursively constrained by the dominant conceptualization of the noise problem. In other words, policy arguments set (social) limits on what can and cannot be said and felt with respect to aircraft noise.

Since the concept of a frame as a coherent constellation of attitudes can explain why substantively independent arguments, beliefs and feelings are empirically interrelated, the discourse resonance theory can account for the common factor structure suggested by the second study and tested in the third. In an indirect way, the results of the second and third study can therefore be taken as evidence in favour of Bröer's inductive theory of aircraft noise.

Using qualitative research methods Bröer (2006) empirically verified the discourse resonance theory. He found three policy-related frames of aircraft noise and several autonomous

[6] A frame is defined as a coherent set of beliefs, attitudes and feelings, like aircraft noise annoyance.

definitions. The aim of the fourth study is to quantitatively objectify the frames. Specifically, its goal is to answer the following research questions:

Which frames of aircraft noise can be quantitatively revealed?

Are the frames related to (noise) policy?

What is the relationship between the frames and aircraft noise annoyance?

In cooperation with Chirstian Bröer Q-methodology is used to answer these research questions. This method allows subjects to construct their own definitions of the topic under study. At the same time, these constructions are quantified and therefore subject to rigorous examination. The study includes a small and strategically-selected sample. Respondents were recruited in 2008 from a single neighbourhood near Amsterdam Schiphol (Amsterdam Osdorp).

1.3.5 Study 5: Policy, structural variables and annoyance

The fourth study reveals a similar set of frames as those found by Bröer (2006). However, given the small and strategically-selected sample, the frames cannot be generalized to the population of residents residing in the Schiphol region. In addition, the small sample size does not allow an assessment of the influence of structural variables (e.g. aircraft noise exposure) on frame membership. The fifth study addresses these concerns and answers the following research questions:

What is the distribution of frames within the population of residents living near Schiphol?

What is the effect of structural variables on the distribution of frame membership?

Latent class analysis is used to this purpose. This method can be used to reveal the (latent) classes that underlie an observed pattern of correlations between a set of indicators (McCutcheon, 1987). Similar to Q-methodology latent class analysis can identify general ways of thinking towards an issue. Unlike Q-methodology, however, the sample size is unlimited. It is therefore a suitable method to reveal the distribution of frames within a population and to investigate the effects of structural variables on frame membership. To estimate the latent class model the same dataset is used as in study 2 (see Section 1.3.2).

1.3.6 Study 6: The effects of survey context

Results of study 4 and 5 show that policy arguments indeed resonate broadly among the population and set limits on what can and cannot be (arguably) said and felt about aircraft noise. The sixth study aims to investigate what happens if the evaluation of aircraft noise is taken out of its everyday (policy-related) context. Specifically, it examines the effects of a typical context used in (aircraft) noise surveys, namely one in which aircraft noise is measured alongside other noise sources in the residential environment (e.g. traffic noise, neighbour noise and railway noise). It is expected that within this (unnatural) context the discursive effects of policy arguments would (partially) be lifted. The sixth addresses the following research questions:

What is the influence of survey context on the response distribution of aircraft noise annoyance?

What is the influence of survey context on the meaning of aircraft noise annoyance?

To answer these research questions a survey was conducted among residents living in Amsterdam Buitenveldert. Bivariate statistical techniques are used to test the formulated hypotheses and answer the research questions.

1.3.7 Study 7: Aircraft noise and residential satisfaction

In contrast to the previous studies the seventh paper takes a relatively independent position. Its aim is to assess the relative effects of aircraft noise exposure and aircraft noise annoyance on residential satisfaction. Indirectly, it is also tests an idea derived from the discourse resonance theory. Based on this theory it could be expected that, given the political nature of aircraft noise annoyance, it will not be strongly related to the concept of residential satisfaction. The study aims to answer two research questions:

What is the relative effect of aircraft noise exposure on residential satisfaction?

What is the relative effect of aircraft noise annoyance on residential satisfaction?

To this purpose a structural equation model is estimated which includes both objective background variables and subjective evaluations of other noise sources (i.e. road traffic noise, railway noise, neighbour noise, etc.). Inclusion of these other noise sources allows an assessment of the relative effects of aircraft noise exposure and aircraft noise annoyance on residential satisfaction. Data from a survey conducted by TNO and RIVM in 1996/7 (TNO and RIVM, 1998) are used to estimate the model. The research was conducted in cooperation with three TNO researchers, namely Sabine Janssen, Henk Miedema and Henk Vos.

1.3.8 Study 8: Policy actors' response to 'non-acoustic factors'

Aircraft noise policy in the Netherlands has a clear acoustic orientation. Over the past decades numerous policy proposals have been written that aimed to accomplish a 'paradigm shift' towards an alternative orientation, one that is informed by the social-psychological nature of annoyance (Smit and Van Gunsteren, 1997; Stallen et al., 2004; Stallen and Van Gunsteren, 2002; Stallen and Smit, 1999). Pieter Jan Stallen, a professor in community annoyance, put much effort in developing and communicating these proposals to the policy field around Schiphol.

However, the resonance of these proposals seems to have been limited; the ideas and concepts discussed in them have not been institutionalized in specific policies. It seems that the ideas have been assimilated by policy actors but that no true accommodation has taken place. In other words, the ideas are internalized as extensions of existing perspectives and not as one or more fully grown autonomous perspectives.

The aim of eighth study is to assess the validity of this expectation. Specifically, it aims to answer the following research question:

How do policy actors involved in the Schiphol-debate integrate the insights in non-acoustic factors in their perspectives on future noise policy?

Via an explorative study, again using the Q-method, the ways are revealed in which the ideas, concepts and policy proposals of Stallen (2004) have resonated among policy actors. The sample consisted of 45 actors involved in Schiphol-noise policy. The research was conducted in cooperation with Menno Huys and Pieter Jan Stallen.

Figure 2 visualizes the complete outline of the thesis. Given that the thesis concerns a collection of research articles, which were written as autonomous contributions, it should be noted that the structure presented here is more explicit than in the actual chapters. In addition, given the progressive nature of the research several contradictions may exist between the individual studies.

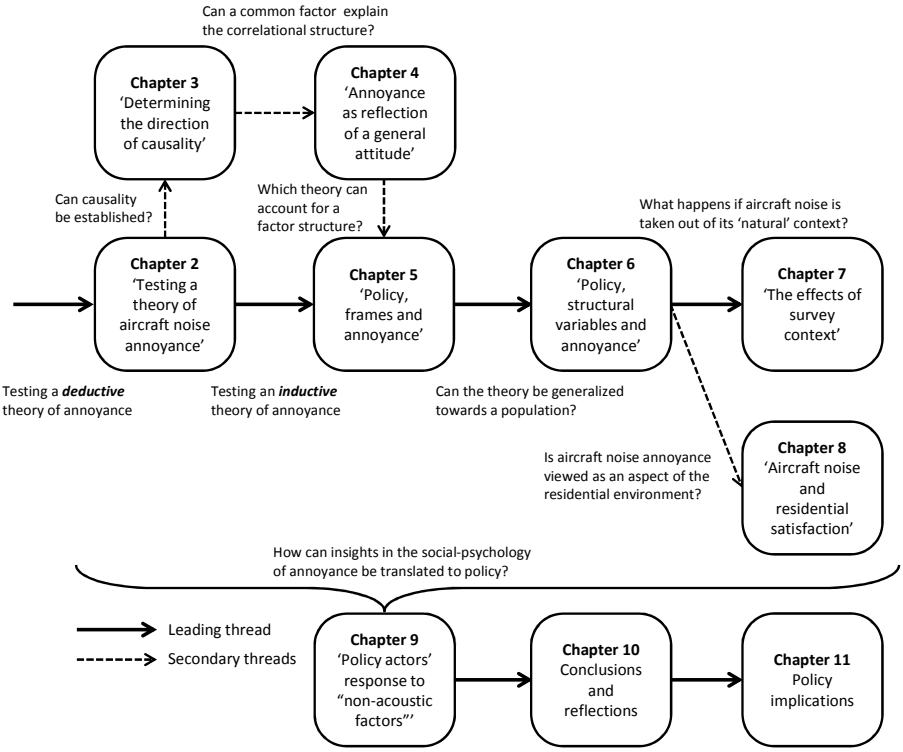

Figure 2. Thesis' structure

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2. Testing a Theory of Aircraft Noise Annoyance

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Abstract

Previous research has stressed the relevance of non-acoustical factors in the perception of aircraft noise. However, it is largely empirically driven and lacks a sound theoretical basis. In this paper, a theoretical model which explains noise annoyance based on the psychological stress theory is empirically tested. The model is estimated by applying structural equation modeling based on data from residents living in the vicinity of Amsterdam Airport Schiphol in The Netherlands. The model provides a good model fit and indicates that concern about the negative health effects of noise and pollution, perceived disturbance, and perceived control and coping capacity are the most important variables that explain noise annoyance. Furthermore, the model provides evidence for the existence of two reciprocal relationships between (1) perceived disturbance and noise annoyance and (2) perceived control and coping capacity and noise annoyance. Lastly, the model yielded two unexpected results. Firstly, the variables noise sensitivity and fear related to the noise source were unable to explain additional variance in the endogenous variables of the model and were therefore excluded from the model. And secondly, the size of the total effect of noise exposure on noise annoyance was relatively small. The paper concludes with some recommended directions for further research.

2.1 Introduction

The global aviation sector has rapidly developed since the beginning of the 1960s. Air travel has grown due to numerous factors such as economic and demographic growth, decreasing market prices, globalization, increasing quality, the introduction of the hub-and-spoke concept, and liberalizing measures. With this growth, the negative externalities of the aviation market have also become more evident: noise, local and global air pollution, and decreasing external safety.

The noise policies adopted by national governments in relation to major airports mainly focus on reducing the level of noise exposure and the number of people who are exposed. However, there is no one-on-one relationship between noise exposure and noise annoyance. Based on 39 empirical studies, Job (1988) concluded that the correlation coefficient for group data (aggregate models) is 0.82 (standard deviation of 0.14) and for individual data 0.42 (standard deviation of 0.12). This means that in the latter case, only 18% of the variance in noise annoyance is explained by noise exposure.[7] One explanation for this weak relationship is that factors other than the level of noise exposure, the so-called non-acoustical factors, influence noise annoyance. Guski (1999) concluded that approximately one-third of the variation in noise annoyance can be explained by acoustical factors (e.g., the sound level, peak levels, sound spectrum, and number of noise events) and a second third by non-acoustical factors. The last third can either be attributed to measurement errors (which decreases the proportion of explained variance in the dependent variables), the presence of yet unknown factors which influence noise annoyance, or stochastic variation related to idiosyncrasies of individuals.

Past studies that investigated relevant non-acoustical factors, however, have two major shortcomings. Firstly, the research can be characterized as highly inductive, which generally means that it lacks a sound theoretical basis (Taylor, 1984). As Taylor noted (1984) (p. 245), "many of the models which are tested by using path analysis are exploratory. As such, they probably do not adequately represent the processes leading to the outcome in question (e.g., noise annoyance). In such cases, causal claims stand on weak ground indeed and sensibly are best avoided." In addition, although not mentioned by Taylor, the lack of elementary understanding related to the topic of noise annoyance can result in misspecification of the statistical model and hence even lead to false inferences related to the effect sizes of relevant variables.

Secondly, the practical relevance and significance of non-acoustical factors in relation to noise annoyance are often based on correlational analysis or multiple regression analysis. Both these methods have severe deficiencies in modeling noise annoyance. As Alexandre (1976) has shown, the results of correlational analysis can be misinterpreted since the effect of the factor under investigation is not controlled for noise exposure or other factors. In addition, the direction of causation remains uncertain. Of the three commonly accepted conditions needed to qualify something as a causal relationship, i.e., time precedence, nonspuriousness, and simple association, only the last one is satisfied. The result is that the relative importance of different factors may be under-or overestimated. With multiple regression analysis, the effects of different non-acoustical factors can be controlled for noise exposure and other factors. However, this method is not suited to model indirect and reciprocal effects. Without being able to include these relationships, the model may contain

[7] Different metrics exist to indicate the level of noise exposure (e.g., energy- based indices and number of events). A study of Vincent et al. (2000) revealed that correlations between these different noise exposure metrics and noise annoyance are both low (r~0.30) and very similar. Hence, it can be concluded that noise level descriptors, in general, are unable to explain individual levels of noise annoyance.

serious misspecifications and hence lead to false inferences about the parameter estimates associated with different causes of annoyance.

This paper aims to overcome these shortcomings by developing and estimating a causal model of aircraft noise annoyance based on theory which includes non-acoustical and acoustical variables. The model is based on a conceptualization of noise annoyance by Stallen (1999) which is rooted in the psychological stress theory of Lazarus (1966). To the authors' knowledge, this is, as of yet, the only theory that gives an explanation for noise annoyance. Since the conceptual model, besides direct relationships, includes indirect and reciprocal relationships between variables, structural equation modeling (SEM) is applied to estimate the model. This method is especially suitable to model these complex causal relationships (Bollen, 1989). An additional advantage of SEM is that it can take measurement errors into account, which results in less bias in the estimated coefficients and potentially larger portions of explained variance. Data to estimate the model are gathered through a survey among residents living inside the 45 L_{den}[8] contour around Amsterdam Airport Schiphol (AAS), the largest airport in The Netherlands.

The structure of this paper is as follows. Section 2.2 discusses the causal model to explain aircraft noise annoyance which is based on the psychological stress theory. The third section presents the research approach and data gathering procedure. Section 2.4 discusses the model results. The last section presents the main conclusions and concludes with some reflective remarks and related recommended directions for further research.

2.2 Toward a causal model of noise annoyance

This section first discusses the definition of noise annoyance, after which the model of Stallen (1999) is presented, which forms the core of the noise annoyance model to be tested in this paper. Following this, relevant acoustical and non-acoustical factors are identified and the constructed causal model is elaborated.

Based on a survey among experts, Guski et al. (1999) concluded that noise annoyance is a multifaceted concept, which covers immediate behavioural noise aspects, such as disturbance and interference with activities, and long-term evaluative aspects such as nuisance, unpleasantness, and getting on one's nerves. Although the two components of noise annoyance, i.e., disturbance and nuisance, can be theoretically distinguished, Guski (1999) noted that it is unknown how the integration of short-term experiences and long-term evaluation related to the acoustic environment takes place. It is unknown whether, for example, the most severe disturbances are remembered or whether a respondent averages all the disturbances he or she can remember. Guski et al. (1999, p. 525) also emphasised that noise annoyance is not just reflecting acoustic characteristics: "noise annoyance describes a situation between an acoustic situation and a person who is forced by noise to do things he or she does not want to do, who cognitively and emotionally evaluates this situation and feels partly helpless." This statement is in line with Stallen's (1999) definition of noise annoyance

[8] DENL (day-evening-night level) is an equivalent sound level of 24 h expressed in decibels on the "A" weighted scale dB(A), which, in this study, is calculated for the period of a year. Sound levels during the evening (7 pm–11 pm) and during the night (11 pm–7 am) are increased by penalties of 5 and 10 dB(A), respectively. This metric is selected by the European Council to monitor and assess noise problems in its member states. It needs to be noted, however, that this metric has been criticized for its use to assess environmental noise because A-weighting approximates the response characteristics of the human ear only for narrow band sounds at low levels. It has been shown to underestimate the effects of low frequency noise on pleasantness and annoyance ratings (e.g., Schomer et al., 2001). In addition, broad band sounds such as aircraft noises are underestimated by A-weighting with respect to their loudness and annoyance by typically 15 dB.

as a form of psychological stress, which constitutes the fundamental idea behind his conceptual model of noise annoyance and is discussed below.

Different models have been developed that aim to provide insight into the processes that result in noise annoyance (Taylor, 1984; Job, 1996; Guski, 1999). However, all these models are developed based on empirical evidence related to previously found correlations between noise annoyance and other variables. Since these associations between noise annoyance and non-acoustical factors have been found in an exploratory manner, these models are based on implicit theory rather than on a predefined theory of noise annoyance. In his application of the psychological stress theory of Lazarus (1966) on the phenomenon noise annoyance, Stallen (1999) developed an explicit theoretical framework for describing the process of noise annoyance. Empirical research by Lazarus (1966) and others has revealed two major determinants of stress: perceived threat and perceived control. Stallen (1999) argued that the perceived disturbance (i.e., short-term or immediate annoyance) and the perceived threat basically form equal concepts. Subsequently, noise annoyance as a form of psychological stress is determined by the extent to which a person perceives a threat (i.e., perceived disturbance) and the possibilities or resources that a person has with which to face this threat (i.e., perceived control) (Stallen, 1999). Stallen's conceptual model is presented in Figure 1. The presented model is a simplified and slightly adapted version of the original model (i.e., perceived control and coping capacity are treated as one factor).

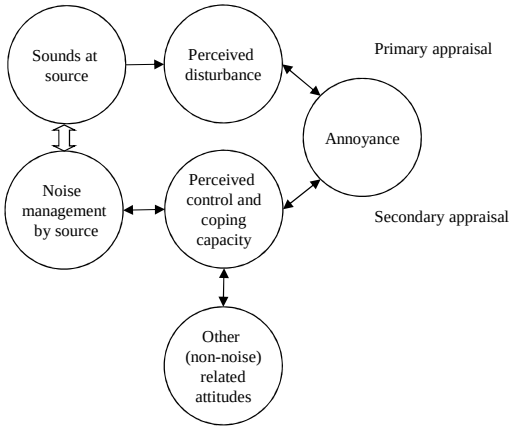

Figure 1. The conceptual model of Stallen (1999) used to explain noise annoyance
Noise annoyance is defined as a form of psychological stress, which is determined by the perceived impact of a stressor and the perceived resources to cope with this stressor.

The level of perceived disturbance, also called the primary appraisal, is a person's evaluation of the impact of the threat or harm in relation to his or her well-being. The acoustic situation to which one is exposed is considered the main determinant of this evaluation. After a threat or harm is recognized, a process of secondary appraisal is triggered. Within this process, the resources to face the threat are evaluated. One potential resource results from the relationship one has with the noise source. If this relationship is good, one is better able to handle the impact of the stressor. However, in the words of Maris et al. (2007, p. 2001): "If the exposed has little control over the source, or little trust in the source, the perceived coping resources will be reduced and psychological stress will arise." Next to the noise management by the source, other non-noise related attitudes can be considered as potential coping resources. In this respect, Stallen (1999) mentioned non-acoustical factors such as beliefs about the

importance of the noise source and annoyance with non-noise impacts of the noise source, which were identified by Fields' extensive review as supported by sufficient evidence (Fields, 1993).

Based on his model, Stallen (1999) argued that if the perceived threat (i.e., noise) is larger than the perceived resources to face the threat (i.e., perceived control and coping capacity), psychological stress (i.e., noise annoyance) will arise. In addition, even though the perceived disturbance may be very high, no noise annoyance will arise if there are sufficient coping resources. Lastly, since the process of coping is in a constant flux, the theoretical framework includes multiple reciprocal relationships between variables.

To further extend the conceptual model of aircraft noise annoyance, relevant acoustical and non-acoustical factors that play a significant role in the noise-reaction relationship are supplemented. These variables are identified based on the results of past studies. In Table 1, the variables found by Lercher (1996) and Guski (1999), based on reviews of studies that investigated the effects of personal, social, and contextual variables on annoyance, are enumerated. The current overview is complemented with studies by Miedema and Vos (1999) and Fields (1993) who assessed the influence of (non)acoustical factors on annoyance via meta-analyses.

To limit the number of variables in order to avoid problems in the data collection phase only the variables of which the evidence is sufficiently present as indicated by the cited authors are included in the extended model of noise annoyance. An additional criterion for inclusion is that a theoretical notion must exist that explains how each variable influences one or more dependent variables (i.e., the "mechanism of causation") in the conceptual model of Stallen (Figure 1). Such theoretical notions could not be given for neighbourhood satisfaction (for which it is more likely to be a dependent variable itself), education, occupational/social status, and household size. In addition, since these latter three variables have only a small effect size on noise annoyance, causing an estimated extra annoyance equivalent to 2 dB day-night level or less (Miedema and Vos, 1999), their exclusion will not substantially affect the model. In addition, the variable "change in noise environment" is omitted. The reason for this is that the structural equation modeling approach assumes that an estimated model and hence the "process of noise annoyance" are in a stable state. The fact that the dose-response function, which predicts the percentage of highly annoyed people for varying levels of noise exposure, has not significantly changed for nearly a decade for residents living around AAS (RIVM and RIGO, 2006), suggests that this assumption holds in our study.[9] The exclusion of noise insulation will be explained in the next section.

The relevant acoustical and non-acoustical variables (Table 1) and the conceptual model of Stallen (1999) (Figure 1) are combined in an extended model of noise annoyance, which is constructed as follows. In line with Stallen's framework, noise annoyance is assumed to have two determinants, the perceived level of disturbance and the perceived level of control and coping capacity, which have a positive and a negative effect on noise annoyance, respectively.

The level of perceived disturbance is assumed to be positively influenced by the level of noise exposure and noise sensitivity. In turn, since noise sensitivity has been shown to be significantly associated with age and length of residence in noisy areas (for a brief review, see Van Kamp et al., 2004), this variable is assumed to be influenced by these variables. Although on the balance of existing evidence, it is concluded that this length of residence in noisy areas has no significant relationship with annoyance (Table 1; Fields, 1993), it is

[9] However, this also means that in situations where drastic changes in exogenous factors take place, our model cannot be used.

plausible that length of stay indirectly influences annoyance through the noise sensitivity of a person.

Table 1. Overview of acoustical and non-acoustical variables

Non-acoustical variables	Sufficient evidence	Reference[c]	Included in the extended model
Critical tendencies[a]		1	
Negative affectivity		1	
Neuroticism/extraversion		1	
Locus of control		1	
Type A/B[b]		1	
Non-complaining attitude		1	
Noise sensitivity	●	1, 2, 3, 4	●
Misfeasance in relation to source authorities	●	1, 2	●
Preventability beliefs	●	1, 4	●
Fear of noise source	●	1, 2, 3, 4	●
Concern about negative health effects of noise	●	1, 2	●
Social evaluation of the source / attitude towards the source	●	1, 2, 4	●
Interference with activities (i.e. activity disturbances)	●	1, 2	●
Controllability/predictability/adaptability in relation to noise situation	●	1	●
Annoyance in relation to non-noise effects (odour, vibrations)	●	1, 4	●
Neighbourhood satisfaction	●	1	
Home ownership / concern about property devaluation	●	1, 3, 4	●
Aesthetic appearance of site		1	
Negative expectations related to future development of noise	●	2	●
Coping capacity	●	1, 2	●
Gender		3, 4	
Age	●	3	●
Education	●	3	
Income		4	
Occupational / social status	●	3	
Household size	●	3	
Personal evaluation of the source / dependency on the noise source	●	2, 3, 4	●
Length of residence / length of residence in noisy areas		4	●
Acoustical variables			
Noise exposure (e.g. L_{den})	●	5	●
History of noise exposure levels / exposure time		1, 2, 4	
Change in noise environment / time since change	●	1, 4	
Home type and design / rooms facing noise source		1, 4	
Noise insulation	●	4	
Background noise level		4	

[a] The general tendency of individuals to express critical or negative judgments

[b] Type A personality is a set of characteristics that includes being impatient, excessively time-conscious, insecure about one's status, highly competitive, hostile and aggressive, and incapable of relaxation (Friedman and Rosenman, 1974).

[c] References: 1=Lercher (1996) and references presented in this paper, 2=Guski (1999) and references presented in this paper, 3=Miedema en Vos (1999), 4=Fields (1993), 5=Job (1988)

The perceived level of control and coping capacity are assumed to be directly influenced by the negative attitude toward noise source authorities and the noise policy (i.e., the noise management by the source) and by other non-acoustical variables (i.e., non-noise related attitudes). Dependent on whether the respective variables “add” or “extract” coping potential,

the sign of the hypothesised relationship is either positive or negative. In addition, the effects of non-acoustical variables on the perceived level of control and coping capacity are assumed to be mediated by the negative attitude toward noise source authorities and the noise policy. For all included non-acoustical variables, the assumption that these variables can deteriorate or improve the relationship between residents around the airport and the noise source authorities (i.e., the government and airport operators) is plausible. Therefore, the hypothesis that these factors influence the attitude toward the source authorities and the policies they adopt to control the noise will also be tested. Hence, it is hypothesized that the non-acoustical variables directly influence the perceived level of control and coping capacity as well as indirectly via the negative attitude toward noise source authorities and the noise management. For example, a strong belief that noise can be prevented can directly lead to a perceived loss of coping potential (i.e., a lack of control over the situation) as well as increase distrust in the authorities and the adopted noise policy through which the coping potential also decreases.

Since, in the words of Stallen (1999), (p. 77), coping is a process with information flowing back and forth (i.e., the process of coping can be seen as a constant reappraisal of the person-environment relationship), Stallen's framework included several reciprocal relationships. In relation to the extended model described here, it is assumed that the perceived level of disturbance not only influences noise annoyance but also noise annoyance in turn, influences the degree of perceived disturbance. The hypothesis is that an annoyed person is more prone to be frequently disturbed by the acoustic environment. A second reciprocal relationship is assumed to be present between noise annoyance and the perceived level of control and coping capacity. It is hypothesized that more stress (annoyance) increases the incentive for people to find direct or indirect ways to cope with the stressor. In other words, it is assumed that being in a state of "high annoyance" leads people to adopt cognitive or direct coping strategies to reduce their level of stress. Glass and Singer (1972) used the term adaptation to characterize this process. They argue that since humans can rely on cognitive processes to achieve adaptation, they have a large variety of adaptive mechanisms at their disposal to protect themselves (Glass and Singer, 1972).[10]

It needs to be noted that the reciprocity assumed between noise annoyance and perceived disturbance is purely cognitive, while the path from perceived control and coping capacity toward noise annoyance is both cognitive (i.e., including latent mental processes such as emotional regulation) and behavioural (i.e., including direct coping strategies such as closing a window). Hence, to correctly model this process would require inclusion of such behavioural strategies in a feedback loop from noise annoyance to perceived control and coping capacity, in addition to the direct feedback loop which represents mental coping. However, by considering the range of different behavioural coping strategies, the fact that such strategies can have both positive and negative outcomes, and the fact that such behavioural responses have other antecedents next to noise annoyance (which would also needed to be taken into account), inclusion of this behaviour in the present model would be too complex to achieve. Therefore, this additional indirect feedback loop is not explicitly modeled but assumed to be sufficiently captured by the direct feedback loop. Hence, it is assumed that these behavioural coping strategies have a net positive effect. The extended causal model is depicted in Figure 2.

[10] Glass and Singer (1972) (p. 10) also note that "continued exposure to a stressor may produce cumulative effects that appear only after stimulation is terminated; it is as though the organism does not experience maximal stress until he is no longer required to cope with the stressor." Since this effect only incurs after the stressful situation has passed, it is not included in our causal model.

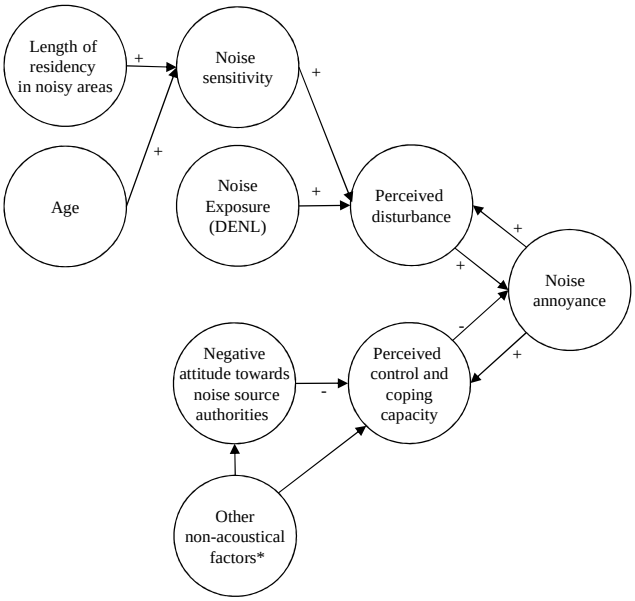

Figure 2. The developed causal model of aircraft noise annoyance

*Included non-acoustical factors are the following: (1) Belief noise can be prevented (-), (2) Positive social evaluation of the noise source (+), (3) Negative expectations related to noise development (-), (4) Personal dependency on noise source (+), (5) Concern about negative health effects of noise and pollution (-), (6) Annoyance by non-noise effects (i.e., vibrations, dust, and odour) (-), (7) Fear related to noise source (-) and (8) Concern about property devaluation (-). The sign in the parentheses relates to the hypothesized relationship of the respective variable with perceived control and coping capacity (the sign of the assumed relationship with the negative attitude toward noise source authorities and the noise policy is the opposite of this sign).

2.3 Research approach

2.3.1 Sample

The extended model depicted in Figure 2 is parametrized in the form of structural equation model. Data to estimate this model were gathered via a survey among residents living inside 45 L_{den} contour around Amsterdam Airport Schiphol (AAS) in The Netherlands. Approximately 1.5 million people live within this area. The lower limit of 45 L_{den} is chosen to physically constrain the size of the geographic survey area. Approximately 85% of all people around AAS who are being highly annoyed by aircraft noise live within this contour (RIVM and RIGO, 2006). Highly annoyed in this respect is defined according to the convention definition of a score of 72 or higher on a scale from 0 (no annoyance at all) to 100 (very high annoyance) (e.g., Miedema and Vos, 1998). The level of noise exposure in the dataset[11] ranges from 45 L_{den} through 58 L_{den} (only 0.8% of the people around AAS exposed to 45 L_{den} or more are exposed to higher levels than 58 L_{den}). Since only residents who are exposed to 60

[11] For every respondent in the sample, the level of noise exposure (a year mean DENL) was calculated by the National Aerospace Laboratory (NLR). This was done by transforming the four-digit two-letter postal code of each respondent's residence, which includes on average an area of 50 m^2 (approximately 15 households) (Batty et al., 2004), into XY-coordinates, which are subsequently used to determine the level of noise exposure at the particular location. Calculations for the level of noise exposure are based on the 12 month period before the execution of the survey (the period from May 2005 to April 2006).

L_{den} or more are eligible to receive noise insulation, and because the upper limit of the level of noise exposure in the sample is 58 L_{den}, the effects of this variable could not be estimated and it was therefore excluded from further analysis.

From the chosen geographical survey area, a random sample of dwellings was selected. Per selected dwelling, one resident was approached via a letter (delivered at the home address) that invited him or her to fill in an online questionnaire. The letter contained the URL of the website where this questionnaire could be reached. The survey was conducted at the beginning of April 2006. Although issues surrounding Airport Schiphol are highly controversial (i.e., expansion, noise pollution, and emissions) (Van Eeten, 2001), there was no public debate or explicit media attention at the time of data collection or in the preceding months.

Considering the large amount of variables and to avoid problems with multicollinearity and/or deviations from normality, the sample size had to be sufficiently large (at least more than 400). Based on an expected response ratio of 10%, 7000 residents were approached. With 646 useable responses, the actual response ratio was 9.2%. The completion ratio was 91.8%, which indicates that there was no serious matter of questionnaire fatigue. The choice for an internet questionnaire was based on the advantages this method brings in term of speed and costs. Based on a comparison of a large internet sample and 500 traditional samples, Gosling et al. (2004) concluded that internet findings are consistent with findings from traditional methods and that these methods can contribute to many areas of psychology. However, the use of this method has been criticized due to (1) problems of internet coverage of the general population (Couper, 2000), (2) the difficulty of drawing probability samples (Couper, 2000), and (3) high nonresponse rates (Braunsberger et al., 2007).

In relation to the first, it can be noted that internet access in The Netherlands is among the highest in the world. In 2005 83% of the Dutch population had access to the internet (CBS, 2006), which suggests that the internet population accurately reflects the general population. However, usual differences found between the general population and the internet population, i.e., people with internet access are generally better educated, have higher incomes and are generally younger, have also been found in our sample (although this also might be due to the fact that, in general, these people are more motivated to participate in surveys). More specifically, a small overrepresentation exists of well-educated respondents and respondents with high incomes. However, the mean age of the respondents in the sample (mean (standard deviation) = 49.8(14.5)) is not much different from (even higher than) the average age of the Dutch population of 18 years and older (mean = 46.7).[12] In addition, since these variables are not strongly related to the main variable of interest, i.e., noise annoyance (see Table 1), the bias present in the sample is considered to be negligible.

With respect to the second point of critique in relation to internet research, it can be noted that the usual problem of self-selection in web-based surveys, which prohibits generalizations in relation to a larger population, has been limited through the use of traditional methods for the sampling and recruitment of respondents. As mentioned earlier, a random sample was drawn from the survey area and respondents were approached via a letter that was delivered at their home address. In addition, the use of cookies prevented multiple entries from the same respondents.

This leaves the issue of nonresponse, which is of course also present in traditional postal or telephone surveys, unaddressed. Nonresponse is undesirable insofar there are main

[12] Ideally, the sample should be compared to the chosen population (i.e., all residents within the 45 DENL contour). However, since no demographic information was available for this population, the sample was compared to the Dutch population of 18 years and above.

differences between the respondents and nonrespondents on the variables of interest. In this study, it is likely that annoyed people are more (than less annoyed people) inclined to participate. Based on the positive correlation found between the difference in the actual and expected response per municipality and the average noise annoyance score per municipality ($r = 0.235$, $p = 0.000$), it can be concluded that the sample has indeed a small bias toward people who experience more noise annoyance than the average person living in the 45 L_{den} contour. However, since, to the authors' knowledge, previous empirical research has never indicated that the relation between non-acoustical factors and noise annoyance is different for varying degrees of noise annoyance, it is assumed that this small overrepresentation did not bias the estimated relationships between noise annoyance and other factors. Yet, this remains an issue of empirical investigation.

2.3.2 Measurements

Except for age, length of residence in noisy areas, concern about property devaluation, and noise exposure, the variables presented in Figure 2 represent complex concepts that are considered to be latent variables. Latent variables are not measured by a single question in the questionnaire, but these are measured with multiple indicators. Noise annoyance and noise sensitivity were measured by previously validated scales. For noise annoyance, two standardized noise reaction items were used (Fields et al., 2001). Since three items per scale form a preferable minimum the scale was expanded with one item, which relates to annoyance due to disturbances. To measure noise sensitivity, the 21-item scale of Weinstein is used (Weinstein, 1978). Because of limited space in the questionnaire, a selection of ten items was included. It has been previously shown that this selection provides a reliable scale for noise sensitivity (Breugelmans et al., 2004). In addition, to increase the reliability of this scale, it is expanded with one general noise sensitivity question measured with an 11-point scale. All other scales are composed of newly formulated indicator variables, which are measured on seven-point Likert-type scales.

Normal procedure in structural equation modeling is to include all indicators of each latent variable into the structural equation model and thereby taking measurement error into account. However, to reduce the overall complexity of the model (i.e., the number of free parameters to be estimated) and since our interest lies in testing the structural part of the model, we constructed the different latent constructs a priori by calculating sum scores of the multiple indicators and including only these summated scales as the indicators of the latent variables in the structural equation model. Following this procedure, the measurement error can still be taken into account (thereby retaining the benefits of a measurement model) if the measurement error of the summated scale is specified in the structural equation model. This is done by fixing the measurement error of the summated scales (the single indicator variable) at a value of 1 minus the Cronbach's alpha of the summated scale (Kelloway, 1998).

To that effect, the Cronbach's alpha of each summated scale was calculated in the statistical software package SPSS. By calculating the Cronbach's alpha, one assumes that the items represent a unidimensional scale, but the measure itself does not reveal whether this is the case or not. Therefore, factor analysis was conducted prior to calculating the Cronbach's alpha to check the unidimensionality of the each intended scale. Except for the construct "belief noise can be prevented," a single factor was found for each construct, implying that the summated scales are unidimensional. For the construct belief noise can be prevented, the item that has the highest correlation with the central variable, i.e., noise annoyance, is chosen as a single indicator to represent that latent variable. Furthermore, to ensure that each item sufficiently contributed to the measurement of the complex construct, only those items remained in the scale that had a factor loading larger than 0.50. Table 2 presents an overview

of the included scales and their respective items. Since no reliability value can be derived for the single item constructs belief noise can be prevented and "concern about property devaluation," these variables are assumed to be measured with the average reliability of all scales ($\alpha = 0.83$). All other constructs were represented by summated scale scores computed as the sum of the individual item scores.

2.4 Results

The model tests and parameters estimates are based on the covariance matrix and used maximum likelihood estimation as implemented in Lisrel 8 (Jöreskog and Sörbom, 1992).[13] After estimation of the full model in Figure 2, the insignificant paths are deleted and the model is re-estimated. Insignificant paths can be considered irrelevant to the model and should, based on the parsimony criterion, be deleted from the model (Byrne, 1998). Hence all insignificant paths are fixed to zero. Variables that are left with no path are deleted from the model, after checking the modification indices to assess whether paths should be drawn that were not theoretically expected. These indices indicate the decrease in the chi-square value (i.e., improved fit) if an extra path between two factors is added. After this step, the following five factors are removed from the model as these have no significant relationships with other variables left: noise sensitivity, fear of noise source, personal dependency on the noise source, length of residence in noisy areas, and age. Hence, taking into account the other variables that are still in the model, these variables are unable to explain additional variance in the endogenous variables. Figure 3 presents the final model.

[13] With respect to the developed causal model in Figure 2, two theoretical uncertainties were identified. Since the ultimate objective was to develop a model that is both theoretically meaningful and statistically well fitting, these two theoretical uncertainties were combined in four alternative model specifications, which all represented plausible views on reality. To find the model that was "most plausible," all four models were estimated and compared. In comparison to the other models, the model discussed in this paper, which is presented in Figure 2, provided the best fit to the data and was therefore assumed to reflect the most plausible view on reality. To be able to present a concise paper, the choice was made not to include the discussion of these alternative models nor their results. These can, however, be requested in correspondence with the authors.

Table 2. Overview of scales, Cronbach's alpha's, items, and item ranges
Items with factors loadings smaller than 0.50 were removed from the solutions.

Scale / latent variable	Alpha	Item	Range
Noise annoyance (past 12 months)	0.89	Level of annoyance due to air traffic 1	0=not annoyed at all - 10=very high annoyance
		Level of annoyance due to air traffic 2	1=not annoyed at all - 5=extremely annoyed
		Level of annoyance due to disturbances	1=not annoyed at all - 7=very high annoyance
Perceived disturbance (past 12 months)	0.88	Disturbances by aviation traffic during daytime	1=never - 5=daily
		Disturbances by aviation traffic in sleep	1=never - 5=daily
		Disturbances by aviation traffic during conversations	1=never - 5=often
		Disturbances by aviation traffic during activities that demand concentration	1=never - 5=often
		Disturbances by aviation traffic during resting	1=never - 5=often
Negative expectations towards noise development	0.83	Belief personal noise situation will worsen	1=noise situation will improve - 5=noise situation will deteriorate
		General belief noise exposure will increase	1=noise level will decrease - 7=noise level will increase
Noise sensitivity	0.86	General noise sensitivity	0=not at all noise sensitive - 10=highly noise sensitive
		I get used to most noises without much difficulty	1=completely agree - 5=completely disagree
		I am good at concentrating no matter what is going on around me	1=completely agree - 5=completely disagree
		I am easily awakened by noise	1=completely agree - 5=completely disagree
		I find it hard to relax in a place that is noisy	1=completely agree - 5=completely disagree
		I am sensitive to noise	1=completely agree - 5=completely disagree
		Sometimes noises get on my nerves and get me irritated	1=completely agree - 5=completely disagree
		I get angry with people making noise	1=completely agree - 5=completely disagree
Fear of noise source	0.76	Fear of aircraft crash in neighbourhood	1=no fear at all - 7=extremely fearful
		Frightened when aircrafts fly over	1=not frightened at all - 7=extremely frightened
Positive social evaluation of noise source	0.79	I believe Schiphol is valuable for the region	1=completely agree - 7=completely disagree
		I believe Schiphol is important for the Dutch economy	1=completely agree - 7=completely disagree
		I believe flying is a sustainable transportation mode	1=completely agree - 7=completely disagree
Negative attitude towards noise source authorities and the noise policy	0.92	I believe Schiphol must be able to grow at its current location	1=completely agree - 7=completely disagree
		General attitude towards Schiphol	1=very negative - 7=very positive
		Satisfaction with Schiphol policy in general	1=not satisfied at all - 7=extremely satisfied
		Belief Schiphol abuses its power	1=no abuse at all - 7=a lot of abuse
		I trust the government to maintain a good balance between environmental and economic factors	1=completely agree - 7=completely disagree
		I trust the government to uphold the environmental norms	1=completely agree - 7=completely disagree
		I believe the government acknowledges the noise problem	1=completely agree - 7=completely disagree
		Satisfaction with government policy on noise	1=not satisfied at all - 7=extremely satisfied
Concern about the negative health effects of noise and pollution	0.91	Concern that pollution leads to negative health effects	1=not concerned at all - 7=very much concerned
		Concern that noise leads to negative health effects	1=not concerned at all - 7=very much concerned
		Concern that noise leads to sleep loss	1=not concerned at all - 7=very much concerned
		Concern that noise leads to more stress	1=not concerned at all - 7=very much concerned
Annoyance related to non-noise effects	0.85	Annoyed by odour due to aircrafts	1=not annoyed at all - 7=very much annoyed
		Annoyed by vibrations due to aircrafts	1=not annoyed at all - 7=very much annoyed
		Annoyed by particles, dust or smoke due to aircrafts	1=not annoyed at all - 7=very much annoyed
Personal dependency on the noise source	0.65	Importance of Schiphol in relation to job	1=not important at all - 7=very important
		Dependency on Schiphol due to travel needs	1=not dependent at all - 7=very dependent
		Financial dependency on Schiphol	1=not dependent at all - 7=very dependent
Perceived control and coping capacity	0.77	Feeling of direct control (via physical measures) over the experienced level of noise exposure	1=no control at all - 7=very much control
		Feeling of being powerless in relation to the noise situation	1=very powerless - 7=not powerless at all
		Capacity to deal with aircraft noise	1=very low capacity - 7=very high capacity

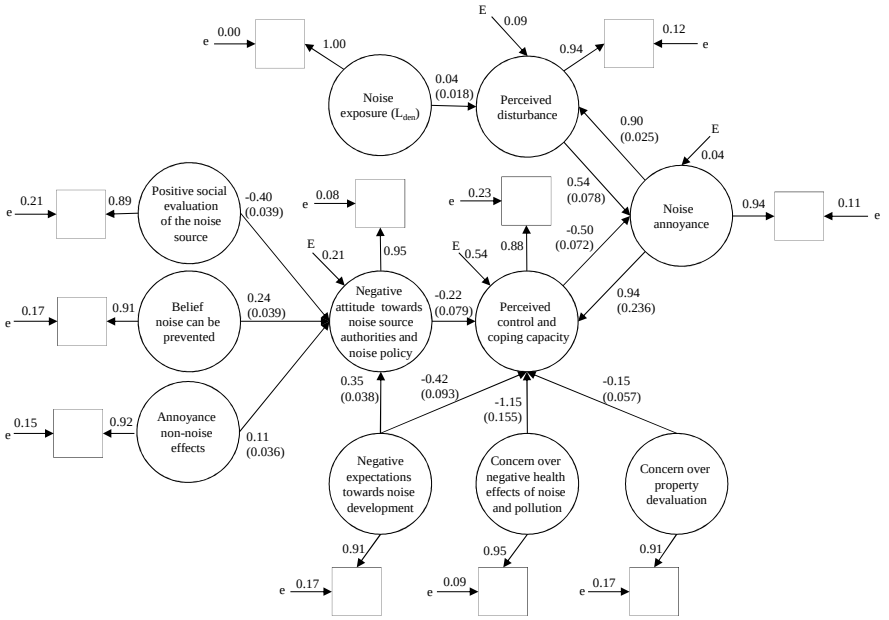

Figure 3. The estimated aircraft noise annoyance model

N = 646, χ^2 = 54.45, p-value = 0.00008, Df = 21, GFI = 0.99, CFI = 1.00, and RMSEA = 0.044. The standardized path estimates are shown. The values in the parentheses represent the t-values of the structural parameter estimates. All parameter estimates are significant ($p < 0.05$).

Legend:

◯ Latent variable
E Error / unexplained variance of latent variable
□ Observed variable (based on single-item composite scale)
e Error / unexplained variance of observed variable

The chi-square value is statistically significant (χ^2 = 54.45, p = 0.00008), which means that the model implied covariance matrix is significantly different from the observed covariance matrix. However, since this statistic is very sensitive for large sample sizes (N > 500), the review of other fit indices is recommended (Browne and Cudeck, 1993; Hu and Bentler, 1995; Schermelleh-Engel et al., 2003). The values for the goodness-of-fit index (GFI) and the comparative fit index (CFI) are well above the recommended lower limit of 0.90, which suggests a good model fit. The root mean square error of approximation (RMSEA), a badness-of-fit index, has a value below the recommended upper limit of 0.05, which again suggests a good model fit. Overall, it can be concluded that the model fit is good. In addition, all the signs of the hypothesised relationships between the variables are as expected.

The values related to each path in Figure 3 represent the standardized parameter estimates. Standardization of the estimates makes comparisons in terms of the relative importance of each path possible. It can be concluded that the effect sizes of perceived disturbance and perceived control and coping capacity on noise annoyance, 0.54 and -0.50, respectively, are quite similar. The effects of noise annoyance on perceived disturbance and perceived control and coping capacity, 0.90 and 0.94, respectively, are also of the same magnitude. It can be concluded that to a large extent, the reciprocal effects between noise annoyance and perceived

disturbance and noise annoyance and perceived control and coping capacity cancel each other out.

The only significant determinant of perceived disturbance is the level of noise exposure. However, the effect size of 0.04 can be qualified as small. The significant determinants of the perceived level of control and coping capacity are the negative attitude toward noise source authorities and the noise policy (-0.22), the negative expectations related to noise development (-0.42), the concern about negative health effects of noise and pollution (-1.15), and the concern about property devaluation (-0.15). Especially, the concern about negative health effects has a large effect on the capacity of people to handle the noise situation.

The positive social evaluation of noise source (-0.40), the belief that noise can be prevented (0.24), and annoyance related to non-noise effects (0.11) influence the negative attitude toward noise source authorities and the noise policy. The most important determinant of this factor is the positive social evaluation.

Only the negative expectation related to the future noise development has both a direct (-0.42) and an indirect effect (0.35 * -0.22 = -0.077) on the perceived level of control and coping capacity. The presence of both effects is theoretically plausible. The indirect effect, via the negative attitude toward source authorities, can be explained by the mechanism that, if the belief exists that the noise situation will worsen, the noise source authorities are to blame for the expected increase in noise, which negatively influences the attitude toward the authorities. The direct effect, on the other hand, can be explained by the mechanism that a negative expectation related to the future noise development creates an immediate sense of despair (i.e., expecting that the situation will be become worse makes the appreciation of the current situation worse).

In order to assess the total effect of each variable on the central variable noise annoyance, the standardized total effects need to be assessed. These are presented in Table 3. The total effect of a variable is the combination of the indirect and direct effects. It can be concluded that the concern about negative health effects of noise and pollution, the perceived disturbance, and the perceived control and coping capacity are the most important determinants of noise annoyance. Noise annoyance (via the reciprocal relationships), noise exposure, and annoyance non-noise effects have the lowest total effects on noise annoyance.

Table 3. Standardized total effects of each variable on noise annoyance

Variable	Effect
Concern about negative health effects of noise and pollution	0.59
Perceived disturbance	0.56
Perceived control and coping capacity	-0.51
Negative expectations towards noise development	0.26
Negative attitude towards source authorities	0.11
Concern about property devaluation	0.08
Positive social evaluation of the noise source	-0.05
Belief noise can be prevented	0.03
Noise annoyance	0.02
Noise exposure (L_{den})	0.02
Annoyance non-noise effects	0.01

The error terms of the latent constructs (i.e., the E's in Figure 3) indicate the proportions of unexplained variance of the endogenous variables. Since the model is nonrecursive (i.e., it includes feedback loops), the interpretation of the proportion of explained variance (1 - E or

R^2) is not the same as it would be in traditional regression analysis (Jöreskog, 2000). This interpretation only holds for the negative attitude toward source authorities and the noise policy. Jöreskog (2000), therefore, advised assessing the R^2's calculated from the reduced form equations, which indicate the proportions of variance in the endogenous variables solely explained by the exogenous variables. For each endogenous variable, the R^2 of the reduced form is presented in Table 4.

Even though the unique portions of variance explained by the endogenous variables in each other are not included, the R^2 values are still high. In addition, the explained variance in noise annoyance, 78%, is considerably higher than in a path model previously estimated on this topic, which was able to explain 42% in noise annoyance (Taylor, 1984).

Table 4. The proportions of explained variance in the endogenous variables (R^2's) based on the reduced form equations

Endogenous variable	R^2
Noise annoyance	0.78
Perceived disturbance	0.65
Perceived control and coping capacity	0.79
Negative attitude towards source authorities	0.79

2.5 Conclusion and discussion

In this study, a structural equation model is developed and estimated to explain aircraft noise annoyance. In contrast to existing models that largely lack a sound theoretical basis, the model presented in this paper is theoretically well founded. As a result, the model provides a better insight into the factors and causal processes that precede and result in aircraft noise annoyance. In addition, the use of SEM to model and explain noise annoyance has proven itself to be a suitable method in overcoming the shortcomings of previously used methods such as correlational analysis and multiple regression analysis. The final model provides a good model fit and supports the presence of indirect and reciprocal effects, which empirically have not previously been identified. It can be concluded that the concern about the negative health effects of noise and pollution, the level of perceived disturbance, and the level of perceived control and coping capacity have the highest total effects on noise annoyance. Finally, the proportion of explained variance in noise annoyance is higher than in previous models.

Controlled for other variables still in the model, the variables noise sensitivity, fear related to the noise source, personal dependency on the noise source, length of residence in noisy areas, and age have no significant relationships with endogenous variables in the model and were therefore excluded from the model. The exclusion of the variables noise sensitivity and fear in relation to the noise source is especially remarkable, since many studies emphasise the importance of these factors (e.g., see Fields, 1993; Van de Kamp et al., 2004; Miedema and Vos, 1999). Although these variables show significant correlations with noise annoyance, 0.51 and 0.50, respectively, they are unable to explain additional variance given the other variables still in the model. With respect to the exclusion of fear related to the noise source, a probable explanation is that the concern about the negative health effects of noise and pollution explains the same variance in the perceived control and coping capacity variable. This explanation seems reasonable since a fairly strong correlation between fear related to the noise source and concern about negative health effects of noise and pollution exists ($r = 0.54$, $p = 0.000$). An explanation of a similar form can be found for the exclusion of noise sensitivity. The variable perceived control and coping capacity show a significant correlation

with noise sensitivity ($r = -0.48$, $p = 0.000$), and its influence in the model is the probable cause for the suppression of the effect of noise sensitivity. However, as opposed to the relation between fear and the concern about negative health effects, we cannot identify a theoretical explanation why noise sensitivity and perceived control and coping capacity are empirically associated. Based on this finding, we recommend future research to address this particular relationship and the theoretical mechanism that underlies it, as well as, from a more general perspective, the relationship between noise sensitivity and other non-acoustical factors.

In relation to this study, some reflective remarks and related recommended directions for further research can be made. The first remark and associated research direction is related to the theoretical framework, developed by Stallen (1999), on which our causal model is based. Based on this theoretical framework, the specified model structure presented in this paper is deemed the most plausible one. The fact that the model is not falsified, however, does not exclude the validity of other theoretical frameworks. With respect to the apparent lack of theoretical insights in the phenomenon noise annoyance, we stress that future research related to the acoustical and non-acoustical antecedents of noise annoyance should focus on the fundamental causal mechanisms that exist between variables, in addition to finding statistically significant associations between them. Rich qualitative descriptions related to the causal mechanisms "at work" between variables can be used to verify or falsify the used model structure or can be used to develop a new theoretical framework and related model structure(s). Since these descriptions cannot be derived from current theoretical insights or from traditional quantitative approaches, other means to derive these will have to be explored. A qualitative research approach (e.g., using in-depth interview techniques) is considered to be suitable in this respect.

A second remark and associated research opportunity, which partly overlaps with the previous one, relates to the assumed temporal causal order between variables. The estimated relationships in the model depicted in Figure 3 are based on the assumption that the identified causes (independent variables) precede the effects (dependent variables) in time. However, as opposed to other causal models, the assumption of time precedence in our aircraft noise annoyance model is questionable. All the variables in the model, except noise exposure, constitute concepts such as beliefs, attitudes, perceptions, expectations, and evaluations. These types of variables are by nature very abstract. Although a causal order can be assumed based on theoretical notions (e.g., a general belief precedes a specific attitude), this assumption cannot be empirically investigated. The reason for this is that the model is based on cross-sectional data. Inferences based on this model about the temporal order between variables and the directions of causation are therefore inherently less strong. This is especially true for the estimated reciprocal relationships (i.e., does perceived control and coping capacity cause noise annoyance, vice versa, or does indeed a reciprocal relationship exist?). Hence, with respect to our developed aircraft noise annoyance model as well as future models to explain noise annoyance, special attention to the tenability of the assumption of time precedence is justified. A suitable approach to empirically investigate the tenability of the time-precedence criterion is through the use of panel data. More specifically, a SEM panel design can yield empirical evidence of a specific causal order between two variables (Finkel, 1995).[14]

[14] Within a SEM panel design, the effect of an independent variable X_0 (read: X at time point 0) on a dependent variable Y_1 is controlled for Y's own stability. Hence, if X_0 is able to explain variation in Y_1, over and above the variation Y_0 can explain in Y_1 (the stability of Y), it can be empirically inferred that X is a causal predictor of Y.

A third direction for further research is to apply the model to residents around other airports in varying countries and explore similarities and differences between them. It should be taken into account that country or airport specific variables can play a role. These variables can be related to cultural characteristics of the country or to the specific policy context of the airport. For example, the qualitative research Bröer (2006) shows that the policy discourse at an airport influences the meaning people attribute to the sound of aircrafts. This, in turn, influences their experienced level of annoyance. In addition, through cross-national comparative research "best practices" of (non-acoustical) sound management can be identified.

The last research direction is related to the inclusion of acoustical and situational factors (e.g., frequency, tone, impulsiveness, time of day, the presence of noise insulation, arrangement of rooms and home type, and background noise level). The model in this study included only a year's mean noise exposure metric (L_{den}). The limited range of this metric (i.e., 45-58 L_{den}) has likely contributed to the relatively low effect of this variable in the estimated model (see also Job, 1988). The assessment of the influence of noise exposure can be improved by taking into account a larger geographical area for sample selection (to include levels below 45 L_{den}) and by oversampling (and subsequent weighting) of residents with high exposure levels (above 58 L_{den}). Especially in the case of AAS, oversampling is necessary since a relatively small proportion of the total population is exposed to these high levels of noise exposure. In addition, the assessment can possibly be improved through the inclusion of noise descriptors based on other weighting filters (e.g., C-weighting) or a dynamic filter (Schomer, 2001). Lastly, to estimate the relative importance of other acoustical and situational variables, we recommend inclusion of these factors in future models of aircraft noise annoyance.

To conclude, we believe that insights into the preceding factors and causal processes of aircraft noise annoyance open the door for revision of existing policies and the design of new policies to reduce this adverse effect. Treating aircraft noise annoyance around airports as a mere technical problem, involving exposure levels and dose-response functions is only one side of addressing the noise problem.

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3. Determining the Direction of Causality

Kroesen, M. Molin, E. J. E. and Van Wee, G. P. (2010) Determining the direction of causality between psychological factors and aircraft noise annoyance. *Noise & Health*, 12, pp. 17-25.

Abstract

In this paper, an attempt is made to establish the direction of causality between a range of psychological factors and aircraft noise annoyance. To this purpose, a panel model was estimated within a structural equation modeling approach. Data were gathered from two surveys conducted in April 2006 and April 2008, respectively, among the same residents living within the 45 Level day-evening-night contour of Amsterdam Airport Schiphol, the largest airport in the Netherlands (N=250). A surprising result is that none of the paths from the psychological factors to aircraft noise annoyance were found to be significant. Yet 2 effects were significant the other way around: (1) from 'aircraft noise annoyance' to 'concern about the negative health effects of noise' and (2) from 'aircraft noise annoyance' to 'belief that noise can be prevented.' Hence aircraft noise annoyance measured at time 1 contained information that can effectively explain changes in these 2 variables at time 2, while controlling for their previous values. Secondary results show that (1) aircraft noise annoyance is very stable through time and (2) that changes in aircraft noise annoyance and the identified psychological factors are correlated.

3.1 Introduction

The degree of human response to aircraft noise is not only a function of acoustic variables but also of certain non-acoustic variables. Insight in these variables is important in order to predict noise annoyance reactions better (Fidell, 1999) and also to deal with the problem of aircraft noise more effectively (Findell and Stallen, 1999; Staples et al., 1999). Although demographic characteristics significantly affect human reaction to noise (Miedema and Vos, 1999), research has shown that the most influential variables are social-psychological in nature, compromising attitudes towards the source, future expectations and feelings of control (Guski, 1999; Kroesen et al., 2008). Yet evidence in support of these subjective (social-psychological) factors is largely based on cross-sectional survey data (Taylor, 1984). Since the independent and dependent variables are measured at the same point in time, the criterion of time precedence (i.e., X precedes Y in time) cannot be empirically investigated. In turn, this means that the direction of causation remains uncertain. In other words, the question remains whether the investigated social-psychological factors cause aircraft noise annoyance or vice versa.

The criterion of time precedence can be controlled under experimental conditions. Experiments allow the researcher to control which subjects are exposed to which treatment. For example, Glass and Singer (1972) have shown via several experiments that an individual's level of perceived control over the degree of noise exposure influences a person's noise reaction. In similar fashion, Maris et al. (2007a ; 2007b) have shown that the fairness of the procedures preceding the actual exposure to noise influences the degree of reported noise annoyance. Although these studies can firmly establish causality for the sample under investigation, the results cannot easily be generalized towards a population living around an airport. Specific sample characteristics, as well as the artificial laboratory settings, may hamper such generalizations.

A way to achieve both high external validity (can the results be generalized to other populations, times and places?) and high internal validity (does the cause X indeed lead to the effect Y?) is to combine the field survey with a certain experimental manipulation, resulting in what can be called a natural experiment. In such a situation, the manipulation is not directly under control by the researcher, but the occasion and the participants are chosen such that respondents can be categorized into a control group and a treatment group. The study by Hatfield et al. (2001) is illustrative. Their study was conducted at Sydney airport, where, due to a runway configuration, aircraft noise levels in nearby areas were expected to increase, decrease or remain the same. In a survey before the actual change, Hatfield et al. found that expectations regarding future noise levels influenced people's psychological and physiological reactions to the noise. Given the methodological design, this result is both internally and externally valid. Of course, suitable occasions have to present themselves to assess the influence of possible other psychological determinants.

In this paper, we also aim to address the issue of causality. Specifically, we aim to establish the direction of causality between 12 (subjective) social-psychological factors, which are identified based on previous research (Kroesen et al., 2008) and noise reaction (i.e., noise annoyance). However, we take a somewhat different approach than the approaches described in the previous paragraphs. In contrast to these methods, we did not apply any manipulation. Instead, we estimated a structural equation model (SEM) based on panel data gathered from the field (i.e., data resulting from repeated measurements from the same individuals). A panel model can provide empirical tests for the time precedence criterion and hence address the issue of temporal order (De Jonge et al., 2001; Finkel, 1995; Zapf et al., 1996). Via this methodological approach, we hope to retain both the advantage of a field study in terms of high external validity and the advantage of an experiment in terms of high internal validity.

3.2 Materials and Methods

3.2.1 A cross-lagged panel model

Association, isolation (the exclusion of 'third variables') and direction of influence (temporal order) are generally viewed as the 3 requirements to establish a causal relationship (Bollen, 1989). An experiment in which the independent variable can be manipulated is a great aid in satisfying these requirements. However, it does not support a one-to-one generalization towards the field. On the other hand, cross-sectional field studies are only able to satisfy the criterion of association and to some extent of isolation (by statistical control of possible 'third variables'). The issue of temporal order can only theoretically be addressed. For example, if, in a cross-sectional study, a covariation is observed between age and the degree of noise annoyance, it is evident that the structural variable age causes noise annoyance and not the other way around. However, if the relation between a certain attitude and noise annoyance is examined, which are both subjective in nature, it becomes difficult to theoretically distinguish cause and effect.

To address the issue of temporal order within the field context and with subjective factors as independent and dependent variables, panel data can be used. Panel data contain measures of the same variables from numerous units observed repeatedly through time. The basic idea behind the specification of a model based on panel data is to estimate the effect of an independent variable X_{T1} (read 'X measured at time T1') on a second variable Y_{T2}, while controlling for Y's prior values (Y_{T1}). If X_{T1} is able to explain variation in Y_{T2} over and above the variation explained by Y itself at a previous point in time (Y_{T1}), it can be concluded that X_{T1} accounts for some change in Y_{T2} and hence that X is indeed a causal predictor of Y. A panel design is therefore effective in determining the temporal order between variables.

In sum, whereas models based on cross-sectional data can only satisfy the criteria of association (covariation) and nonspuriousness, a panel model can also empirically test the condition of time precedence. As such, it allows the researcher to investigate the 3 necessary conditions to establish a causal relationship. It needs to be noted, however, that although panel data offer ways to strengthen the causal inference process, they are not a cure-all for all the problems of causal inference in nonexperimental research (Finkel, 1995). Panel models still depend on (untestable) assumptions that have to be justified given the specific situations.

If the researcher has no prior conceptions about the temporal order between variables, the most appropriate model to test is a cross-lagged panel model. In this model, the dependent variables at time 2 are predicted by their previous values as well as the time 1 values of the other variable of interest. An example of a 2-wave cross-lagged panel model is depicted in Figure 1. The term 'cross-lagged' refers to the 2 lagged effects which cross each other in the middle.

In this model, parameters P1 and P2 represent the stability coefficients. These values can be interpreted as test-retest correlations, with values closer to 1 indicating higher relative stabilities. The remaining unexplained variation in X and Y at time point T2 can be regarded as variance resulting from individual changes which have occurred in the period between the two measurements (assuming that the model is corrected for measurement errors in the observed variables).

Correlations C1 and C2 account for unmeasured variables and/or unmodeled effects. Correlation C1 controls for the initial overlap between the exogenous variables X_{T1} and Y_{T1}, correcting for (1) previous causal influences between both variables and/or (2) the effects of possible third variables. The error terms E1 and E2 indicate the variability in the endogenous variables X_{T2} and Y_{T2}, which is associated with unknown (unmodeled) factors. As a result, the

correlation C2 accounts for (1) possible third variables that have influenced both X and Y within the period between the two measurements and (2) possible synchronous effects between X and Y. A synchronous effect should be understood as a change in Y at the second occasion (T2) resulting from a change in X at some time *after* the first occasion (T1).

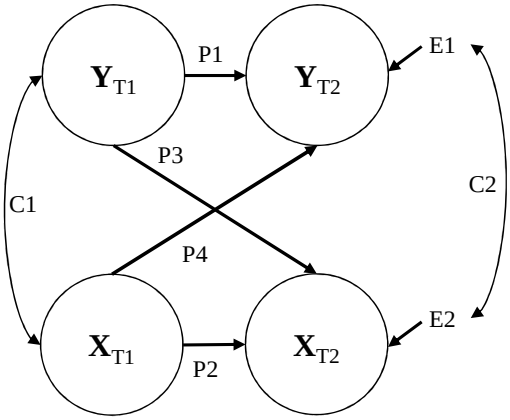

Figure 1. Specification of a two-wave cross-lagged panel model

While controlling for the initial overlap (C1) as well as for the influences of third variables and synchronous causal influences during the period between the two surveys (C2), the cross-lagged parameters P3 and P4 attempt to explain variance in X_{T2} and Y_{T2} which is not already explained by their respective stability coefficients (P1 and P2). The significance and strength of the parameters P3 and P4 inform us which of the two variables, X or Y, is the strongest temporal predictor.

3.2.2 Model specification and comparison

In addition to the reaction variable, aircraft noise annoyance, 13 factors are taken into account (see also section 3.2.4, 'measures'). These factors are identified based on a previous literature study and a related empirical analysis (Kroesen et al., 2008). Twelve of these are social-psychological and thus subjective in nature; while 1, the level of aircraft noise exposure, is objective. The 14 variables are combined into a 2-wave cross-lagged panel design as specified in Figure 2.

To investigate the different explanations for the observed covariance structure, 5 nested models are tested. First, we estimate a baseline model. This model consists of the 14 stability parameters, one for each of the included factors; and 91 correlations between the exogenous factors at time 1 [{N*(N-1)}/2 with N = 14] (depicted on the left side in Figure 2).

In the second model, we also include the 91 correlations between the error terms of endogenous variables at time 2 (depicted on the right side in Figure 2). This model can provide insight into the extent to which the changes in the variables are correlated. These correlations are necessary to control for the influences of third variables and the presence of synchronous causal relationships between the model variables during the period between the two surveys.

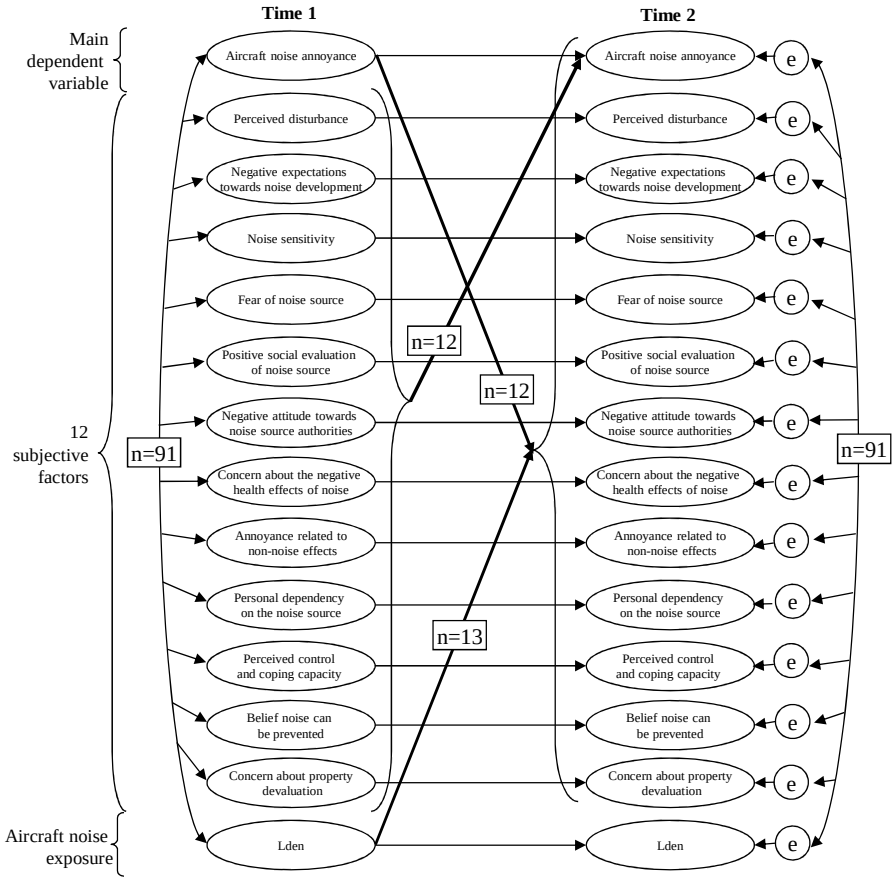

Figure 2. Model specification

In the third model, we estimate the 13 lagged effects of the level of aircraft noise exposure (L_{den}) on the endogenous variables, i.e., aircraft noise annoyance and the 12 psychological factors. (To keep the model clear, the arrows are taken together.) The reason for the inclusion of the aircraft noise exposure level is that it is a plausible 'third variable' which can underlie changes in the subjective variables (aircraft noise annoyance and the psychological factors). For example, a change in both 'aircraft noise annoyance' and 'attitude towards the noise source' might be due to a change in aircraft noise exposure. Inclusion of aircraft noise exposure is necessary to correct the lagged effects between these two variables for its influence. Hence the 13 lagged effects of aircraft noise exposure on the endogenous variables correct the estimations of the lagged effects between the 12 psychological factors and aircraft noise annoyance.

In the fourth and fifth model, we estimate the 12 paths from the psychological factors to aircraft noise annoyance and the 12 paths from aircraft noise annoyance to the psychological factors, respectively. Examination of the significance and strengths of these parameters can inform us whether the psychological factors or aircraft noise annoyance is/are the predominant causal predictor(s), or whether perhaps reciprocal relationships exist. Our prime

hypothesis is that the identified psychological factors influence aircraft noise annoyance. However, since there is little theory to support the hypothesis that the causal direction indeed flows from the identified factors to aircraft noise annoyance, the reverse hypothesis, i.e., aircraft noise annoyance influences the identified psychological variables, is also tested.

In line with the recommendations of Hu and Bentler (1999) the following fit indices are used to evaluate the models: the root mean square error of approximation (RMSEA) (Browne and Cudeck, 1993), which measures the discrepancy between the model implied and observed covariance matrix per degree of freedom; the standardized root mean residual (SRMR) (Bentler, 1995), which measures the mean of the squared residuals (the differences between the sample and model-implied covariance matrices) divided by the standard deviations of the respective manifest variables; and the comparative fit index (CFI) (Bentler, 1990), which provides a comparison between the specified model and a baseline model with zero constraints. A well-fitting model is defined as having values below 0.06 and 0.08 for RSMEA and SRMR, respectively, and a CFI value greater than 0.95 (Hu and Bentler, 1999). In addition, to support model comparisons, we rely on chi-square difference tests, which can be performed for nested models.

3.2.3 Data-gathering procedures

The data were gathered in two surveys conducted in the periods April 2006 (time 1) and April 2008 (time 2). The details of the first survey (April 2006) are described in the study by Kroesen et al. (2008) The main characteristics are reiterated here.

In all, 7000 residents living within the 45 L_{den} contour around Amsterdam Airport Schiphol were randomly sampled from the total population within this contour (approximately 1.5 million people aged 18 or above). Those sampled were invited via a letter to fill in an online questionnaire. With 646 useable responses, the response ratio was 9.2%. The mean sample age of 49.8 years deviated slightly from the mean population age of 46.7 years. Furthermore, residents with better education and a higher income were overrepresented. Such deviations can bias the results but also typical for postal or telephone surveys (Roster et al., 2004). Hence they are generally difficult to avoid. At the end of the questionnaire, respondents could indicate whether they would be willing to participate in a second survey. In all, 505 people were willing and provided their e-mail address. These people were again approached 2 years later, in April 2008. A total of 269 people responded positively and filled in the exactly same questionnaire. Fifteen respondents were excluded from the analysis because their sex and age did not match between the two surveys. Twenty-three respondents indicated that they had moved in the period between the two surveys; however, 19 of them had moved to a location still within the 45 L_{den} contour around the airport. Three of the other 4 indicated that their reason to move was aircraft noise.

The final response group consisted of 250 (= 269 - 15 - 4) useable responses. Hence the response rate for the second survey was 50.3%. The panel data provided us with the opportunity to empirically assess the degree of nonresponse bias. In our particular case, it is plausible that people who are exposed to higher levels of aircraft noise or who are more annoyed by the noise are also more inclined to participate in a survey about the airport. The results indicated this was not the case. The mean L_{den} of nonrespondents in the second survey (N = 236), 50.0 dB(A), did not differ significantly from the mean L_{den} of 50.1 dB(A) for those who did participate in the second survey (N = 250). For the annoyance response, only the results of the first survey could be compared. The mean annoyance score in the first survey of those who were approached for the second survey but did not respond (N = 236) was 4.2 [on a scale from 0 (‘not at all annoyed’) to 10 (‘very much annoyed’)], again not significantly different from the mean annoyance score of 4.1 for those who participated in the second

survey also (N = 250). Hence in April 2006, nonrespondents for the survey of April 2008 were equally annoyed by aircraft noise as respondents who participated in both surveys.

Ideally the time lag between measurements should be chosen such that it reflects the time it takes for the causal effect to evolve (Lorenz et al., 1995). However, in most cases one can only guess how long that is. Given that in the present study we measured several attitudinal constructs, which are generally relatively stable through time, we assumed that a period of 2 years was long enough for changes in individual scores to occur, but not too long for too much nonresponse. Moreover, with a time lag of 2 whole years, the design controlled for the seasonal fluctuation in annoyance response, i.e., the empirical trend that in the summer noise reaction is slightly greater than in the winter (Miedema et al., 2005).

3.2.4 Measures

The main dependent variable, aircraft noise annoyance, and the 12 psychological factors were measured via multiple items to increase their reliability. The constructs are calculated through summation of the individual items. An overview of the construct labels, the number of items per construct, the construct means and standard deviations, and the construct reliabilities at both time points is provided in Table 1. Details on the individual items used can be found in the study by Kroesen et al (2008).

With one exception, the constructs showed acceptable construct reliability (Cronbach's alpha >0.70). Each construct was included in the structural model as a latent variable with a single observed indicator, which is represented by the summated scale. The reliability of each latent variable is taken into account by fixing the measurement error of the indicator variable at a value of [(1-Cronbach's alpha) multiplied by the variance of the respective summated scale] (Kelloway, 1998). In this way, the parameters associated with the structural paths in the model are corrected for measurement errors, leading to less biased estimations.

Table 1. An overview of the constructs

N = 250		**Mean**		**Standard Deviation**		**Cronbach's alpha**		**Δ T1-T2**	
Main dependent variable (summated scale)	**# items**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**mean**	**sign.**
Aircraft noise annoyance (past 12 months)	2	6.2	6.0	3.5	3.5	0.92	0.91	-0.2	0.27
Determinant (summated scale)									
Perceived disturbance	5	12.7	12.8	4.9	4.8	0.88	0.89	0.1	0.63
Negative expectations towards noise development	2	10.1	9.7	2.6	2.6	0.83	0.82	-0.4	0.01
Noise sensitivity	8	26.6	25.9	8.1	8.3	0.86	0.87	-0.7	0.09
Fear of noise source	2	4.3	3.9	2.6	2.4	0.76	0.74	-0.4	0.00
Positive social evaluation of noise source	3	17.7	16.2	3.2	3.6	0.79	0.81	-1.5	0.00
Negative attitude towards noise source authorities	8	32.8	33.5	11.4	11.8	0.91	0.94	0.7	0.18
Concern about the negative health effects of noise and pollution	4	13.8	14.3	7.2	6.9	0.92	0.93	0.5	0.22
Annoyance related to non-noise effects	3	7.3	7.4	4.7	4.6	0.85	0.86	0.1	0.62
Personal dependency on the noise source	3	5.6	5.8	4.3	4.1	0.69	0.70	0.2	0.49
Perceived control and coping capacity	3	13.3	13.8	4.6	4.5	0.78	0.77	0.5	0.01
Belief that noise can be prevented	1	4.6	4.4	1.4	1.5	0.83	0.83	-0.2	0.03
Concern about property devaluation	1	1.9	2.1	2.0	2.0	0.83	0.83	0.2	0.27
Aircraft noise exposure									
L_{den} dB(A)	-	50.1	50.1	2.3	2.5	-	-	0.0	1.00

In addition to the subjective constructs, the degree of aircraft noise exposure is included in the model and represented by the noise exposure metric L_{den} dB(A). For every respondent in the sample, the level of noise exposure (a year's mean level based on the 12-month period preceding the surveys) was calculated by the National Aerospace Laboratory (NLR), the Netherlands. This was done by transforming the 4-digit 2-letter postal code of each respondent's residence, which includes on an average an area of 50 m^2 (approximately 15 households) into XY-coordinates, which are subsequently used to determine the level of noise exposure at the particular location.

3.3 Results

Four construct means differed significantly between the two measurements (Table 1). The means of the variables 'negative expectation towards noise development,' 'fear of the noise source,' 'positive social evaluation of the noise source' and 'belief that noise can be prevented' decreased significantly. The mean of the variable 'perceived control and coping capacity' increased significantly. Overall, the deviations were minor, even the significant ones.

Five models were estimated using the standard maximum likelihood procedure. The software package AMOS 7 was used for this purpose. In Table 2, the fit indices of the models are presented.

The fit of the baseline model (M1) was found to be poor. The values of the RMSEA and CFI were outside the respective acceptable cut-off values (RMSEA > 0.06 and CFI < 0.95). Only the value of the SRMR lay within the acceptable range (SRMR < 0.08).

Addition of the correlations between the error terms of the endogenous variables (the time 2 variables) was found to drastically improve the model fit. The three fit indices then showed an acceptable model fit, and the chi-square difference test showed that the improvement in model fit between model 1 and model 2 was indeed significant (M2 vs. M1: $\Delta\chi^2 = 477.36$; $\Delta Df = 91$; $p < 0.000$). The large improvement in model fit can be taken as evidence for either the influence of unmeasured third variables or the presence of synchronous effects between the variables in the model. However, we cannot empirically assess which of the two explanations is (more) valid.

Table 2. Model evaluation and comparison

Model	Specification	RMSEA	SRMR	CFI	χ	df	*p*	Model comparison	$\Delta\chi$	Δdf	*P*
M1	91 correlations between exogenous variables (T1) and 14 stability coefficients (baseline model)	0.084	0.060	0.91	751.60	273	0.000				
M2	M1 + 91 correlations between error terms of endogenous variables (T2)	0.045	0.045	0.98	274.24	182	0.000	M2 vs. M1	477.36	91	0.000
M3	M2 + 13 paths from L_{den} (T1) to endogenous variables (T2)	0.041	0.040	0.99	237.32	169	0.000	M3 vs. M2	36.92	13	0.000
M4	M3 +12 paths from psychological factors (T1) to aircraft noise annoyance (T2)	0.042	0.040	0.99	225.07	157	0.000	M4 vs. M3	12.25	12	0.426
M5	M3 +12 paths from aircraft noise annoyance (T1) to psychological factors (T2)	0.034	0.027	0.99	201.02	157	0.006	M5 vs. M3	36.30	12	0.000

RMSEA: root mean square error of approximation
SRMR: standardized root mean residual
CFI: comparative fit index

Addition of the paths from L_{den} at time 1 to the 13 endogenous variables at time 2, i.e., aircraft noise annoyance and the 12 psychological factors, also shows a significant improvement in model fit (M3 vs. M2: $\Delta\chi^2 = 36.92$; $\Delta Df = 13$; $p < 0.000$). Looking at the (standardized) parameter estimates, the following paths are significant: $L_{den} \rightarrow$ concern about the negative health effects of noise ($\beta = 0.138$; $p = 0.000$); and $L_{den} \rightarrow$ annoyance related to non-noise effects ($\beta = 0.128$; $p = 0.004$). Hence changes that have occurred in these variables in the period between the two surveys can be explained by the level of aircraft noise exposure at time 1.

Model 4 introduces the lagged effects of the psychological factors on aircraft noise annoyance. With this addition, no improvement in model fit occurred. Hence we can conclude that variance in the psychological factors at T1 is unable to explain variance in aircraft noise annoyance at T2, controlling for the influence of aircraft noise annoyance at T1. In other words, the psychological factors at T1 contain no information through which we can determine how people's annoyance response has changed within the period between the two measurements.

The reverse hypothesis, i.e., aircraft noise annoyance influences the psychological factors, is supported by the data. The difference in the chi-square values of models 5 and 3, 36.92 ($\Delta Df = 12$), is statistically significant ($p = 0.000$), again indicating an improvement in model fit. Hence aircraft noise annoyance at T1 can predict changes in the identified factors at T2, while controlling for the factors' previous values. Examination of the parameter estimates shows that 2 paths are significant: (1) aircraft noise annoyance → concern about the negative health effects of noise ($\beta = 0.181$; $P = 0.002$) and (2) aircraft noise annoyance → belief that noise can be prevented ($\beta = 0.298$; $p = 0.000$). Changes in these variables are predicted by aircraft noise annoyance at T1.

Given the objective of the present paper, the results are contrary to expectations. We were not able to reveal any significant effects from the psychological factors to aircraft noise annoyance. Moreover, only 2 effects were significant the other way around. Yet we can offer two explanations for the present results, which are intrinsically relevant in light of our aim. The empirical evidence for these explanations is provided in Table 3, which presents the 91 correlations between the time 1 exogenous variables and the 14 stability coefficients (on the diagonal).

The first explanation relates to the correlations between the time 1 exogenous variables. It can be observed that the intercorrelations between the constructs are generally high. The strong overlap between the exogenous variables has a suppressive effect on the estimated cross-lagged relationships. Hence, given that several 'time 1' variables are (empirically) indistinctive, they have no explanatory force over and above the autoregressive effects (i.e., the stability coefficients).

The second explanation relates to the stability coefficients. These coefficients are generally high, ranging from 0.58 (for 'belief that noise can be prevented') to 0.92 (for 'personal dependency on the noise source'), indicating that the psychological variables are very stable. In other words, little individual changes had occurred in the period between the two surveys. Given that the unexplained proportions of variance in the endogenous variables were small, there remained little variance to be predicted by the time 1 exogenous variables, which, in turn, decreased the probability of any cross-lagged effect to become significant.

Hence due to the consistency of variable scores at one moment in time, as well as the consistency of variable scores over time, any lagged effect has to be very strong to overcome these two 'suppressors.' Model 5 showed that only 2 lagged effects were indeed strong enough to become significant. Although the presence of lagged effects can be largely excluded, the substantial increase in model fit between models 1 and 2 (with the addition of

correlations between the error terms of the endogenous variables) indicates that changes in the model variables are correlated. Table 4 presents the correlations between the error terms of the endogenous variables. Here, a significant correlation between 2 residual terms indicates that the changes in the 2 respective variables are correlated. From this table, it can be deduced that change in aircraft noise annoyance is significantly associated with changes in the other variables. These parallel changes cannot be explained by the cross-lagged relationships.

Table 3. Correlations between exogenous variables (in the lower left triangle) and stability coefficients (on the diagonal)

Construct	NA	PD	NE	NS	FN	PS	AS	CH	NN	DS	CC	BP	DV	L_{den}
Noise annoyance (NA)	**.80**													
Perceived disturbance (PD)	.92	**.86**												
Negative expectations towards noise development (NE)	.68	.66	**.62**											
Noise sensitivity (NS)	.52	.52	.42	**.91**										
Fear of noise source (FN)	.61	.60	.52	.44	**.82**									
Positive social evaluation of noise source (PS)	-.53	-.48	-.57	-.45	-.54	**.82**								
Negative attitude towards noise source authorities (AS)	.65	.59	.74	.50	.54	-.84	**.84**							
Concern about the negative health effects of noise and pollution (CH)	.80	.79	.70	.57	.67	-.63	.74	**.87**						
Annoyance related to non-noise effects (NN)	.64	.62	.49	.43	.62	-.56	.59	.78	**.90**					
Personal dependency on the noise source (DS)	-.18	-.21	-.38	-.13	-.12	.27	-.39	-.26	-.08	**.92**				
Perceived control and coping capacity (CC)	-.78	-.73	-.71	-.57	-.54	.55	-.74	-.83	-.61	.28	**.91**			
Belief that noise can be prevented (BP)	.52	.50	.59	.32	.46	-.61	.68	.59	.45	-.23	-.59	**.58**		
Concern about property devaluation (DV)	.46	.44	.43	.27	.39	-.29	.45	.48	.41	-.09	-.42	.40	**.80**	
Aircraft noise exposure (L_{den})	.17	.19	.13	.17	.06	-.15	.26	.17	.24	-.07	-.16	.09	.17	**.98**

Underlined: significant at $P < .05$

3.4 Discussion

Although the presence of lagged effects can be (largely) excluded, the substantial correlations between the error terms of the endogenous variables (Table 4) indicate that the model variables did change in the same directions. Two explanations can account for this empirical trend. One is that unmeasured third variables had influenced the model variables during the period between the two surveys; the other is that (unidirectional or reciprocal) synchronous effects between the variables exist.

Related to the first explanation ('third variable' influence), can speculate that (1) a psychological explanation, (2) a social explanation and/ or (3) an acoustical explanation can account for the correlated changes. Related to the psychological explanation, it might be that a personal factor like 'negative affectivity,' a general tendency to have a negative view of oneself and the environment (Watson and Clark, 1984) is responsible for the changes in pairs of variables. The permanent exposure to noise may eventually bring people into a negative affective state (Miedema and Vos, 2003).

Table 4. Correlations between the error terms of the endogenous variables

Construct	NA	PD	NE	NS	FN	PS	AS	CH	NN	DS	CC	BP	DV
Noise annoyance (NA)													
Perceived disturbance (PD)	.95												
Negative expectations towards noise development (NE)	.45	.46											
Noise sensitivity (NS)	.31	.16	.22										
Fear of noise source (FN)	.25	.24	.22	.21									
Positive social evaluation of noise source (PS)	-.07	-.14	-.05	-.07	-.11								
Negative attitude towards noise source authorities (AS)	.28	.22	.53	.11	.01	-.49							
Concern about the negative health effects of noise and pollution (CH)	.53	.54	.34	.48	.17	-.30	.37						
Annoyance related to non-noise effects (NN)	.21	.27	.21	.66	.35	-.09	.18	.29					
Personal dependency on the noise source (DS)	-.07	.05	-.12	-.29	-.02	.30	-.18	-.17	-.14				
Perceived control and coping capacity (CC)	-.77	-.77	-.48	-.38	-.10	.63	-.65	-.72	-.32	-.05			
Belief that noise can be prevented (BP)	.24	.22	.35	.29	.28	-.34	.44	.19	.35	-.32	-.19		
Concern about property devaluation (DV)	.23	.22	.36	.07	.30	-.51	.29	.47	.44	-.19	-.44	.19	
Aircraft noise exposure (L_{den})	-.08	-.11	-.02	-.02	.02	.16	-.09	.07	.06	.07	.24	-.05	-.08

Underlined: significant at $P< .05$

Alternatively, it might be that some sort of socialization process underlies the correlated changes. Bröer (2006) and Kroesen and Bröer (2009) recently showed the relevance of this explanation. These authors assumed that policy actors' conceptualization of the noise problem would resonate among the general public and would shape the necessary evaluative frames to feel annoyed. Since these frames were defined as sets of interrelated positions, this explanation fits nicely with the observed correlational pattern in Table 4, which shows that many changes among the variables are correlated. In other words, the interrelated changes are congruent with the idea of a frame, which, if a shift occurs, would result in a change in a whole set of different variables.

An acoustical explanation can also not wholly be ruled out. In the model, all effects between exogenous and endogenous variables are controlled for the level of aircraft noise exposure in L_{den} at time 1 (model 3). In addition, given that this variable has a stability coefficient of 0.98 (Table 3), very few changes occurred in this variable between the two surveys. Yet, although L_{den} cannot be responsible, it might be that changes occurred in the structure of the noise load. In this respect, Guski (2004) mentions the empirical trend that the average noise load of single events generally decreases, but that the number of events increases. Such a change would be concealed by an annual energy-equivalent noise metric like L_{den} and can also provide a plausible 'third-variable' explanation.

Finally, it should be noted that the psychological, social and acoustical explanations do not cancel each other out and may be empirically interwoven in many ways.

The second explanation for the correlated error terms is that synchronous effects between the variables exist, which would imply that changes in the variables after the first measurement at time 1 led to the changes in the endogenous variables at the second measurement (De Jonge et al., 2001). In our model, such synchronous effects would also be captured by the correlations between the error terms of the endogenous variables.

Again, however, we cannot empirically assess the validity of these competing explanations (i.e., the influence of 'third variables' versus that of synchronous effects). The only

conclusion we can draw that is relevant in light of our aim is that the values of many variables in the model had changed in similar directions.

In all, we can conclude that establishing the direction of causality between aircraft noise annoyance and psychological variables in the field remains a difficult project. As the present study has illustrated, this conclusion holds even when panel data are available. Although providing direct (internally and externally valid) evidence remains difficult, it should be noted that the lack of explanatory power of acoustic variables in relation to individual subjective noise reactions can be taken as indirect evidence that these social-psychological variables do indeed matter.

3.5 Conclusion

In this paper, we aimed to establish the direction of causality between several psychological factors and aircraft noise annoyance. For this purpose, a panel model was estimated within a structural equation modeling approach. Data were gathered at two moments in time from the population living within the 45 L_{den} contour around Schiphol airport. Preliminary analysis of the data showed that there was no nonresponse bias with respect to aircraft noise exposure and aircraft noise annoyance. The results of the main analysis indicate that none of the paths from the psychological factors to aircraft noise annoyance are significant. Yet 2 effects were found to be significant the other way around: (1) from 'aircraft noise annoyance' to 'concern about the negative health effects of noise' and (2) from 'aircraft noise annoyance' to 'belief that noise can be prevented.' Hence aircraft noise annoyance measured at time 1 contained information that can effectively explain changes in these 2 variables at time 2, while controlling for their previous values. In sum, our main hypothesis, i.e., the identified psychological factors influence aircraft noise annoyance, could not be confirmed.

Secondary results show that (1) aircraft noise annoyance is very stable through time (stability coefficient of 0.83) and (2) that changes in aircraft noise annoyance and the identified psychological factors are correlated. Establishing the direction of causality between aircraft noise annoyance and possible social-psychological factors is important for noise policy. Policies specifically aimed at these factors can only be effective if the causality indeed 'flows' from these factors to aircraft noise annoyance. A second and related issue, which is also relevant for policy, is whether individual differences can be attributed to social or psychological variables and processes. If, for instance, personality traits appear to be dominant in the explanation of individual differences, more individually 'tailored' noise policies would be preferable. If, on the other hand, social representations are dominant in structuring noise perception and evaluation, a closer examination of the collective noise policy and the message it brings across would be more appropriate.

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4. Annoyance as a Reflection of a General Attitude

Kroesen, M. and Schreckenberg, D. (2011) A measurement model for general noise reaction in response to aircraft noise. *Journal of the Acoustical Society of America*, 129, pp. 200-210.

Abstract

In this paper a measurement model for general noise reaction (GNR) in response to aircraft noise is developed to assess the performance of aircraft noise annoyance and a direct measure of general reaction as indicators of this concept. For this purpose GNR is conceptualized as a superordinate latent construct underlying particular manifestations. This conceptualization is empirically tested through estimation of a second-order factor model. Data from a community survey at Frankfurt Airport are used for this purpose (N = 2206). The data fit the hypothesized factor structure well and support the conceptualization of GNR as a superordinate construct. It is concluded that noise annoyance and a direct measure of general reaction to noise capture a large part of the negative feelings and emotions in response to aircraft noise but are unable to capture all relevant variance. The paper concludes with recommendations for the valid measurement of community reaction and several directions for further research.

4.1 Introduction

As indicated by Job et al. (2001) the valid measurement of community reaction in response to environmental noise is important for two reasons: First, it, in itself, can be regarded as an important negative health factor defined broadly as the absence of social well-being, and second, it may contribute to noise-induced health problems (e.g., self-reported symptoms, hypertension, mental health problems). The latter reason becomes even more important since there is evidence that reaction to noise is a better predictor of noise-related health effects than noise exposure itself (Job, 1996; Job et al., 2001). Furthermore, Job et al. (2001) contend that noise annoyance questions, which are mainly used to assess negative reaction in socio-acoustic surveys, fail to measure many possible and important reactions to noise. According to the authors, noise annoyance measures are too narrow to capture the full breadth of human reaction. Obviously, this is a serious problem if associations between subjective reaction to noise and possible consequences are studied.

Job et al. (2001) illustrate the narrowness of noise annoyance as a measure of general negative reaction to noise with reference to Hede et al. (1979) who found that respondents use many different words, other than and (semantically) unrelated with annoyance, to describe their feelings in response to noise. Hence, as argued by Job and Sakashita (2007), it is likely that measures, such as the standardized noise annoyance questions of Fields et al. (2001), capture only a part of subjects' overall (negative) assessment with respect to the impact of a certain noise source on one's living conditions. Job et al. (2001) substantiate this argument by showing that general measures of reaction to noise (being dissatisfied by noise and perceived affectedness) have superior psychometric properties in comparison to specific reactions such as noise annoyance.[15] According to Job and Sakashita (2007) the inclusion of these general measures is therefore imperative for the valid measurement of human reaction to noise.

By measuring general reaction to noise via direct measures, Job et al. (2001) implicitly assume the existence of an abstract underlying construct in which all negative feelings and emotions in response to (aircraft) noise are integrated. In addition, by showing that the general noise reaction (GNR) measures are more strongly correlated with the measures of activity disturbance than the noise annoyance measures, they support the conclusion that GNR measures are able to capture more relevant variance in responses to noise. However, although Job et al. (2001) show that general measures capture more relevant variance in the prediction of other concepts (i.e., activity disturbance), it remains unclear whether these measures indeed capture all the relevant variance. In addition, to assess the validity of direct general reaction measures, preferably criteria outside the content domain of general reaction to noise should be used. Similar to noise annoyance, activity disturbance can be regarded as a particular dimension of general reaction and not as a relevant criterion variable of this construct.

With this background the main aim of the present study is to develop a measurement model of GNR, which can be shown to capture all relevant variance in response to aircraft noise. To develop this model we conceptualize GNR as a latent multidimensional construct that underlies particular manifestations such as noise annoyance and activity disturbance. Based on classical test theory we assume that noise annoyance and other measures of subjective reaction to noise contain, in part, "true" variance related to the theoretical concept we wish to measure (i.e., GNR) and, in part, dimension specific variance. By measuring GNR indirectly via multiple dimensions the concept is "stripped" from dimension specific variance. Only the

[15] The study of Job et al. (2001) was based on a relatively small number of subjects (N = 97) in a change situation. Their results with respect to the reliability and validity of general reaction measures should therefore be interpreted with care.

variance common to all dimensions remains. Next, by modeling the specific dimensions as well as the second-order concept (GNR) in a single model together with aircraft noise exposure and relevant criterion variables, it can be assessed whether the variance captured by GNR indeed represents all of the relevant subjective variability resulting from exposure to aircraft noise.

In this study, perceived mental health and physical health are identified as relevant criterion variables. Research has previously established associations between subjective noise reaction and health outcomes, ranging from self-reported effects, such as (self-reported) psychosocial well-being (Job, 1996), to objective medical outcomes, such as increased blood pressure (Babisch et al., 2007). Based on these previously established relationships we assume that GNR influences a person's mental and physical health and that these assumed consequences of GNR are suitable as criteria for validity analysis of GNR.

If sufficient support is found for the validity of the proposed conceptualization, which would support the conclusion that GNR indeed captures all the relevant subjective variability resulting from exposure to aircraft noise, the secondary aim is to examine how well aircraft noise annoyance and a direct measure of general reaction to noise (dissatisfaction with aircraft noise) perform as indicators of this construct.

To attain the above-stated aims a structural equation model is estimated based on data from a field survey conducted near Frankfurt airport. Within this modeling approach the dimensions of GNR, as well as GNR as a second-order factor, can be specified in a single confirmatory factor model, allowing us to assess and compare the predictive ability of GNR versus the dimensions of GNR in relation to the included criterion variables. Additionally, a structural equation model can account for measurement errors (present in observed variables) leading to less biased parameter estimates between the structural variables.

4.2 Development of a measurement model for GNR

In this section the measurement model for GNR will be developed. First, the theoretical background of multidimensional constructs is described (Section 4.2.1). Second, the content domain of GNR will be established (Section 4.2.2). Finally, it concludes with the specification of the measurement model of GNR and its theoretical underpinnings (Section 4.2.3).

4.2.1 Multidimensional constructs

According to Law et al. (1998) a multidimensional construct can be conceptualized as an overall abstraction that represents several distinct but interrelated dimensions which can be grouped together into a single theoretical concept. It can therefore be distinguished both from a unidimensional construct, which refers to a single theoretical concept (e.g., noise annoyance), and from multiple dimensions, which may be related but cannot be unified in an overall theoretical concept (Edwards, 2001).

In principle, there are two ways to specify a multidimensional construct (see Figure 1). The first assumes the direction of causality to flow from the construct to the dimensions, which is called a reflective (latent factor) model (Nunnally, 1978; Bollen, 1989), and the second assumes the direction of causality to be from the dimensions to the construct, which is called a formative (aggregate composite) model (Fornell and Bookstein, 1982; Bollen and Lennox, 1991). Jarvis et al. (2003) give an exhaustive overview of the differences between formative or reflective models, which will be briefly described in the following paragraphs.

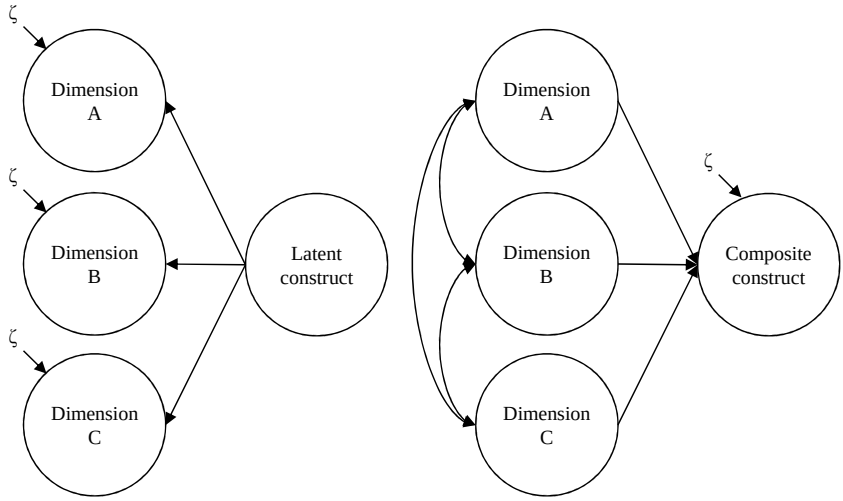

Figure 1. Reflective (left) and formative (right) measurement model. Explanation of terms: ζ: Error term of latent construct

A reflective model assumes that the dimensions are manifestations of the underlying construct. Any change in the construct will result in changes in the dimensions and the dimensions are therefore expected to covary. In addition, the dimensions share a common theme, which means that they are interchangeable and that dropping a dimension does not alter the conceptual domain of the construct. Finally, because the dimensions share the same nomological net they are assumed to have the same consequences and antecedents.

In contrast, the formative model assumes that the dimensions are defining components of the construct. It is therefore important that all components relevant to the conceptual definition of the construct are included as dimensions. Changes in these dimensions are assumed to cause changes in the construct and not vice versa. Hence, these dimensions do not share a common theme, are not necessarily assumed to covary, are not interchangeable, and can have different antecedents and consequences.

Jarvis et al. (2003) also mention two similarities between formative and reflective models. First, both models capture surplus meaning beyond the specific components used to measure the constructs. They represent abstract entities that are not wholly reducible to empirical terms. A reflective construct is reduced to the common part (factor) of a set of dimensions, in effect, capturing a more complex and abstract idea than all dimensions individually. A formative construct combines the individual components and, as a result, captures the meaning of the individual dimensions taken together, which also goes beyond the meaning of the dimensions individually. A second similarity, which is related to the previous one, is that neither model can be adequately represented by a scale score, which, if adopted, would lead to inconsistent structural estimates between the construct and other latent variables (Jarvis et al., 2003).

To specify a construct it must be identified as either reflective or formative. For this purpose Jarvis et al. (2003) developed a comprehensive list of criteria to guide the specification of the relationships between the dimensions and the construct. These are presented in Table 1 and will be used in Section 4.2.3 to identify the construct of GNR to aircraft noise as either formative or reflective.

Table 1. Criteria for determining whether a construct is formative or reflective

	Reflective model	Formative model
1. Direction of causality from construct to dimension implied by the conceptual definition	Direction of causality is from construct to dimensions	Direction of causality is from dimensions to construct
	Dimensions are manifestations of the construct	Dimensions are defining characteristics of the construct
2. Interchangeability of the dimensions	Dimensions should be interchangeable	Dimensions need not be interchangeable
	Dimensions should share a common theme	Dimensions need not share a common theme
	Dropping a dimensions should not alter the conceptual domain of the construct	Dropping a dimensions may alter the conceptual domain of the construct
3. Covariation among the indicators	Dimensions are expected to covary	Dimensions need not necessarily covary
4. Nomological net of the construct dimensions	Nomological net of the construct dimensions should not differ	Nomological net of the construct dimensions may differ
	Dimensions are required to have the same antecedents and consequences	Dimensions are not required to have the same antecedents and consequences

Source: Jarvis *et al.* (2003)

4.2.2 Dimensions of GNR

In order to measure GNR to aircraft noise its content domain has to be established. Based on a review of the literature three dimensions of GNR are identified: Noise annoyance, activity disturbance, and feelings of anxiety and fear.

Noise annoyance

Aircraft noise annoyance is the most often used indicator to assess negative reaction to noise in socio-acoustic surveys (Job et al., 2001). According to Guski (1999) indicator captures the (long-term) evaluative aspect of the reaction to aircraft noise. Since there is ample evidence that this dimension is associated with aircraft noise exposure (see, e.g., Schultz, 1978; Fidell et al., 1991), it can be identified as a relevant dimension of GNR.

Activity disturbance

This concept has been given different labels by various authors, but they all convey the same general meaning. For instance, Taylor (1984) uses sleep disturbance and speech interferences to capture its nature; Ahrlin (1988) uses the term interference with daily activities which he decomposes into speech interference, interference with resting and sleeping, and the awakening effect; Guski (1999) refers to it as short-term annoyance; and Guski et al. (1999), based on the results of an expert review, refer to it as immediate behavioural noise effects. Among others, Kryter (1982) and Taylor (1984) show that activity disturbance increases with higher levels of noise exposure [using metrics as L_{dn} and $L_{eq(24)}$]. It can therefore be concluded that the concept of activity disturbance forms a relevant dimension of GNR.

Feelings of anxiety and fear

This dimension includes the evaluation of physical risks associated with the presence of the airport, like the fear for an aircraft crash or anxiety related to the negative health effects of noise, as well as the evaluation of non-physical risks, and like the fear that noise levels will increase in the future or the concern about property devaluation. Again, previous research has

established significant correlations between indicators of this dimension and aircraft noise exposure (see, e.g., Alexandre, 1976, for the association between noise exposure and "fear for an aircraft crash"). It can therefore be identified as a relevant dimension of GNR.

Table 2 summarizes the identified dimensions and possible alternative labels. It can be argued that several relevant reactions to aircraft noise have not been exhaustively sampled (e.g., related to anger, perceived control, trust in the authorities). These dimensions were not considered because the present questionnaire did not include appropriate indicators to measure them. Yet, since GNR is conceptualized as a reflective multidimensional construct, this possible omission is not problematic. For a reflective construct it holds that dropping a dimension does not alter the conceptual domain of the underlying construct (Jarvis et al., 2003). It is therefore not imperative that all manifestations of GNR are included. The choice for a reflective model is justified in the next section.

Table 2. Identified dimensions of GNR to aircraft noise and alternative labels

Dimension	Alternative labels
Noise annoyance (NA)	- Nuisance, unpleasantness, and getting on one's nerves (evaluative aspects of noise) (Guski *et al.*, 1999)
Activity disturbance (AD)	- Sleep disturbance, speech interferences (Taylor, 1984); - Speech interference, interference with resting and sleeping and the awakening effect (Ahrlin, 1988); - Activity interference (Hall *et al.*, 1985; Lercher, 1996); - Short-term reactions (Guski, 1999); - Immediate behavioural noise effects (Guski *et al.*, 1999).
Feelings of anxiety and fear (AF)	- Perceived health effects of noise (McKennell, 1963); - Fear of aircraft accidents (Leonard and Borsky, 1973); - Fear of danger/health effect (Lercher, 1996); - Fear of the noise source (Miedema and Vos, 1999); - Fear or harm connected with the noise source (Guski, 1999). - Fear of property devaluation due to aircraft noise (Kroesen et al., 2008).

4.2.3 Specification of GNR

Based on the decisional rules presented in Table 1 GNR to aircraft noise is identified as a reflective multidimensional construct. The justification is elaborated below.

Related to the first rule it is assumed that GNR is an abstract negative feeling that becomes manifested in particular responses to aircraft noise. Based on previous research of Bröer (2006), Bröer and Duyvendak (2009), and Kroesen and Bröer (2009), we expect that people develop a general attitude about aircraft noise, which becomes manifested in particular responses to the noise. Therefore, in line with the reflective model, the direction of causality is assumed to flow from the construct to the dimensions. Related to the second rule it can be determined that the identified dimensions of GNR all share a common theme, namely the (negative) response to aircraft noise. Hence, in contrast to the formative model, dropping or omitting a dimension does not alter the conceptual definition of the construct, which is also why it is not imperative that all possible dimensions are included. Related to the third rule it is expected that the dimensions of GNR covary. For example, if one becomes more annoyed by aircraft noise, one is also expected to be more disturbed by it and become more fearful and worried about the risks. Hence, we expect that the dimensions are mutually interrelated. Finally, the dimensions of GNR share the same nomological net. They are expected to have similar antecedents (e.g., the level of aircraft noise exposure) and consequences (e.g., mental and physical health). Hence, each dimension can be placed in a similar nomological network.

To operationalize GNR as a reflective construct it could be specified as a first-order latent factor with its dimensions as observed variables. However, as Edwards (2001) notes, this

approach confounds random measurement error (present in observed items) with dimension specificity (i.e., the systematic variance not captured by GNR) and ignores differences in the relationships between each dimension and its measures. Therefore, to exclude measurement errors at the level of the dimensions, the dimensions are not measured directly but indirectly via multiple observed indicators (Bagozzi and Edwards, 1998). In effect, GNR, as a second-order latent factor, will only extract the common variance from these "pure" dimensions. The left side of Figure 2 presents the second-order factor model. In the terminology of Edwards (2001) this model can be classified as a superordinate construct. In the remainder of this paper we will discuss about the present conceptualization as such.

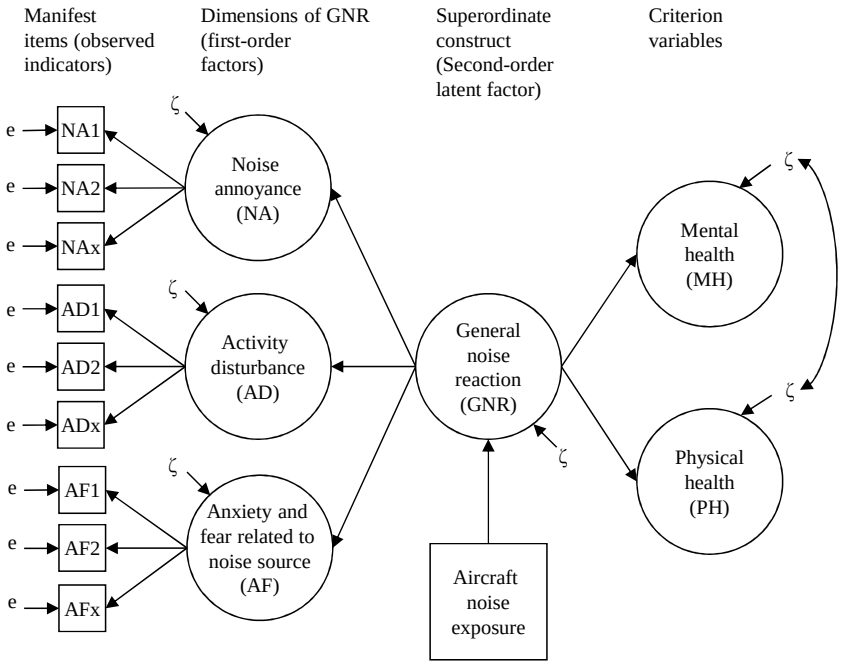

Figure 2. Superordinate construct model of GNR as a cause of mental and physical health
Explanation of terms: e: Error term of observed variable, ζ: Error term of latent construct

4.3 Method

4.3.1 Validation approach

The validity of GNR as a superordinate construct is tested in three ways. First, the model fit will be reviewed to assess whether the data support the second-order factor structure. Given the large sample size, the χ^2 statistic, which indicates the discrepancy between the model-observed and the model-implied covariance matrices, will be significant even with trivial differences between the matrices. The following fit indices, which are not dependent on sample size, are therefore used to evaluate the fit of the estimated model: The root mean square error of approximation (RMSEA) (Browne and Cudeck, 1993), the standardized root mean residual (SRMR), and the comparative fit index (CFI) (Bentler, 1990). A well-fitting

model is defined as having values below 0.06 and 0.08 for RSMEA and SRMR, respectively, and a CFI value greater than 0.95 (Hu and Bentler, 1999).

Second, the convergent validity will be examined by assessing the size and significance of the parameter estimates (i.e., the factor loadings) and the residual covariances to exclude the presence of local misspecifications (i.e., cross-loadings and/or correlations between the error terms).

Third, in line with the strategy outlined by Edwards (2001), the construct validity of GNR will be assessed. This will be done in three ways. First, it will be examined whether the specific dimensions (i.e., noise annoyance, activity disturbance, and feelings of anxiety and fear) can explain variance in the two outcome variables, i.e., (self-reported) physical health and mental health, over and above the GNR construct, or whether GNR indeed captures all relevant variances for this prediction. If the latter is the case, this would support the construct validity of the GNR construct; for it would show that variance specific to the dimensions is irrelevant in the prediction of the criterion variables. In other words, that only the variance that is common to all dimensions (captured by GNR) is relevant.

Second, it will be assessed whether GNR can effectively mediate the effects of aircraft noise exposure on the dimensions of GNR. If, on the one hand, the direct paths between aircraft noise exposure and the dimensions of GNR are zero (after controlling for the indirect paths via GNR), it can be inferred that variance specific to the dimensions of GNR cannot be attributed to exposure to aircraft noise. It would then be legitimate to ignore specific dimension variance and regard the common variance captured by the second-order construct (GNR) as the only true variance. If, on the other hand, the specific variance in the dimensions can be explained by aircraft noise exposure (over and above GNR), dimension specificity can and should not be neglected, since it constitutes subjective variability resulting from exposure to aircraft noise.

Third, it will be assessed whether GNR can effectively mediate the effects of aircraft noise exposure on the criterion variables of GNR, i.e., mental and physical health. This would reflect the idea that only those consciously affected by aircraft noise (as a form of stress) will suffer from (mental and/or physical) health effects due to the noise. If the direct relationships between aircraft noise exposure and the criterion variables are insignificant, it can be inferred that there are no other cognitive mediators present in the noise–health relationship (other than GNR). In other words, that GNR is the only relevant cognitive mediator. It should be noted that, however, the presence of direct effects between noise exposure and the criterion variables does not directly invalidate GNR. Previous research has shown that direct effects between noise and health are present for which it is less likely that they are mediated by cognitive variables [see, e.g., Haralabidis et al. (2008) who found a significant direct effect between night-time noise exposure and blood pressure]. Hence, the presence of significant direct effects does not necessarily indicate that there are other intervening psychological variables at work in the noise-health relationship.

To summarize, evidence of construct validity of GNR is present when (1) the direct paths from the dimensions to the criterion variables are zero, (2) the direct paths from aircraft noise exposure to the dimensions are zero, and (3) the direct paths from aircraft noise exposure to the criterion variables are zero.

Mental health and physical health are chosen as criterion variables because (1) the concepts lie outside the content domain of noise reaction, (2) the concepts are sufficiently broad to function as relevant criterion variables (Edwards, 2001), and (3) health-related variables have previously been shown to be associated with noise reaction. With respect to the last point it has previously been established that noise reaction is associated with mental health (Van Kamp et al., 2007), blood pressure (Babisch et al., 2007), (self-reported) high blood pressure

(Black et al., 2007), antihypertensive treatment use (Neus et al., 1983), and (self-reported) physical health problems (Hatfield et al., 2001). These studies were based on cross-sectional data and so do not provide definitive evidence of causality. It might be that, for example, the direction of causation is opposite, i.e., bad health causes increased noise reaction (Job, 1996; Tarnopolsky et al., 1978). Alternatively, a "third" underlying variable might explain the association between noise reaction and health, e.g., noise sensitivity (Stansfeld, 1992), positive affect (Cohen and Pressman, 2006), or negative affect (Watson, 1988). Theoretical and empirical considerations, however, suggest that a causal relationship exists between psychological reaction and health (Job, 1996). In all, we believe that (self-reported) mental health and physical health are suited as criterion variables to assess the validity of GNR.

The criterion variables are included in the model (see the right side of Figure 2). Since these variables may covary for reasons other than sharing the superordinate construct as a cause (e.g., they may influence each other or both be influenced by a third variable), the error terms of these constructs are allowed to correlate.

If the results are supportive for the specified factor structure, the question to what extent noise annoyance captures the relevant variance resulting from exposure to aircraft noise can be easily answered through examination of the (standardized) factor loadings of this dimension and its indicators. In addition, the correlation coefficient between GNR and a direct measure of general reaction to noise (dissatisfaction with aircraft noise) will be computed to provide information as to how well this measure performs as an indicator of GNR.

4.3.2 Data

The data to test the hypothesized model in Figure 2 is obtained from an aircraft noise study conducted in Germany at Frankfurt Airport (N = 2,312), described in Schreckenberg and Meis (2006). This survey was conducted in the period April through December 2005. Within this study a random sample was drawn from residents living in 66 residential areas located within a 40 km radius around the Frankfurt Airport. The selection of these areas resulted from the combination of different strata for the level of noise exposure and four directions from the airport (northwest, east, south, and west). In practice, this resulted in an oversampling of residents living close to the airport. The response rate was 61%. Cases with more than 10% of the values missing are deleted (N = 106), and the remaining missing values (1.1%) are imputed via the expectation-maximization algorithm of SPSS.

4.3.3 Measures

To exclude the presence of measurement errors at the level of the dimensions they are treated as latent constructs and measured with multiple observed indicators. Table 3 presents the used indicators of the dimensions of GNR. The items used for noise annoyance (NA1 and NA2) exactly match the standardized noise reaction questions developed by Fields et al. (2001). These questions are formulated as follows: (1) "Thinking about the last 12 months or so, when you are here at home, how much does noise from aircraft noise bother, disturb, or annoy you?" and (2) "Next is a zero to ten opinion scale for how much aircraft noise bothers, disturbs, or annoys you when you are here at home. If you are not at all annoyed choose zero, if you are extremely annoyed choose ten, if you are somewhere in between choose a number between zero and ten. Thinking about the last 12 months or so, what number from zero to ten best shows how much you are bothered, disturbed, or annoyed by aircraft noise?" (Fields et al., 2001).

The direct measure of general reaction to noise (presented in the second last row of Table 3) related to the question "How satisfied are you with respect to the environmental condition of aircraft noise?" (Responses are recoded.)

Table 3. The constructs and their indicators (label, range, mean and standard deviation)

Dimension	Observed indicator	Label	Range	Mean	S.D.
Noise annoyance	Aircraft noise annoyance (past 12 months)	NA1	[0=not at all annoyed - 10=extremely annoyed]	4.85	3.17
	Aircraft noise annoyance (past 12 months)	NA2	[1=not at all, 2=slightly, 3=moderately, 4=very, 5=extremely]	3.07	1.34
Activity disturbance	Disturbance during relaxation	AD1	[1=not at all, 2=slightly, 3=moderately, 4=very, 5=extremely]	2.36	1.32
	Disturbance during conversations/telephone calls	AD2	[1=not at all, 2=slightly, 3=moderately, 4=very, 5=extremely]	2.23	1.28
	Disturbance during reading, concentrating	AD3	[1=not at all, 2=slightly, 3=moderately, 4=very, 5=extremely]	2.19	1.29
	Disturbance during domestic cosiness or visitation	AD4	[1=not at all, 2=slightly, 3=moderately, 4=very, 5=extremely]	2.13	1.23
	Disturbance during sleeping	AD5	[1=not at all, 2=slightly, 3=moderately, 4=very, 5=extremely]	2.00	1.28
Anxiety and fear related to the noise source	Health threatened by stress caused by aircrafts	AF1	[1=not, 2=a little, 3=reasonably, 4=fairly, 5=very]	2.16	1.34
	Hearing threatened by aircraft noise	AF2	[1=not, 2=a little, 3=reasonably, 4=fairly, 5=very]	1.92	1.16
	Threatened by the low altitude of over flying aircrafts	AF3	[1=not, 2=a little, 3=reasonably, 4=fairly, 5=very]	2.27	1.35
	Threatened by property devaluation due to aircraft noise	AF4	[1=not, 2=a little, 3=reasonably, 4=fairly, 5=very]	2.37	1.53
Direct measure	**Observed indicator**	**Label**	**Range**	**Mean**	**S.D.**
General reaction to noise	Dissatisfaction with aircraft noise	-	[1=very satisfied, 2=fairly satisfied, 3=rather satisfied, 4=rather dissatisfied, 5=dissatisfied] (recoded)	3.63	1.03
Cause	**Observed indicator**	**Label**	**Range**	**Mean**	**S.D.**
Aircraft noise exposure	L_{den} dB(A)	L_{den}	[43.8-70.3]	56.9	6.87

For each address individual aircraft noise levels were calculated on the basis of flight movements of the six busiest months of the year 2005 according to the German regulation for aircraft noise calculation. For the present study L_{den} [i.e., level day–evening–night in dB(A)] is selected as a measure of the level of aircraft noise exposure.[16] Univariate statistics for this measure are presented in the last row of Table 3.

Physical health and mental health are measured using the previously validated scales of the 12-item Short Form (SF-12) Health Survey (Ware et al., 1996). The SF-12 Health Survey constitutes a subset of 12 items from the SF-36 Health Survey (with 36 items) and covers eight health concepts: Physical functioning, role limitations due to physical health, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems, and mental health (Ware and Sherbourne, 1992). Studies of the factor structure of the SF-36 Health Survey consistently revealed two underlying dimensions of these concepts, namely

[16] L_{den} is an equivalent sound level of 24h expressed in decibels (dB) on the "A" weighted scale dB(A). Sound levels during the evening (7 p.m. to 11 p.m.) and during the night (11 p.m. to 7 a.m.) are increased by a penalty of 5 and 10 dB(A), respectively.

physical health and mental health (Ware et al., 1998). This factor structure (eight first-order factors and two second-order factors) has been validated in a confirmatory factor model with data from multiple countries (Keller et al., 1998). It has been shown that the SF-12 Health Survey can adequately reproduce the physical and mental components of the SF-36 (Gandek et al., 1998). For a German sample, correlations between the SF-12 and the SF-36 summary measures were 0.96 and 0.94 for the physical and mental health summary measures, respectively (Gandek et al., 1998). For the present study physical and mental component measures are computed based on population normative data derived from a German sample (Bullinger and Kirchberger, 1998). These measures are included as observed indicators of two respective latent variables (i.e., physical and mental health) in the structural equation model. The reliability of the latent variables is fixed based on previously observed test-retest correlations of 0.89 and 0.76 for the physical and mental health summary measures, respectively (Ware et al., 1996). In effect, the parameter estimates of the paths between GNR and the criterion variables are corrected for random measurement errors.

4.3.4 Estimation procedure

With the exception of aircraft noise exposure the indicators in Table 3 are measured on ordinal scales. For these measures polychoric correlations are computed. Compared to three other types of correlations (e.g., Pearson, Spearman, and Kendall) the polychoric correlation has been shown to be the least biased in the case of ordinal variables (Jöreskog and Sörbom, 1996). In addition, this bias becomes negligible for moderate to large sample sizes (Jöreskog and Sörbom, 1996). Finally, the polychoric correlation estimates have been shown to be robust to moderate violations of normality of the assumed underlying continuous variables (Flora and Curran, 2004).

Substituting the polychoric correlation matrix with the product-moment correlation matrix and applying the usual maximum likelihood estimation function will yield consistent parameter estimates, but incorrect test statistics and standard errors. In response, the weighted least squares (WLS) approach has been developed to yield unbiased estimates and standard errors (Browne, 1984). In this study, robust WLS approach is used to estimate the model. Based on the results of a simulation study Flora and Curran (2004) concluded that this estimation method performs well under various conditions (i.e., at varying sample sizes, underlying distributions of the continuous variables, numbers of indicators, and numbers of categories of the indicators). The authors recommended its use especially for medium-to-large models with ordinal variables.

The polychoric correlation matrix and the asymptotic covariance matrix, which are necessary for the use of the robust WLS method, are calculated in PRELIS 2, and LISREL 8.8 is used to estimate the structural equation model.

4.4 Results

4.4.1 Model fit

Based on the fit statistics it can be concluded that the data set fits the second-order factor structure described in Figure 2 well. All statistics are above or below their respective lower and upper limits < 0.06, SRMR = 0.036 < 0.08, and CFI = 0.99 > 0.95).

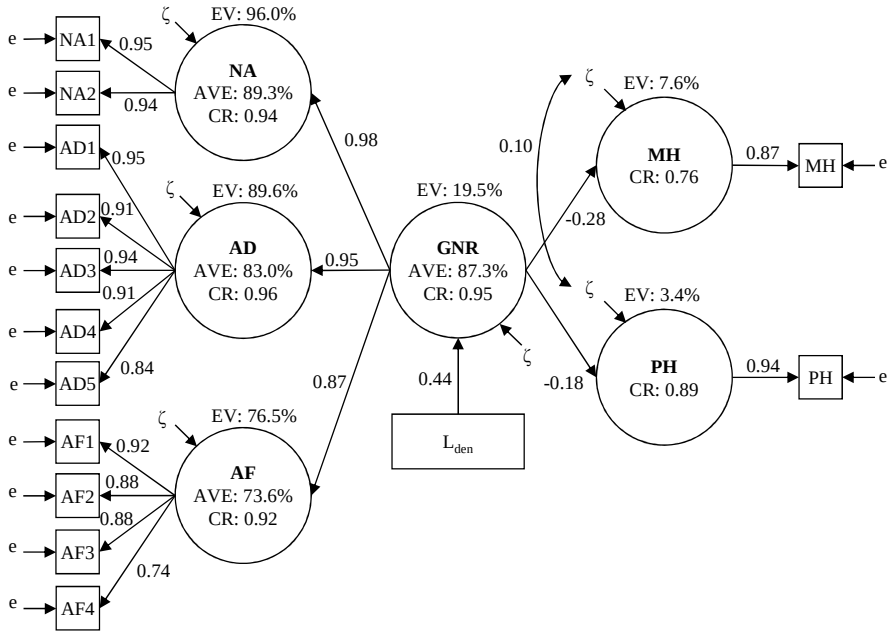

Figure 3. Standardized solution of the superordinate construct model (N = 2,206)
Fit statistics: χ^2 = 430.8, *Df* = 73, RMSEA = 0.042, SRMR = 0.036, CFI = 0.99. EV: Explained variance; AVE: Average variance extracted; CR: Construct reliability; e: Error term of observed variable; and ζ: Error term of latent construct.

4.4.2 Convergent validity

The estimated factor loadings are all significant ($p < 0.001$) and exceed the preferable minimum criterion of 0.70. Hence, the measures and the dimensions converge on their hypothesized underlying constructs. Additional evidence for the convergent validity of the hypothesized model is provided by the variance-extracted estimates and the construct reliabilities, which are presented within each latent construct in Figure 3. The average variance-extracted estimates are above the conventional minimum criterion of 50% and the construct reliabilities all exceed the minimum criterion of 0.70. Taken together, the evidence supports the convergent validity of the measurement model.

A review of the residual covariances shows that the fit of the model cannot be substantially improved by adding additional parameters. Therefore the presence of local misspecifications - i.e., covariances between the error terms of the measures/dimensions and cross-loadings (i.e., factor loadings of indicators on constructs other than the one they were intended to measure) - can be excluded. This means that, as hypothesized, the specified dimensions and criterion variables are the sole causes for the structural (common) variance in their respective observed indicators and that GNR as superordinate construct is the sole cause for the structural (common) variance in the three dimensions.

4.4.3 Construct validity

The third step in the adopted validation approach is to assess the significance of (1) the direct effects of the dimensions of GNR on the included criterion variables (4 x 2 = 8 paths); (2) the direct effects of aircraft noise exposure on the dimensions of GNR (1 x 4 = 4 paths); and (3)

the direct effects of aircraft noise exposure on the criterion variables (1 x 2 = 2 paths). For this purpose the modification indices related to these paths are reviewed. These indices indicate the expected drop in the χ^2 test statistics if an additional path is drawn.

To avoid capitalization on chance in finding a significant effect while there is in fact none (i.e., a type I error), the usually adopted significance level of 0.05 is divided by the number of modification indices examined (i.e., 14), yielding a critical p-value of 0.00357 and a corresponding χ^2 value of 8.49. Based on this criterion it is concluded that none of the reviewed modification indices are significant.

Substantively, this means that (1) there is no specific variance in the dimensions which can be used to explain additional variance in the criterion variables (over and above the variance explained by GNR); (2) dimension specific variance is unrelated to aircraft noise exposure and thus originates from another source; and (3) GNR effectively mediates the relationship between the aircraft noise exposure and the criterion variables. The findings are supportive of the conclusion that GNR captures all the relevant subjective variability resulting from exposure to aircraft noise.

4.4.4 Summary

Based on the overall model fit and the convergent and construct validity it is concluded that GNR as a superordinate construct is a valid conceptualization and indeed measures what it is intended to measure. Substantively, this supports the notion that people develop a general attitude of aircraft noise which is reflected in particular responses to the noise.

The variance which is shared by the dimensions of GNR is effectively captured by the superordinate construct. Only this shared variance, and not variance specific to the dimensions, is relevant in the prediction of two criterion variables.

4.4.5 Performance of noise annoyance and a general measure of negative reaction

Now that the validity of GNR as a latent superordinate construct is sufficiently supported it can be examined how well noise annoyance, its indicators, and a direct measure of general reaction to noise (i.e., dissatisfaction with the noise) perform as manifestations of this construct. This information is presented in Table 4.

Table 4. Performance of noise annoyance and a direct measure of general negative reaction in comparison with GNR as a superordinate construct

		Explained variance (%)	
		Mental health	**Physical health**
GNR (superordinate construct; Figure 3)		7.6	3.4
Dimension	**Factor loading**		
Noise annoyance	0.98	5.3	1.9
Observed indicator	**(indirect) Factor loading[a]**		
NA1	0.93	5.3	1.8
NA2	0.92	4.0	1.5
Observed indicator	**Correlation with GNR**		
General reaction to noise	0.85	6.1	2.8

[a] Computed by taking the product of the factor loading of the observed indicator on noise annoyance and the factor loading of noise annoyance on GNR.

It can be concluded that noise annoyance is a strong reflection of GNR (factor loading of 0.98). Hence, a large part of all negative feelings and emotions in response to the aircraft noise is captured by noise annoyance. However, as expected, noise annoyance does not reflect all relevant variance. This also becomes apparent when noise annoyance is used as a sole determinant in predicting the two criterion variables. The percentages of explained variance in these variables are substantially lower in comparison to GNR as determinant.

Examination of the factor loadings and proportions of explained variance for the indicators of noise annoyance (NA1 and NA2) clearly shows the additional effect of measurement error (on top of dimension specificity) which is present in the observed indicators and which biases the structural estimates of the relationships between the latent variables. In comparison to the noise annoyance dimension the indicators are (by definition) weaker reflections of GNR and, when used as direct determinants of the criterion variables, can also explain less variance in these variables. Hence, the measurement error present in these observed indicators suppresses the real associations between the factors. Preferably, the observed indicators should therefore not be used in isolation.

Finally, the performance of the direct measure of general reaction to noise (dissatisfaction with aircraft noise) is assessed. This measure is also strongly correlated with GNR ($r = 0.85$). In addition, bearing in mind that this measure is also "contaminated" with measurement error, its performance in terms of the explained variance in the criterion variables is remarkable. Fitting the previous results of Job et al. (2001) the conclusion can be drawn that measures of general reaction perform better than specific measures of noise reaction, such as noise annoyance.

4.5 Conclusion

In this study a measurement model is developed to measure general negative reaction to aircraft noise. Estimation of the model yielded a good fit to the data and supported the second-order factor structure. Additional support for the specified structure is found in the convergence and construct validity of GNR as a superordinate construct. Based on the factor loadings on GNR it is inferred that noise annoyance and its observed indicators are strong reflections of this construct but do not capture all relevant variance. To a lesser extent the same conclusion holds for a direct measure of general negative reaction to noise, i.e., dissatisfaction with aircraft noise.

The results of the present study are in line with the previous findings of Job et al. (2001) and indicate that general measures are more valid indicators of negative reaction to (aircraft) noise than specific dimensions such as annoyance or disturbance. Therefore, we also endorse their recommendation to include such general measures in future community surveys. In addition, we advise the use of multiple observed indicators to control for random measurement errors. As the present study has confirmed, these random errors suppress the real associations between the constructs of interest.

As a by-product of our approach the developed model provides us insight into the overall experience of aircraft noise. Based on the results it is apparent that this experience is multifacetted and includes at least three, but possibly many other, dimensions. In addition, from the factor loadings on GNR it can be inferred that dimensions such as noise annoyance and activity disturbance lie at the core of GNR, while the anxiety and fear dimension operates at a more distant level.

Based on the results of the present study several interesting directions for future research can be identified. One would be to explore additional dimensions of general negative reaction such as perceived control or the attitude toward the noise source authorities. Using the

approach followed in this study it can be assessed whether such factors also form an integral part of people's general reaction toward aircraft noise or whether these should be viewed as independent variables.

A second research direction is to explore the factor structure for different subsets of the population. An interesting question, for example, would be whether the pattern of factor loadings is different for people living close to the airport in comparison to people living distant from it. More specifically, it can be hypothesized that within the former group reactions like fear plays a greater role within the general reaction construct and hence would receive a greater factor loading. This would mean that the meaning of the concept of general reaction differs for this group and also that it might be differently related to the criterion variables.

To conclude, we emphasize that reaction to aircraft noise must not be understood as a narrow experience like noise annoyance but as an aspect of a broader multidimensional construct that compromises many other feelings, emotions, and beliefs related to aircraft noise in the residential environment.

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5. Policy, Frames and Aircraft Noise Annoyance

Kroesen, M. and Bröer, C. (2009). Policy discourse, people's internal frames, and declared aircraft noise annoyance: An application of Q-methodology. *Journal of the Acoustical Society of America*, 126, pp. 195-207.

Abstract

Aircraft noise annoyance is studied extensively, but often without an explicit theoretical framework. In this article, a social approach for noise annoyance is proposed. The idea that aircraft noise is meaningful to people within a socially produced discourse is assumed and tested. More particularly, it is expected that the noise policy discourse influences people's assessment of aircraft noise. To this end, Q-methodology is used, which, to the best of the authors' knowledge, has not been used for aircraft noise annoyance so far. Through factor analysis five distinct frames are revealed: "Long live aviation!," "aviation: an ecological threat," "aviation and the environment: a solvable problem," "aircraft noise: not a problem," and "aviation: a local problem." It is shown that the former three frames are clearly related to the policy discourse. Based on this observation it is argued that policy making is a possible mechanism through which the sound of aircraft is turned into annoyance. In addition, it is concluded that the experience of aircraft noise and, in particular, noise annoyance is part of coherent frames of mind, which consist of mutually reinforcing positions and include non-acoustical factors.

5.1 Introduction

Exposure to aircraft noise in residential areas is a prime focus of protests and policy in many countries. In Europe it is estimated that in 2006 $2.2*10^6$ people were exposed to annual aircraft noise exposure levels of L_{den} 55 dB(A) or more and $3.0*10^6$ Europeans were exposed to night-time noise levels of L_{night} 45 dB(A) or more (MPD, 2007). In addition, the population within the L_{den} 55 dB(A) is expected to increase to 2.3-2.4 million in 2010 and to 2.6-2.7 million in 2015 (MPD, 2007).

While aviation generally increased over the past decades, noise tolerance seems to decrease. Today less noise is necessary to have an equal portion of highly annoyed people (Guski, 2002, 2004; Bröer and Wirth, 2004; Van Kempen and Van Kamp, 2005; Schreckenberg and Meis, 2007). In an updated review of Van Kempen and Van Kamp (2005), Schreckenberg and Meis (2007) showed that exposure-response functions of the period 1990-2008 are different from those collected in the period 1965-1992 on which EU policy is based (Miedema and Oudshoorn, 2001; European Communities, 2002). The older "EU-curve" is found to structurally underestimate the negative community response observed presently.

Several explanations for this trend have been provided. One is the change in the structure of the noise load: The average noise load of single events has decreased, but the number of events has increased (Guski, 2004). This change is concealed by annual energy equivalent noise metrics, which are generally used to predict noise annoyance, and the new structure might be experienced as more annoying. Other explanations focus on changes in individual characteristics (e.g., noise sensitivity) or on changes in attitudes such as trust in the noise source authorities, which might have come about due to the advent of the risk averse society (Wirth and Bröer, 2004). Guski (2004) provided yet another reason in arguing that recent aircraft noise studies have been done in the context of step changes in noise exposure levels, which are known to cause so-called excess negative response on top of the response to be expected from exposure-response curves derived from steady-state situations.

In this study, however, we focus on a different explanation, one which has received little attention in previous research. This explanation focuses on the policy discourse at airports. A policy discourse is defined as the way policy actors socially and publicly define and handle problems. We hypothesize that public definitions of aircraft noise are internalized in frames, which people adopt to evaluate aircraft noise. For example, if the policy discourse identifies aircraft noise as an important problem, we expect that people will internalize this definition, and in doing so, become more annoyed by the noise. The explanation for the trend toward higher annoyance then lies in changes in the policy discourse.

In this article we propose a social explanation for declared noise annoyance. Based on previous work of Bröer (2006) the main hypothesis of the present study is that policy making is a possible mechanism through which the sound environment due to aircrafts is turned into noise annoyance. The main assumptions underlying this hypothesis are that (1) people make use of already existing frames to appraise an environmental stimulus such as aircraft noise (cf. Nijhof, 1995, 1998, 2003) and (2) one of the most influential sources of these frames is the policy discourse. More specifically, the hypothesis can be decomposed into two distinctive processes: an internalization process of the policy discourse in internal frames of people and, second, using this internal frame, an appraisal process of aircraft noise. It is assumed that the policy discourse (and subsequently also the internal frame) contains "feeling rules" (Hochschild, 1979): It legitimizes or delegitimizes concerns, complaints, or fears. This can be modeled like the following: The policy discourse treats aircraft noise as a problem and (de)legitimizes annoyance → cognition and feeling rules are internalized by people around the airport → people feel annoyed by aircraft noise.

We do not claim that these relationships are unidirectional. A policy discourse can develop within a field of multiple actors, including citizens. Furthermore, people's frames can depend on personal characteristics such as gender, age, or noise sensitivity. Their role, however, is not the focus of the present study.

Focusing on the criterion of association the present article will investigate the relationship between the policy discourse and the internal frames of people. To that effect the following approach is adopted. First, the policy discourse at one airport, namely, Amsterdam Schiphol (the largest airport in The Netherlands), is characterized. This particular airport is chosen for two reasons. First, the policy discourse at Amsterdam Schiphol explicitly defines aircraft noise annoyance as a problem, a necessary condition if the aim is to investigate whether this definition resonates with the internal frames of people. And second, sufficient previous research is already available to provide a satisfactory description of the policy discourse. Second, the different perspectives used to study aircraft noise annoyance will be reviewed. This review shows that to assess subjectivity, Q-methodology is well-suited. Third, we reveal the frames people adopt to evaluate aircraft noise and how these relate to the policy discourse and to the declared level of noise annoyance. The rationale behind the approach described here is that if (1) a resemblance is found between the internal frames and the policy discourse (at a single moment in time) and (2) noise annoyance response is found to be intrinsically related to the revealed internal frames, there will be sufficient evidence to support the hypothesis that there is a strong relation between the policy discourse and aircraft noise annoyance.

5.2 Noise policy discourse at Amsterdam Schiphol

Hajer (1995) (p. 264) defined a discourse[17] as "an ensemble of ideas, concepts, and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices." Hence, a policy discourse can be regarded as the way policy actors (socially) define and handle public problems. Useful elements to guide these definitions are policy concepts, story-lines, and metaphors. In addition, although multiple discourses surrounding an issue can be identified, only one of those is (usually) dominant. Hajer (2006) defined dominance using two criteria, namely, discourse structuration and discourse institutionalization. The former relates to the degree a particular discourse dominates a given social unit (e.g., a policy domain). It refers to the degree a discourse is shared among multiple actors, the so-called discourse-coalition.[18] The latter relates to the degree a discourse is institutionalized in policy processes and policy measures. When both conditions are satisfied a discourse is said to be dominant. The current description of the policy discourse will only focus on the dominant discourse. Although alternative discourses can be identified, this focus is justified by the argument that this discourse is most visible to residents around the airport.[19]

[17] There are several variants of discourse analysis, even within social psychology. What matters most to this study is the fact that "language in use" structures what can and cannot be said and thought in a specific situation. Discourse is different from "discussion" in the sense that it points to a pattern of the discussion.

[18] Hajer (1995) indicated that the term discourse-coalition differs from Sabatier's (1988) advocacy-coalition, which is a coalition of actors that share similar normative beliefs and/or interests. The essence of the term discourse-coalition is that actors with different and even competing goals (who by definition do not form an advocacy-coalition) can still be united under the flag of a discourse (in the sense that they share similar ways of thinking and acting).

[19] For the purpose of readability the term "dominant policy discourse" is therefore, in the remainder of this paper, equated and replaced with "policy discourse."

The present description of the policy discourse related to the issue of aircraft at Amsterdam Schiphol is based on several existing studies (Dierikx and Bouwens, 1997; Van Eeten, 1999, 2001; Abma, 2001; Wagenaar and Cook, 2003; Bröer, 2006). It is meant to identify the dominant policy discourse for noise annoyance in The Netherlands.

Before aircraft became a problem of noise annoyance, aviation had been introduced to The Netherlands as an economic asset and as a part of national development since 1919. In policy documents Schiphol airport and aviation were placed in a historical perspective, relating them to the image of The Netherlands as a successful seafaring nation in the golden age. Based on this analogy the airport should be regarded as something to be trusted and accepted and the government should strive to develop an airport that plays a role on a global scale.

In the mid-1950s aircraft noise was first identified as a (potential) problem. In the following decades this problem was, in line with the physical expansion of the airport, treated as a spatial planning problem. The fundament of the noise policy was to fit the airport, with its noise footprints, in the residential environment surrounding the airport, such that the flight routes avoided living areas. Other (implicit) assumptions followed from this central planning perspective. First, human response to aircraft noise was expected to be uniform. The physical noise level therefore became the central outcome of interest for policy regulation. Second, since spatial planning was a matter of centralistic control, a major role was given to national governmental bodies and (acoustical) experts in the development of the airport, while residents surrounding the airport were assumed to be passive. Third, planning and noise policy focused on long term developments, which were expressed in statistics, maps (showing noise contours), and scenarios. And lastly, solutions proposed by policy makers and advisory commissions to solve the noise problem were spatial and technocratic in nature (e.g., repositioning runways or flight routes, improving aircraft engines, restrictive land-use policies, and relocation of the airport to the sea).

However, the planning discourse failed because flight operations and housing more and more overlapped. From the 1960s onwards, therefore, policy makers accepted noise pollution in residential areas. Citizens around Amsterdam Schiphol, however, following the discourse's own premise that aircraft noise is an important problem, did not settle in their role as passive receivers. In the period between 1965 and 1995 the history of Schiphol knows many citizens' protests. In these protests the disciplinary effect of the policy discourse can be observed. Although citizens oppose the policy they still express themselves in terms of the planning discourse by advocating for solutions such as the repositioning of runways and relocation of the airport. The unsolvable conflict caused by the planning discourse (i.e., "noise is an avoidable problem" versus "some noise needs to be accepted") as well as the (resulting) protests led to a deadlock. To escape it a new (international) story-line was introduced in the 1990s, called "ecological modernization" (Weale, 1992; Mol and Spaargaren, 1993; Hajer, 1995). The combination of this story-line with the existing discourse has led to the policy discourse that exists to the present day, which Bröer (2006) termed the "mainport and environmental discourse."

The basic assumption of this new story-line was that economy and environment could be developed at the same time; the attainment of both economic and ecological goals should be regarded as a positive-sum game. The promise of ecological modernization relied strongly on developments in science and technology and market-based policy instruments (e.g., environmental taxes). Related to Amsterdam Schiphol the economic benefits of aviation became known under the umbrella of the "mainport," which was considered a vital entity to The Netherlands if it were to play a role in the globalizing economy. Schiphol should be seen as an "engine of the economy." The ecological negative externalities, most notably noise, but

also risk and pollution, became known under the umbrella of the "environment."[20] From 1990s the mainport and environment discourse was spread among citizens through extended participatory processes. Repeatedly, citizens were called upon to be alert, to be informed, and to express their interests. In 1995, the mainport and environment discourse was institutionalized, when the decision was made to construct Schiphol's fifth runway (mainport) and to implement noise contours (environment).

Although the principle of ecological modernization seems to have provided a viable new perspective, it can actually be seen as an explicit reformulation of the existing problem conceptualization (i.e., the planning discourse) in modern (neo-liberal) terms. Policy makers seek to accommodate growth of the airport while trying to avoid its negative effects on the environment via traditional planning instruments. The only difference is the explicit acknowledgment of both economic and environmental effects/values.

5.3 Three perspectives to study aircraft noise annoyance

In studying noise annoyance three perspectives and related research approaches can be distinguished: the acoustical aggregate model, the (non-)acoustical disaggregate approach, and the discourse approach. In the following these three perspectives will be briefly discussed and their suitability to our research aim indicated.

The acoustical aggregate model has focused on the most obvious determinant of noise annoyance: the physical level of noise exposure. The effects of this variable are presented as exposure-response relationships, e.g., the percentage of highly annoyed people, at a given level of noise exposure, calculated or measured with energy-based noise metrics such as L_{den}. Schultz (1978), who was the first to integrate the results of 11 community surveys, developed a general exposure-response relationship for transportation noise, which was updated by Fidell et al. (1991) and Miedema and Vos (1998). The physical level of noise exposure can reveal community response but cannot account for all individual variability in noise annoyance. Based on review of 39 surveys Job (1988) concluded that only 9–29% of the variation in negative reaction (i.e., noise annoyance) can be explained by noise exposure. Since the aim of the present study is to elucidate the different frames of people, this model, which focuses on community response, does not suit our purpose well. The disaggregate non-acoustical approach [also termed the individual or situational difference model (Lercher, 1996)], which developed in response to the limitations of the acoustical model, is more in line with our aim, but it still does not fully suffice.

Within this disaggregate non-acoustical modeling approach the effects of personal and situational variables on individual levels of noise annoyance are studied via survey research or experiments, controlling for the level of noise exposure. Several non-acoustical factors have been identified. Borsky (1961), McKennell (1963), and Leonard and Borsky (1973) showed that noise annoyance is associated with source evaluation, misfeasance in relation to the authorities, fear of an aircraft crash, and concern about health effects. Job (1988) found that the attitude to the noise source and sensitivity to the noise account for more variance in annoyance than noise exposure does. A meta-analysis of Fields (1993), based on 136 surveys, revealed that socioeconomic and demographic variables (age, sex, social status, income, education, home ownership, dwelling type, length of residence, and personal benefit) had no influence on the level of noise annoyance. Instead, annoyance was related to the amount of insulation from sound at home, fear of danger from the noise source, noise prevention beliefs, general noise sensitivity, beliefs about the importance of the noise source, and annoyance with non-noise impacts of the noise source. Similar results were obtained by Miedema and

[20] Therefore, the remainder of this paper will treat the terms ecological and environmental interchangeably.

Vos (1999). Overviews of relevant non-acoustical factors are given by Lercher (1996), Guski (1999), and Kroesen et al. (2008). The last mentioned authors identified 28 (potentially relevant) non-acoustical factors.

The disaggregate approach uncovered a wide range of factors empirically related to aircraft noise annoyance. In addition, it seems well-suited to investigate the causal structure, which underlies noise annoyance. Still, for our aim, it is unfit. In the first place, we are not interested in the statistical associations between variables, but in the frames people adopt to evaluate aircraft noise. (Linear) combinations of variables can be used to predict (or explain) annoyance response, but they are not suited to capture or qualify the frames we hope to reveal. Second, the disaggregate approach recognizes that annoyance is partly based on subjectivity, but (implicitly) assumes that all people have the same understanding of nonacoustical factors such as trust in the source authorities or noise sensitivity. Hence, the approach generally assumes an objective and unchanging frame of reference when different people respond to different questions. A concept such as noise annoyance, however, can be subject to a host of different definitions, each of which may be sensible within a specific social context. An a priori meaning of the concept introduces arbitrary subjectivity in the measurement process, which carries the risk of missing or misinterpreting meaning from the respondents own frame of reference.

A study of King et al. (2004) is illustrative for the way a social or political context can cause differences in internal frames of reference. They measured the perceived level of political efficacy within a Mexican and Chinese sample with the following question: “How much say do you have in getting the government to address issues that interest you?” It turned out that 50% of the Mexicans, while living in a democratic country, reported to have no say, in contrast to 30% of the Chinese, while living in a non-democratic (communist) country, reported to have no say. According to King et al. (2004) the explanation lies in the fact that Chinese have lower standards for what counts as satisfying the level described by any given response category. Hence, although their “actual” level of political efficacy is lower, the difference in the frame of reference between Mexicans and Chinese is cause for the found opposite result. This exemplifies the need to have an understanding and operationalization of an issue, which is grounded in specificities of a field.

The aggregate model or disaggregate modeling approach provide valuable insights on their own terms. In addition, it has been shown possible to make inferences about the internal frames of people with traditional questionnaire techniques and statistical analysis (Raimbault et al., 2003). Yet, we want to put forward now a different approach, which pays more attention to differences in frames of reference.

A step toward an alternative approach was taken by Bröer (2006, 2007a, 2007b). His main thrust was to understand aircraft noise annoyance from subjects’ own frame of reference. Instead of testing an already existing theory, his aim was to develop a new theory, which is grounded in the meaning people attribute to sound (Glaser and Strauss, 1967; Blumer, 1969; Charmaz, 2006). In line with the present study he assumed that sound is meaningful within a coherent frame, a concept which is connected to discursive psychology (Billig, 1987; Potter and Wetherell, 1987; Edwards and Potter, 1992). Here, a frame is defined as a discourse that operates at the individual level a coherent set of beliefs and attitudes that people use to observe and give meaning to reality. In general, frames guide the extraction of relevant cues from ongoing flows of events and act as filters through which we (selectively) observe the world, attribute meaning to it, and act on it (Goffman, 1974; Rein and Schön, 1993; Schön and Rein, 1994; Weick, 1995). Bröer (2006) argued that phenomena labeled “non-acoustical factors” can be part of such a frame. Furthermore, Bröer (2006) assumed that people learn or internalize frames socially and hypothesized that the frames’ subjects develop to give

meaning to the experience of aircraft noise are influenced by the policy discourse related to the issue of aircraft noise at an airport.

If the policy discourse influences people's attitude to aircraft noise, one would find different kinds of noise annoyance in different political settings. Therefore Bröer (2006) studied the policy discourses and people's frames of aircraft noise at two European airports: Amsterdam Airport Schiphol in The Netherlands and Zurich Kloten in Switzerland. He found that at similar sound levels the aircraft noise was indeed experienced differently between the two cases and that those differences can be traced back to different noise policies. Different attitudes toward noise within a case were related to the dominant policy discourse too: Typically people strongly adopted part of the dominant policy discourse and rejected or downplayed other parts. In general, people were found to evaluate noise policy when they heard aircraft sound and to have internalized the language and the logic of the policy. Based on these results Bröer (2006) concluded that noise annoyance is shaped by the policy discourse.

This third perspective is most closely related to our formulated aim. However, Bröer (2006) worked with an interpretative approach, which begs the questions if the frames he found can be objectified. Therefore, in contrast to Bröer's (2006) qualitative methodology, we use Q-methodology. In line with Bröer's (2006) approach this method assumes that subjectivity is anchored in self-reference. However, in contrast to Bröer's (2006) approach, the Q-method can be used to render internal frames of people manifest in an objective way (Brown, 1980; McKeown and Thomas, 1988).

The three perspectives are summarized in Figure 1 and Table 1. The present study will be in line with the discourse model and will further investigate the hypothesis that the policy discourse surrounding a particular airport becomes internalized in the frames people adopt to evaluate the meaning of aircraft noise. Yet, in contrast to Bröer's (2006) qualitative methodology, we use Q-methodology to render the internal frames of people visible. Lastly, we acknowledge the influence of personal determinants (e.g., age, gender, and noise sensitivity) and the physical level of aircraft noise exposure on people's frames, but these influences are not assessed.

5.4 Q-Method

The basic idea of Q-methodology (Brown, 1980) is that people rank-order statements derived from everyday communication and that these rank-orderings (i.e., so-called Q-sorts), instead of traits related to the individual, are correlated and factor analyzed. When two Q-sorts are shown to correlate, the persons who constructed them are said to share a similar frame. By factor-analyzing a correlation matrix of n*n persons/Q-sorts, shared frames can be extracted. Underlying this procedure is the premise that subjectivity is anchored in self-reference. Subjects are encouraged to actively construct their opinion on the topic at hand. In addition, by letting the subjects rank-order the statements (on a single scale), they are evaluating and interpreting them in relation to each other. If, like in our study, subjects sort 48 statements, this involves, at least implicitly (1/2)(48)(48-1) = 1128 judgments. This procedure is based on the assumption that meaning is relational: A specific statement cannot be seen in isolation but derives meaning from its relation to other statements (a position common in Gestalt psychology, philosophy of language, discourse analysis, and large parts of interpretive social science). For example, when two people strongly agree with the statement "I am annoyed by aircraft noise," survey research treats those expressions as part of the same category. In a relational perspective, the statement might refer to disturbance or to unfair treatment and can therefore constitute two (or even more) different kinds of annoyance. Since the aim of the present study is to explore the different frames in which people are (not) annoyed by aircraft

noise, Q-methodology seems well-suited for this task. Below we describe the way Q-method is applied to our case.

Table 1. Three perspectives to study the effect of aircraft noise on humans

Acoustical aggregate model (top figure in Figure 1)	**(Non-)acoustical disaggregate approach (middle figure in Figure 1)**	**Discourse approach (bottom figure in Figure 1)**
Main objective: (given the noise level) to predict aggregated levels of noise annoyance (i.e. community response).	**Main objective**: to predict/explain variation in individual levels of noise annoyance.	**Main objective**: to study the link between policy discourses and the internal frames which people adopt to qualify aircraft noise (non-acoustical factors can be part of the internal frames).
Limitations: (1) Large portions of variance in (community) reaction remain unexplained and (2) unable to reveal internal frames.	**Limitations**: (1) Difficult to reveal internal frames and (2) implicit assumption of an objective frame of reference.	**Limitation**: difficult to generalize the results to a larger population.

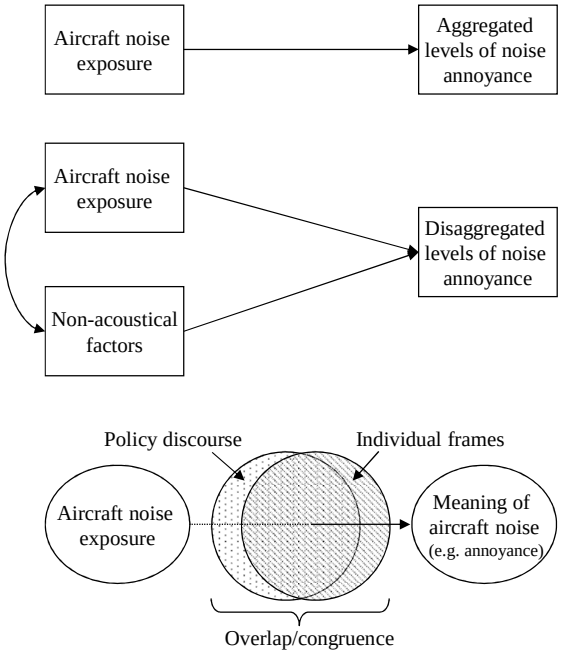

Figure 1. Model structures of the three perspectives
The aggregate acoustical model (top figure), the disaggregate approach (middle figure), and the discourse approach (lower figure). The discourse approach assumes that meaning is provided to aircraft noise through an individual frame, which is schematized here as a filter. Second, it assumes that the individual frames are congruent with the policy discourse. We schematized the entities in the discourse approach as ovals to indicate their nature as fixed qualities. In contrast to the other two approaches were the entities (rectangles) relate to variable quantities.

5.4.1 Defining the Q-sample

First, one has to define the "concourse": the whole of statements of opinion, related to a certain topic that can be found among members of a social group (Stephenson, 1978; Brown, 1980). In this case the concourse encompasses all expressions by residents living in the vicinity of Schiphol Airport related to the topic of aircraft noise. Based on previous research of Bröer (2006) statements were theoretically sampled (Glaser and Strauss, 1967; Charmaz, 2006) from four diverse sources: thematically structured interviews with residents living in Amsterdam Osdorp related to the topic of aircraft noise (n = 47), complaints to the Commission Regional Dialogue Schiphol (n = 130), letters to the editor from residents around Schiphol published in three national newspapers (n = 71), and statements from residents during public inquiry procedures (n = 18). This provided us with 240 different statements about aircraft noise.

To select a Q-sample from these statements we used academic literature to identify four key themes: (1) perceptions of aircraft noise (covering statements related to hearing aircraft, being disturbed by aircraft, fear, noise annoyance, etc.), (2) non-acoustical factors (covering statements related to trust in noise source authorities, perceived control, expectations, etc.), (3) policy story-lines (covering statements related to economic benefits, ecological costs of aviation, complaining, etc.), and (4) "autonomous noise annoyance definitions," which are not covered in one of the first three and are rather unusual (covering statements such as "people have the right for silence"). To arrive at a representative sample, statements within each category were selected until all (sub)categories were covered. The final Q-set consisted of 48 statements and can be found in Table 2 (section 5.5). The final sample is naturalistic in the sense that the statements were derived from participants' own communications about aircraft noise and structured in the sense that theoretical (sub)themes were used to categorize the concourse, which ensured coverage of all relevant issues related to aircraft noise in the final sample (McKeown and Thomas, 1988).

5.4.2 Participants and procedures

We presented the selection of statements to residents of part of Amsterdam Osdorp, in The Netherlands. This was also the area were the initial interviews were held. All respondents were exposed to the same aircraft noise. The average noise level in this neighbourhood, calculated over the period of 1 year, is approximately L_{den} 53 dB(A) (Bröer, 2007a). It is located approximately 5 km from the center of Amsterdam Schiphol. For the Q-method, 40–60 subjects are sufficient (Watts and Stenner, 2005). Respondents are chosen strategically: based on criteria derived from theory. In this case we included people who are highly, moderately, and not annoyed. The data were collected at people's homes, by students under the close supervision of both authors in the period March-April 2008. We asked respondents to rank-order the 48 statements according to the following: "To which extent do you agree/disagree with the following statements?" The scale ranged from -5 (most disagree) to +5 (most agree). In total 43 respondents completed the Q-sorting task and participated in a short interview afterwards. The interview asked for reasons behind respondents' rankings, additional topics, and noise annoyance, measured with the first item of the standardized noise annoyance scale developed by Fields et al. (2001).

5.4.3 Analysis

To identify similarly patterned Q-sorts, a correlation matrix of n x n Q-sorts (n = 43 subjects) was calculated and factor analyzed using the method of centroid factor analysis (Brown,

1980). The PQMETHOD software (Schmolck, 2002) was used for this purpose. Based on Brown's (1980) recommendation seven factors were initially extracted. Next, the varimax rotation method was used to approximate simple structure. In line with standard Q-methodological practice only factors with two or more significant loadings[21] and an eigenvalue greater than 1 were considered acceptable. After rotation it was found that two factors did not satisfy these criteria. These were therefore disregarded from further analyses.

Next, factor exemplars to compute the composite factor arrays are identified. These are participants' Q-sorts that significantly and solely load on a factor and can therefore be considered as representative for the thought pattern present in the factor on which they load. Via the formula 2.58 * (1 / √N) and with N = 48 (i.e., the number of statements) it can be calculated that loadings greater than ±0.37 are significant at the 0.01 level. However, following the approach described by Watts and Stenner (2005), the confounding of participants (i.e., the number of participants that load on two or more factors) is minimized by raising this level to ±0.40. At this level 37 participants load solely on one factor, 3 participants load on two factors, and 3 participants load on none of the factor. Hence, 86% of the data are used in the final analysis of the factors.

Lastly, the factor exemplars are merged into factor arrays, which represent "idealized" Q-sorts of hypothetical persons loading 100% on the factors.

5.5 Results

5.5.1 Frames of residents around Schiphol

In the following the factors will be interpreted based on the computed factor arrays (Table 2). For each factor, we indicate its relation to the noise policy discourse. Central to the first three factors is their relation to the mainport and environment policy discourse. In line with our theoretical argument, the factors are called frames below.

Frame A: Long live aviation! (the economic stance)

This frame is shared by 14 subjects and can account for 17% of the total variance of the correlation matrix.[22] In line with the policy discourse it strongly emphasizes the economic benefits of Schiphol airport (34: 5; read: statement 34, score 5) and of aviation in general (36: 5). According to this account we should be proud of our national airport (35: 4) and be cheerful about it (2: 4). Schiphol should grow (42: -3) and certainly not be relocated to the sea (47: -5). In this frame, one is optimistic about the future: Technology will reduce aircraft noise (26: 4) and aircraft noise is not expected to increase (4: -1).

While this frame strongly subscribes to the economic argument of the noise policy, it plays down the ecological arguments: Aviation is not considered a threat to the environment (38: 0) and noise annoyance is not considered a major problem (37: 0). Subjects tend to disagree with statements that aircraft noise is a hazard to public health (11: -2) and are indifferent about the statement that growth of Schiphol reduces the quality of life (12: -1).

In line with playing down the ecological arguments, complaining about noise is not supported: Subjects are indifferent about the statement that those who complain about noise are selfish and do not see the bigger picture (22: 1). They believe that residents around the

[21] Unlike in traditional applications of factor analysis the aim is not to account for as much variance as possible, instead its primary aim lies in finding unique shared viewpoints. At minimum, such a shared viewpoint can be identified based on two subjects.

[22] This value is calculated via the following formula: 100*(factor eigenvalue/number of subjects) (Brown, 1980).

airport receive sufficient consideration (20: 2) and they have no intention to engage in a collective action to address the noise problem (21: -1).

Table 2. Factor arrays of the five rotated factors

No.	Statement	A	B	C	D	E
1	It is convenient to live near Schiphol.	3	-1	1	-1	-1
2	Schiphol should be allowed to stay: long live aviation!	4	-1	0	2	0
3	I regularly hear aircrafts.	3	4	3	-2	5
4	I fear that aircraft noise will increase.	-1	2	1	-4	5
5	I have the feeling that aircraft noise is forced upon me.	-2	4	-3	-3	-4
6	The sound of aircrafts belongs to this day and age.	3	-2	0	2	1
7	If you cannot stand aircraft noise, you should go and live somewhere else.	1	-3	0	-3	-4
8	It is acceptable that people are disturbed by aircraft noise in their dwelling.	0	-5	-4	-2	-3
9	It is acceptable that people have to interrupt a conversation due to aircraft noise.	-2	-5	-2	0	-1
10	I am annoyed by aircraft noise.	-5	2	-1	-4	2
11	Air traffic is a hazard for public health.	-2	1	1	0	3
12	The growth of Schiphol goes at the expense of the quality of life of many citizens.	-1	5	-3	-1	2
13	I cannot control the noise and this makes me feel angry and powerless.	-4	0	-2	-3	-3
14	If you do not pay attention to it (i.e. the noise) then you will not be bothered by it.	3	-4	1	0	-3
15	I can do something against the noise.	1	-2	-1	-2	-5
16	If I could I would move to a quiet neighbourhood.	-4	-1	-4	-1	4
17	I am afraid that one day an aircraft will crash nearby.	-2	-1	-5	1	-3
18	As citizen you are powerless against Schiphol.	-3	1	0	3	-2
19	It does not help to complain about aircraft noise.	-1	0	-1	3	0
20	There is sufficient consideration for residents around Schiphol.	2	-4	-2	3	0
21	Citizens should collectively move up against aircraft noise.	-1	0	-3	-4	2
22	If people complain about aircraft noise they mainly serve their self-interest. They do not realize how important Schiphol is to the Netherlands.	1	-3	-2	5	2
23	There is too much attention for a small group of complainants around Schiphol.	0	-3	1	2	0
24	You cannot solve the “annoyance” problem. Schiphol has been around for a long time and this is something we have to deal with.	2	-1	-1	3	0
25	Flying is too cheap.	-4	0	-3	-1	-5
26	More technology will be developed that will reduce the noise.	4	1	3	0	3
27	Schiphol acts as a free state making its own rules and regulations.	-1	1	-5	0	-4
28	I believe that Schiphol always gets his way.	-3	3	0	0	2
29	Schiphol does enough to reduce the noise.	0	-4	-2	-1	-2
30	The government does enough to reduce the noise.	0	-3	-1	-5	-2
31	The government does not live up to her promise to reduce the noise.	-1	1	-4	3	1
32	It is a good thing that the environmental movement and local action groups stand up for residents living around Schiphol.	1	3	2	-1	3
33	They always expand the airport first, and then raise the norms for the allowed levels of noise.	0	2	0	2	1
34	Schiphol is an engine of the economy.	5	0	5	1	0
35	We should be proud of our national airport.	4	0	2	1	-2
36	Aviation is important for the employment.	5	3	5	1	1
37	Noise annoyance from aircrafts is an important problem.	0	4	2	-3	-1
38	Aviation is a threat to the environment.	0	5	2	1	1
39	The government should strive for reducing noise annoyance.	2	2	3	0	4
40	The government should strive for growth of Schiphol.	1	-2	-1	-5	-1
41	Economic interests are more important than reducing the level of noise annoyance.	1	-2	2	-2	0
42	Schiphol is big enough and should not be allowed to grow any further.	-3	1	3	4	-1
43	The double-sided aim (more growth but not more annoyance) of the government has failed. In the end the choice is always made to accommodate growth.	2	2	1	4	0
44	People have the right for silence.	0	3	4	2	4
45	Aircraft noise is “meaningless” (Dutch: zinloos) noise.	-3	-1	0	0	-1
46	I think it is a good idea to have an “aircraft-free-Sunday” every now and then.	-2	-2	4	0	3
47	Schiphol should be relocated to the sea.	-5	0	4	-2	-2
48	Further away from Schiphol aircraft noise is not really a problem.	2	0	0	5	1

Given the support for economic reasoning, subjects are indifferent about the efforts of the government and Schiphol to reduce the noise (30: 0 and 31: 0). The relationship with the noise source authorities is mildly positive to neutral. Subjects do not believe Schiphol always

gets its way (28: -3) and are indifferent about the statement that this actor makes its own rules and regulations (27: -1). This indifference can also be observed in relation to the statement that the government does not live up to its promise to reduce the noise (31: -1).

In this frame, the aim of the government to combine economic growth and ecology has failed (43: 2), but this does not go together with an overall negative attitude toward authorities.

Subjects subscribing to this frame do not consider themselves to be annoyed by the aircraft noise (10: -5), although they do regularly hear aircraft (3: 3). In addition, they have no intention of moving to a quieter place (16: -4).

Lastly, the frame acknowledges that we live in modern times: The sound of aircraft belongs to this day and age (6: 3) and aviation is just something we need to deal with (24: 2). This is typical for a "go with the flow" attitude toward modernity. Altogether, frame A has a clear structure: It strongly favours economic arguments and plays down everything related to ecology.

Frame B: Aviation: An ecological threat (the environmental stance)

This frame is shared by 15 subjects and can explain 18% of the total variance. In contrast to frame A, this frame emphasizes that aviation is an environmental threat (38: 5), that growth of Schiphol goes at the expense of the quality of life of many citizens (12: 5), that disturbance by noise is completely unacceptable (8: 5, 9: 5), and that aircraft noise annoyance is an important problem (37: 4), which cannot be ignored (14: -4). In line with the policy discourse, this account subscribes to the conceptualization of aviation as an important environmental problem.

While the frame stresses "ecology" it is less supportive of "economy." Subjects neither confirm nor disconfirm that Schiphol is an engine of the economy (34: 0). Aviation, however, is considered to be important for employment (36: 3). Compared to frame A, there is a strong support for one half of the policy discourse, but less criticism toward the other half.

Like subjects in frame A, subjects in frame B agree with the statement that the double-sided aim has failed and that in the end the government always chooses to accommodate growth (43: 2). But, different from frame A, in frame B this is combined with an elaborate negative attitude toward authorities. One believes that there is insufficient consideration for residents around Schiphol (20: -4) and that the government and Schiphol are not putting in enough effort to reduce the noise (29: -4 and 30: -3). Subjects believe Schiphol always gets its way (28: 3) and that the noise norms are purposively manipulated following expansion of the airport (33: 2). Consequently and in contrast to all other frames, subjects feel that aircraft noise is forced on them (5: 4), that something which is net undesirable (38: 5 versus 34: 0 and 36: 3) is unwillingly/forcefully and unasked (20: -4) being imposed on them. Policy has failed in the sense that noise annoyance is out of control. It is only in this frame that subjects do not think that aviation belongs to this day and age (6: -2). Instead, it is a runaway train, which threatens citizens and the environment.

Within the account people support complaining (22: -3 and 23: -3) and environmental movements (32: 3). This support is stronger than in all other frames. This is of course in line with the ecological stance. It might also be interpreted as a way to counter the criticism often raised against complainants in The Netherlands.

Subjects within this frame consider themselves moderately annoyed by aircraft noise (10: 2) and claim they regularly hear aircraft (3: 4).

Altogether, frame B has a clear structure: It strongly favours ecology, puts less emphasis on economy, is strikingly critical about noise policy, and portrays noise as an uncontrolled ecological threat.

Frame C: Aviation and the environment: A solvable problem (the technocratic stance)

This frame is shared by three subjects and can explain 5% of the total variance. This particular frame closely resembles the policy discourse with regard to Schiphol. It underlines the benefits of aviation for the economy (34: 5) and employment (36: 5), but also mildly agrees with the statements that aviation is a threat to the environment (38: 2) and that noise annoyance is an important problem (37: 2). Environmental pressure groups are viewed positively (32: 2).

Complaining, in this frame, is necessary and useful in general (19: -1, 22: -2), but subjects are indifferent about the statement that there is too much attention for a small group of serial complainers (23: 1).

This frame accurately reproduces the dominant policy and supports the government's policy stronger than any other frame. Subjects strongly disagree with the statement that the government does not live up to its promise to reduce the noise (31: -4) and with the statement that Schiphol acts as a "free-state" (27: -5). Subjects do not feel powerless (13: -2) and do not have the idea that the sound is forced on them (5: -3). Still, subjects weakly disagree with the statements that the government and Schiphol do enough to reduce the noise (29: -2 and 30: -1, respectively). So even in this frame achievement of the double-sided aim of the government is not supported (43: 1).

It seems as if in this frame, subjects have internalized the dominant policy, but feel disappointed with the results. Subjects strongly agree with statements that Schiphol should be relocated to the sea (47: 4) and that it would be a good idea to have an "aircraft-free-Sunday" every now and then (46: 4). The first measure has been debated since the 1960s; the second one is in no way part of the dominant policy discourse.

In addition, subjects have faith in technology to reduce noise (26: 3) as well as in technology in general. This latter remark is supported by the fact that subjects within the frame are least fearful of a nearby aircraft crash (17: -5). It is plausible that the acknowledged failure of the double-sided aim does not lie in subjects' belief that this is a wrong aim to strive for but probably lies in subjects' belief that wrong or too few solutions are being implemented.

Lastly, although subjects do regularly hear aircraft (3: 3), they are not particularly annoyed by aircraft noise (10: -1). They do, however, find it unacceptable that people are disturbed by aircraft noise in their dwelling (8: -4) or that people have to interrupt a conversation due to the noise (9: -2).

The structure of this frame closely resembles the dominant policy. In this frame, a "technological fix" is the prime solution for the still existing tension between economy and ecology.

Frame D: Noise is not a problem (the antigovernment stance)

This frame is shared by two subjects and can explain 4% of the total variance. This account neither strongly concurs with the policy discourse's propagation of aviation as an important driver of the economy (35: 1 and 36: 1), nor with its propagation of aviation as an important environmental threat (38: 1). Moreover, subjects even disagree with the statement that noise annoyance is an important problem (37: -3). The denial of aircraft noise as an important problem also becomes apparent from other statements: Subjects are not annoyed by aircraft noise (10: -4), they do not believe that the government should strive for reducing noise annoyance (39: 0), nor do they fear that aircraft noise will increase (4: -4), and they strongly agree with the statement that farther away from Schiphol aircraft noise is not really a problem (48: 5). In addition, subjects in this frame do not regularly hear aircraft (3: -2) in contrast to the other frames in which subjects agree to this statement.

The attitude that aircraft noise is not a problem is consistent with the strong non-complaining attitude present in this frame. Subjects strongly agree with the statement that people who complain about aircraft noise only serve their self-interest and wrongfully neglect the importance of Schiphol to The Netherlands (22: 5). In addition, they do not believe that citizens should move up collectively against the noise (21: -4) and agree with the statement that there is sufficient consideration for residents around Schiphol (20: 3).

Still, subjects believe that the government does not do enough to reduce the noise (30: -5), that the double-sided aim of the government has failed (43: 4), and that the government does not live up to its promise to reduce the noise (31: 3). Since subjects in this frame do not subscribe to the ecological or the economic arguments, their dissatisfaction is derived from a different argument. In this frame, subjects most strongly state that government should not strive for growth of the airport (40: -5) and that Schiphol is big enough and should not be allowed to grow any further (42: 4). Subjects probably fear the growth of the airport for which they blame politicians, not the industry. They do not believe Schiphol always gets its way (28: 0) or that it acts as a free-state (27: 0).

As mentioned earlier, subjects adhering to this frame do not find themselves annoyed by aircraft noise (10: -4), nor do they regularly hear aircraft (3: -2). As in frame A, subjects in frame D are rather indifferent about the acceptability of being disturbed by aircraft noise (8: -2 and 9: 0).

This frame is structured around the idea that the physical growth of the airport is insufficiently controlled by politicians, but this problem is not connected to either environmental or economic arguments. It might relate to a conservative anti-government frame in which the airport as such is big enough.

Frame E: Aviation, a local problem (the a-political stance)

This frame is shared by three subjects and can explain 5% of the total variance. Subjects in frame E are, similar to those in frame D, not very concerned with the positive economic effects (34: 0 and 36: 1) or the negative environmental effects (38: -1 and 39: 1) of the airport. Instead the consistent theme in this frame is that subjects evaluate the statements in terms of the direct consequences they hold to their personal situations. Therefore, subjects do not take a strong position in the wider public controversy related to the economy-ecology conflict, but instead react with strong agreement to the statements such as “I fear aircraft noise will increase” (4: 5) and “Air traffic is a hazard for public health” (11: 3).

The most striking feature of frame E is the subjects’ desire to move to a quieter neighbourhood (16: 4). In addition, subjects strongly disagree with the statement “I can do something about the noise” (15: -5). Only in this frame, people do not think that one should be proud of the airport (34: -2).

Subjects strongly believe that the government should strive for noise reduction (39: 4) and deny that noise annoyance is an important problem at the same time. They weakly believe that the government and Schiphol are not putting in enough effort to reduce noise (30: -2 and 31: -2) and that Schiphol always gets its way (28: 2). They support an “aircraft-free-Sunday” (46: 3), but relocation of the airport is not considered a good idea (47: -2). Although such a measure would of course result in direct positive effects (i.e., no more aircraft noise) it also has its direct disadvantages, for it would probably raise the price for air travel. This goes against subjects’ desire to travel by air, which can be inferred from subjects’ strong disagreement with the statement that flying is too cheap (25: -5).

Similar to subjects in frame B, subjects within this frame consider themselves to be moderately annoyed by aircraft noise (10: 2) and subjects regularly hear aircraft (3: 5). Lastly, they find it unacceptable to be disturbed by aircraft noise (7: -4 and 8: -3).

The line of reasoning in this frame is difficult to interpret. It does not resemble the dominant policy and seems inherently contradictory. What seems to stand out is a fear of personal damage, a desire to move away from the neighbourhood, and no identification with the airport. This might be seen as an a-political stance. The ecology-economy conflict is turned into a local and personal problem, which can be solved with a local solution, i.e., moving to a quieter place.

5.5.2 The relation between the policy discourse and internal frames

We expected that the ways people approach aircraft noise (described in Section 5.5.1) are related to the way this noise is approached in policy discourse (Section 5.2). Based on the results it can be concluded that the first three frames are clearly related to the policy discourse. Frame A follows the economic argument, and frames B and C follow both the economic and environmental arguments. Moreover, none of the frames denies the economic or environmental trains of thought. Frame A, the economic frame, does not acknowledge the environmental problems posed by aviation, but also does not deny them. Statements related to environmental concerns receive a neutral score, not a negative one. Frame B, the environmental frame, moderately agrees with part of the economic reasoning (i.e., employment). Lastly, frame C also sides with both arguments, but, in contrast to frame B, emphasizes the economic values. In addition, since the first three frames account for the major part of the total portion of explained variance (cumulative 40% of the total 49%), it can be concluded that the lines of reasoning expressed within the policy discourse interact with most of the participants' beliefs. Hence, the way the problem is framed in the policy discourse becomes internalized in the internal frames of people.

5.5.3 Noise annoyance response within the frames

Next, the noise annoyance response within each frame is assessed. This is done through examination of the position of statement 10, "I am annoyed by aircraft noise," in the factor arrays (see Table 2). In addition, this information is supplemented with results from the standardized noise annoyance question posed in the short interview conducted after the Q-sorting exercise. The Q-methodological and traditional survey results are both reported to cross-validate the observations.[23] From Table 3 it can be deduced that the position of statement 10 for the different frames is overall consistent with the mean scores of the standardized noise annoyance item.

Differences greater than 2-3 between statement scores can be treated as significant (Brown, 1980). Based on this rule-of-thumb it is concluded that several annoyance scores vary significantly across frames. More specifically, the following comparisons are significant: frames A and D versus the other frames, frames B and E versus the other frames, and frame C versus the other frames.

[23] We acknowledge that the sample is too small to provide reliable estimates for the means and standard deviations. These figures are regarded as indicative.

Table 3. Position of statement 10 and the means and standard deviations of the standardized noise annoyance item

		Noise annoyance (0-10)		
Frame	**Position s10**	**Mean**	**S.D.**	**N**
A - Long live aviation!	-5	1.43	1.45	14
B - Aviation: an ecological threat	2	6.00	2.37	15
C - Aviation and the environment: a solvable problem	-1	4.00	1.00	3
D - Aircraft noise: not a problem	-4	2.50	0.71	2
E - Aviation: a local problem	2	6.33	3.21	3

Within frames A and D annoyance is strongly denied. For frame A the denial of aircraft noise as annoying is consistent with the belief that aviation has only economic benefits and is not associated with environmental costs. Frame D even explicitly denies aircraft noise as a problem. On the contrary, for frames B and E, annoyance is (moderately) justified. Frame B prioritizes ecological concerns over the economic benefits. Aircraft noise is regarded as a serious problem. Frame E does not relate to the environment-economy dichotomy. However, here, the local conflict justifies a negative response to noise. It is important to note, however, that frames B and E do not legitimize an extreme annoyance response. After all, benefits of aviation (being national or individual) are acknowledged, so one cannot totally oppose aviation/Schiphol. Lastly, frame C strongly supports economic benefits but also acknowledges environmental values. This goes together with an average noise annoyance score, which deviates significantly from the annoyance scores in the other frames.

Overall, it can be concluded that annoyance response is intrinsically related to the frames and that the frames legitimize or delegitimize different degrees of annoyance response. The variance in annoyance response (i.e., after controlling for the level of noise exposure by keeping its level constant) aligns well with the variation in frames. The present approach therefore provides an adequate means of understanding this variation.

5.6 Discussion

Finally, we would like to reflect on the results of our analysis and focus our attention on two issues: the observed variation in frames and the noise annoyance response within the frames.

The first issue relates to the finding that people's frames and the policy discourse indeed overlap. With respect to this observation it can be questioned why we did not find one frame that fully resembles the policy discourse. In the following an argumentation will be provided why this finding would have been unlikely.

It could be speculated that a frame fully reflective of the policy discourse would position both economic and environmental arguments on the right side of the scale; after all, both are considered very important in the policy discourse. In line with the policy discourse, subjects would trust central planning authorities. However, such a frame was not found. Instead, subjects across all frames (mildly) agree with the statement that the government has failed to achieve the double-sided aim (statement 43: to let the airport grow and restrict environmental impacts at the same time). This critical evaluation can be explained by an inherent contradiction present within the policy discourse because, on the one side, the policy discourse relies strongly on technological advances, which are said to "fix" the problem, but, on the other side, these technological advances contribute to the growth of aviation. Hence, the situation remains that some aircraft noise will have to be accepted. The policy does not provide a clear solution to the economy-ecology conflict. Therefore, an inconsistency can be

perceived within the policy discourse because it reproduces the contradiction it claims to solve.

Subsequently, in line with Festinger's (1957) theory of cognitive dissonance, which postulates that inconsistency among beliefs will cause an uncomfortable psychological tension, it can be argued that people are forced to resolve this inconsistency. It can be observed that each frame related to the policy discourse (i.e., frames A-C) has a distinct way of doing this. Frame A simply resolves the inconsistency by playing down the environmental arguments. For frame B, which prioritizes environment over economy, but indeed subscribes to both arguments, the inconsistency is resolved by "adding" other cognitions and feelings: a negative attitude toward the authorities, distrust that they will successfully handle the noise problem and feelings of a lack of control. The government makes a promise (less noise) but does not keep it (aviation and Schiphol keep growing), and is therefore not to be trusted. The well-established "non-acoustical factors" such as trust and control serve the purpose of resolving the perceived dissonance. Lastly, frame C, which prioritizes economy over environment, but also subscribes to both arguments, resolves the inconsistency via two ways. Like frame B it "adds" cognitions that the authorities fail to do their job, but distinctively, it also places high hopes on possible future solutions, most notably, the relocation of the airport to the sea.[24]

Altogether, it can be argued that subjects experience an inconsistency within the policy discourse. The different ways to resolve the perceived dissonance lead to different frames. As can be observed from the lines of reasoning expressed in the frames, each has developed its own distinctive way of doing this. In addition, established "non-acoustical factors" such as trust and control are internalized as part of the frames and hence as part of an argumentative relation with policy makers. In fact, they can hardly be treated as isolated variables, but should be approached as part of specific discourses.

A second issue on which we want to focus relates to the noise annoyance response within the frames. In the present study it is assumed that the position of aircraft noise annoyance follows from the lines of reasoning present within the frames. However, it can be argued that the varying levels of disturbance, which people experience, dictates the adoption of specific policy arguments. A person who regularly feels disturbed by aircraft noise (e.g., who is interrupted in a conversation or awakened during sleep) might be selective in the adoption of the arguments that are congruent with this state. We hold the (preliminary) belief that people "construct" their experience of aircraft noise on the basis of the disturbances they experience as well as under influence of socially sanctioned arguments provided by the policy discourse. It can be argued that it is unlikely that people will become annoyed by the noise if they are not disturbed by it in any way and that, the other way around, people who have to interrupt a conversation due to the noise might not classify this as particularly annoying if the policy discourse would not legitimate such concerns. To substantiate this point further, it can be observed that in frame D, a person claims not to hear aircraft with any regularity (see statement 3 in Table 2). This particular frame selectively ignores aircraft noise as relevant. This observation is consistent with a literature review of Stallen (2008), which suggests that (even) the perceived loudness of a stimulus is not determined by its physical characteristics alone but also by its (social) context, an insight which already existed in relation to noise annoyance (Maris et al., 2007a, 2007b).

[24] Here, a nice analogy between frame C and a particular smoker can be drawn. A smoker, who feels an inconsistency between smoking behavior and the cognition that smoking is bad for health, can neutralize this inconsistency by resolving to stop smoking in the (near) future. This postpones the feeling of being inconsistent.

5.7 Conclusion

In this study the hypothesis is investigated that policy making is a possible mechanism through which the sound environment due to aircraft is turned into annoyance. To this effect, the policy discourse is described and the internal frames of people are revealed via Q-methodology. The factor analysis revealed five frames, which residents around Amsterdam Schiphol adopt to evaluate aircraft noise. We showed that the three main frames are related to the policy discourse. Based on these results it is concluded that the policy discourse is a source of arguments, which plays a role in structuring the frames of people. Second, it is shown that the experience of aircraft noise, and, in particular, noise annoyance, is intrinsically related to whole and consistent frames: the meaning of sound depends on a large set of mutually reinforcing positions. Non-acoustical factors should be regarded as part of these specific comprehensive frames and serve the purpose of making these frames internally consistent. Lastly, it can be concluded that our approach has been effective in explaining the variation in annoyance response controlled for the level of noise exposure. The analysis has provided a better understanding of the (negative) experience of aircraft noise.

Finally, we can relate our findings to our point of departure, namely, the observable trend that presently people are more annoyed than several decades ago at equal (annual equivalent energy) noise levels. Our analysis suggests that this trend can be explained by the fact that today's policy discourses explicitly recognize aircraft noise as an important problem. This definition becomes internalized by people affected by aircraft noise and structures the experience of noise as negative.

To investigate our hypothesis further, the following directions for further research can be formulated. First, our research focused on the relationship between the policy discourse and individual frames at one moment in time without considering which of the two takes causal precedence. Bröer's (2006, 2007b) research provides data, which point at least to a historic precedence of policy arguments before people's frames. But the issue of causality remains. One might argue that annoyance is part of a field in which multiple actors (including policy makers, stakeholders, and citizens) together construct annoyance policy and frames. Further research should focus on this process. Particularly, one should focus on the micro-processes in which people develop perceptions of aircraft sound. By studying this process insights could be gained as to whether these coherent frames are built around experienced disturbances due to aircraft noise (which subsequently dictate the adoption of specific policy arguments) or around the arguments put forward by the policy discourse (which facilitates the formation of negative feelings and increases the proneness of being disturbed) or whether it is, in fact, a co-evolutionary process in which both processes mutually reinforce each other.

The second possible focus of future research is the distribution of the frames over the population. A mixed-method approach, combining Q-methodology with traditional survey methods, would have to be followed to gain information about the exact distribution. Within such a mixed-method model the effects of the physical level of aircraft noise exposure (which presently is not part of our model) could also be investigated. For example, it could be hypothesized that the distribution of different frames is different for varying levels of noise exposure.

A third direction is to study the policy discourse and individual frames at other airports. In this study the relationship between the policy discourse and the individual frames are studied for one airport only. To find further support for our hypothesis that the policy discourse shapes individual frames this relationship should be studied at multiple airports where different problem definitions exist. Airports where no well-defined noise policies exist would be even more interesting cases. In such instances one might find little negative response to

aircraft noise, find that those who are annoyed might need to go at great length to develop comprehensive frames that rationalize their negative experiences (since no pre-existing frames are available), find that other institutions provide people with a framework to interpret noise, or find that a much larger variety of individual frames exist (since no common frame is available). In short, research focused on such cases can yield interesting results.

Lastly, we would like to relate our findings to the policy practice. The analysis shows that the conceptualization of aircraft noise as an important problem by policy makers disciplines the way aircraft noise is evaluated. Should policy makers therefore stop treating aircraft noise as a problem? We do not believe so. In the first place, as we have seen in our analysis, there are frames that do no relate to the policy discourse and in which annoyance response to aircraft noise is still present. In addition, next to the disciplinary effect of the policy discourse on community response, we believe that the policy discourse also serves the function of channeling response. As mentioned in the previous paragraph, without this common discourse that people can fall back on in qualifying the sound of aircraft, it can be speculated that the variety of frames would probably be much larger and maybe more extreme. We believe that denial of aircraft noise as a problem should therefore not be regarded as a successful strategy.

However, the way policy deals with aircraft noise after acknowledging it as a problem is another issue. At Amsterdam Schiphol the mainport and environmental discourse is based on the premise that technological development is able to uncouple the divergent goals. Yet, in all of the revealed frames, whether pro-economy, pro-environment, or its combination, it is believed that achievement of the double-sided aim (growth and reduction in annoyance) has failed. If we relate this observation to Dryzek's (2001) (p. 652) notion of discursive legitimacy, which he defined as "the degree that collective outcomes are responsive to the balance of competing discourse in the public sphere," it can be concluded that the policy discourse's main premise is inconsistent with the frames shared among the public. This inconsistency undermines the legitimacy (and credibility) of the noise policy. Along this line of reasoning it would be better to let go the idea of a technological fix and explicitly choose for either economy or ecology.

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6. Policy, Structural Variables and Annoyance

Kroesen, M., Molin, E. J. E. and Van Wee, G. P. (2010) Policy, personal dispositions and the evaluation of aircraft noise. *Journal of Environmental Psychology* (in press).

Abstract

In this paper, we hypothesize and test the ideas that (1) people's subjectivity in relation to aircraft noise is shaped by the policy discourse, (2) this results in a limited number of frames towards aircraft noise, (3) the frames inform people how to think and feel about aircraft noise and (4) the distribution of the frames in the population is dependent on structural variables related to the individual. To reveal subjects' frames of aircraft noise a latent class model is estimated based on survey data gathered among a sample of 250 residents living near Amsterdam Airport Schiphol, a major international airport in the Netherlands. In line with expectations, the results show that there are four evaluative frames of aircraft noise, three of which are strongly linked to the policy discourse. The frames are associated with fitting levels of annoyance response. In turn, frame membership is influenced by two structural variables, namely aircraft noise exposure and noise sensitivity. The results indicate that social factors operate discursively in the explanation of subjective reaction to noise, while personal factors operate within a traditional cause-and-effect model. The paper concludes with several policy implications.

6.1 Introduction

Noise annoyance is one of the main consequences of exposure to aircraft noise in residential areas. Previous research has consistently shown that the degree of noise annoyance is a direct function of the level of noise exposure (Fidell et al., 1991; Schultz, 1978). However, since humans are essentially interpretative beings, noise annoyance (by definition) arises within a particular evaluative context. Like exposure to noise this evaluative context may be regarded as a necessary condition to feel annoyed by aircraft noise.

The discourse resonance theory (Bröer, 2006, 2007, 2008; Bröer and Duyvendak, 2009) assumes that the evaluative context of aircraft noise is effectively shaped by the way policy actors conceptualize the noise problem. Based on work of Hajer (1995), Bröer (2006) expected that through a process of institutionalization one conceptualization of the noise problem would become dominant during the policy process. A policy discourse that can be expected to become dominant is generally one which can accommodate varying (and competing) interests of multiple policy actors. Bröer (2006) assumed that the dominant policy discourse would resonate among people living near an airport and provide them with the necessary frames of reference to provide meaning to aircraft noise. According to Bröer (2006) people regularly come into contact with the policy discourse via participatory policy processes, public meetings, referenda, news media, complaint procedures, and other policy measures (e.g. insulation policies). As a result, policy concepts become taken for granted in everyday life. Eventually, the macro policy frame becomes reflected in people's individual frames towards noise. Drawing from literature in the political, policy and communications sciences, a frame is defined here as a coherent set of beliefs, attitudes and feelings that people use to observe and give meaning to reality (Benford and Snow, 2000; Entman, 1993; Goffman, 1974; Schön and Rein, 1994; Snow et al., 1986). The concept of a frame, we believe, is interchangeable with the concept of a schema (Bartlett, 1932), which can be defined as a mental representation of any given class of objects. A frame, however, is distinguishable from an attitude in the sense that it does not represent an evaluation along a single continuum, but represents a (multidimensional) attitude structure.

In qualitative research, conducted at Amsterdam Schiphol (The Netherlands) and Zürich-Kloten (Switserland), Bröer (2006) indeed found dominant policy discourses for each airport: noise as an environmental problem (Amsterdam) and noise as a distributional problem (Zürich). As expected, these conceptualizations resonated among the residents living near these airports and shaped the evaluative frames to feel annoyed. In sum, the frames found among the general public resembled the collective public representations of the noise problem. In a follow-up study Kroesen and Bröer (2009) used Q-methodology to quantitatively investigate people's evaluative frames at Amsterdam Schiphol. This method is suitable to identify clusters of similar response patterns (Brown, 1980). The study revealed five frames related to the topic of aircraft noise, three of which were strongly linked to the policy discourse. The frames were found to strongly correlate with annoyance response.

The aim of the Q-study of Kroesen and Bröer (2009), in line with the study of Bröer (2006), was to identify generalized ways of thinking and feeling towards aircraft noise. In both studies the sample was small and strategically chosen to ensure that all possible frames would be revealed. It therefore remained unknown to what extent the revealed frames would be present among the population of residents living near Schiphol airport. In addition, given the small sample size the frames could not be linked to structural variables related to the individual (i.e. situational variables and personal dispositions).

The main aim of the present study is to validate the frames and generalize them towards the population of residents living within the 45 L_{den} dB(A) contour of Amsterdam Schiphol. In

addition, we investigate the effects of two structural variables, i.e. aircraft noise exposure and noise sensitivity, on frame membership. To attain these aims we estimate a latent class model based on data from a community survey conducted in 2008 near Amsterdam Airport Schiphol. Latent class analysis can be used to reveal the (latent) classes that underlie an observed pattern of correlations between a set of indicators (McCutcheon, 1987). Similar to Q-methodology latent class analysis can therefore identify general ways of thinking towards an issue. Unlike Q-methodology, however, the sample size is unlimited. It is therefore a suitable method to quantitatively validate the frames and generalize them towards a population.

6.2 Theory and conceptual model

In the following the discourse resonance theory will be described, two studies that applied the theory will be reviewed and the directions of the assumed relationships will be discussed. The section concludes with the development of a conceptual model to generalize the theory to the population living near Schiphol airport.

6.2.1 A description of the discourse resonance theory

The discourse resonance theory developed by Bröer (2006), posits that people, when confronted with an environmental stressor like aircraft noise, adopt shared collective frames to evaluate it. According to Bröer (2006) these common frames result from the interaction of individual pre-existing mindsets and the dominant policy discourse. A dominant policy discourse is defined here as a shared conceptualization of public actors towards a policy issue, which has been institutionalized in policy (Hajer, 1995). Inspired by the work of Koopmans and Olzak (2004), Bröer (2006) identifies two possible outcomes of the interaction between the (macro) policy discourse and the (micro) individual frames: consonance and dissonance. People can either support the policy discourse (consonance) or partly diverge from and partly support it (dissonance). Consonance means that the policy discourse 'strikes a responsive chord' in people. This happens when the policy discourse is perceived to be in line with people's own cognitions and feelings. As a result, people will tend to reproduce the discourse. Dissonance also means that a responsive chord is struck, but that the policy discourse is perceived to be internally inconsistent or inconsistent with already existing cognitions and feelings. As a result, people will only partially reproduce the policy discourse and partially oppose or diverge from it. Consonance and dissonance both constitute forms of resonance of individual frames with the macro policy frames (Bröer, 2006; Bröer and Duyvendak, 2009). Bröer (2006) also identifies a third option, which he calls autonomy. In this case people derive their evaluative frame of reference from another source than the dominant policy discourse.

The discourse resonance theory outlined by Bröer (2006) implies that policy making is one of the most important 'meaning-producing' processes in our society. In effect, this theory also adds to another conceptual model used to explain individual perceptions within the social context, namely the theory of the social amplification of risk (Frewer et al., 2002; Kasperson and Kasperson, 1996; Kasperson et al., 1988). This theory also assumes that there exist social transmitting stations (media, government and nongovernment organizations, opinions leaders, social groups, etc.), which attenuate or amplify information about risks and thereby shape individual perceptions of risk. The difference between the social amplification theory and the discourse resonance theory is that the former assumes that these social stations, depending on their role, will transmit different idiosyncratic messages, while the latter assumes that the signals from these transmitting stations already conform to an underlying comprehensive whole, namely the dominant policy discourse. Hence, in contrast to the social amplification

theory, the discourse resonance theory is explicit about where shared meanings are actually constructed, namely within the policy making process. This idea is also congruent with many theories on policy making, which generally describe this process as one in which problems are (publicly) conceptualized and handled (Hajer, 1995; Kingdon, 1984; Schön and Rein, 1994).

Through resonance the noise policy discourse shapes the individual frames of people. In turn, these frames act as the evaluative contexts to feel (or not feel) annoyed by aircraft noise. Hence, they contain certain 'feeling rules' (Hochschild, 1979). According to Hochschild (1979) individuals often work to induce feelings which are considered appropriate given their perception of the situation. So if the policy identifies aircraft noise as an important problem and this definition resonates among those people who are affected by aircraft noise, feelings of annoyance will be aroused.

6.2.2 Applications of the discourse resonance theory

To verify the discourse resonance theory Bröer (2006) studied the (macro) policy discourse and (micro) individual frames at two airports: Amsterdam Schiphol and Zürich-Kloten. At both airports he found that the macro policy discourse posited growth of air mobility as necessary for the national economy. In order to compete in a globalizing economy growth was assumed to be inescapable. According to Bröer (2006), this trend argument (growth is natural/ inescapable) was dominant in both countries and formed the contextual background of the noise policy, which did differ across the two countries.

In the Netherlands he found that aircraft noise was conceptualized as an environmental problem that needed to be addressed through central planning measures. The underlying idea was that through careful planning the airport would be able to grow, while aircraft noise in residential areas could largely be avoided. During the 1980s this positive-sum logic became explicit with the ideas of 'ecological modernization' (Hajer, 1995) resulting in what Bröer termed the mainport[25] and environment discourse. He showed how central policy measures (a new runway and collective cumulative noise limits) could be seen as institutionalizations of this line of thought. In Switzerland, on the other hand, he found that noise was conceptualized as a distributional problem. Here, citizens were informed by political actors that flight paths might be distributed differently. Within this discourse aircraft noise became conceptualized as a threat to the local community. This led to a zero-sum game, in which local communities stood up for the protection of their local 'soundscape', often at the cost of other communities.

In studying the individual frames of residents at both airports Bröer (2006) indeed found that people in their everyday conversations about aircraft noise adopt the logic of the policy discourse. At Schiphol airport, he found one consonant and two dissonant frames. The consonant frame ('mainport and environment') replicated the positive-sum logic of the Dutch policy. Residents in this frame believed that development of the airport and noise control could be achieved at the same time. In contrast, the dissonant frames only reproduced part of the policy discourse and thereby assumed a trade-off logic. The first dissonant frame, 'don't complain', replicated only the economic or 'mainport' argument. In this frame, the environmental argument was downplayed and complainants were ridiculed. The second

[25] The term mainport was introduced in the Dutch political field in the 1980's and was initially applied to the seaport of Rotterdam and later also to airport of Amsterdam (Schiphol). The mainport concept combines the identification of several external forces (internationalization, liberalization and the development of hub-and-spoke networks) with the necessity of a strong national strategy (concentration and large infrastructure development) in order to bring about national economic prosperity (to create so-called 'engines of the economy') (Bröer, 2006).

dissonant frame, 'free state Schiphol', showed the opposite pattern, and only supported the argument of aircraft noise as an important environmental threat. In this frame, the economic benefits of the airport were criticized and air mobility was conceptualized as a being out of control.

At Zürich-Kloten, Bröer (2006) found one consonant and three dissonant frames. The consonant frame replicated both the trend argument (growth is inescapable/natural) and aircraft noise as a distributional problem (noise must be fairly distributed). The first dissonant frame, 'exaggerated annoyance', resembled the noncomplaining frame at Schiphol airport. It emphasized the benefits of the airport and denied the existence of any real annoyance. The second dissonant frame, 'local resistance', emphasized only the second part of the discourse (distribution). Following this part it defined aircraft noise as a threat to the local community and legitimized (local) action to oppose aircraft noise. The third dissonant frame, 'limits to distribution', criticized the trend argument and defined aircraft noise not as a local but as a general problem.

At both airports, Bröer (2006) also found instances of autonomy: 'noise as the violation of a basic human right' and 'noise as a local problem' at Schiphol airport and 'noise as contextual problem' (evaluation of aircraft noise in relation to other noise sources) and 'noise as an environmental problem' at Zürich-Kloten. In both cases the percentage of autonomous frames was approximately 10%. Consonant and dissonant frames both constituted approximately 45% in the two samples.

Finally, following Hochschild's (1979) notion of feeling rules, Bröer (2006) showed how the frames correlated with varying levels of annoyance response. Consonant frames went along with an annoyance score consistent with the overall average score of the respective cases. The dissonant frames 'don't complain' and 'exaggerated annoyance' were related to an average annoyance score below the overall average, while the dissonant frames 'free state Schiphol', 'local resistance' and 'limits to distribution' were related to an average annoyance score above the overall average. It should be noted that, given the fact that subjects were sampled from a single neighbourhood (to keep the physical aircraft noise exposure level constant), these differences are not necessarily representative for the population.

Bröer (2006) used an interpretative approach to identify the individual frames (only noise annoyance was quantitatively measured). To quantitatively objectify the frames Kroesen and Bröer (2009) applied Q-methodology in a follow-up study among residents at Amsterdam Schiphol. In this study, the subjects were again sampled from one neighbourhood near the airport to keep the noise exposure level constant. In total, 5 frames were revealed, three of which were substantively linked with the policy discourse. In all, 86% of the participants in the sample loaded on one of these frames, again indicating that the policy discourse resonated (be it consonant or dissonant) broadly among the subjects. Consistent with findings of Bröer (2006) the frames were associated with varying levels of annoyance response.

6.2.3 The directions of causality

The discourse resonance theory assumes the existence of two relationships, between the policy discourse and people's frames and between people's frames and noise annoyance. In this section, we elaborate on the underlying theoretical mechanisms and our assumptions about the directions of the relationships.

To describe the theoretical mechanism involved in the relationship between noise policy and people's frames, Bröer (2006) used the term resonance. According to Bröer (2006) people regularly come into contact with the policy discourse via newspapers, public meetings, information provided by public authorities, participatory policy processes, referenda and

policy measures. In these moments of contact, the concepts and labels used by policy makers and scientists are transferred to the general public. As a result, people are socialized in the policy process. This process can occur unconsciously, in the case of consonance, when people (inactively) get familiarized with the policy discourse and start to reproduce it. Or, in the case of dissonance, this process can involve conscious deliberation, when people take an active stance in opposition to the policy discourse. In order to express critique they nevertheless need to reproduce parts of the policy discourse. In either case (consonance or dissonance) the original message of the policy discourse is reproduced and becomes more diffused.

The discourse resonance theory assumes a unidirectional relationship between the policy discourse and people's frames. It can be objected, however, that this relationship not necessarily unidirectional. Theoretically, it can be expected that people use their own definitions and construct their own evaluative frames of annoyance. Preliminary empirical evidence, however, suggests this is not the case. The research of Bröer (2006) and Kroesen en and Bröer (2009), indicates that the frames which people adopt to evaluate aircraft noise are limited in number and that the dominant frames are related to policy. If people would indeed construct their own frames, their number and variety would likely be much greater. Second, Bröer (2008) has shown that the construction of meaning in the policy process precedes community response in time. In the Netherlands, the central planning discourse already identified aircraft noise as a potential problem in the 1950's (and defined it as a spatial planning problem), long before large-scale discontent was experienced and uttered by citizens at the end of the 1960's. Finally, even when citizens and activists become actively involved in the policy process, their opposition is already shaped by the policy discourse. For example, protest groups in the Netherlands pleaded for measures which fitted the acoustic and technocratic model of spatial planning, like the repositioning and relocation of runways (Bröer, 2006). Hence, the opposition strengthened the dominant planning discourse and did not introduce alterative meanings in the policy process (e.g. noise as an economic or a social problem). In sum, although citizens can have definitive roles in the conceptualization of policy issues, their role concerning the definition of aircraft noise was generally passive (or re-active).

With respect to the second relationship, i.e. between people's frames and noise annoyance, Bröer (2006) relied on Hochschild's notion of feeling rules as the underlying theoretical mechanism. This notion implies that a definition of the situation accommodates feelings consonant with this definition (and excludes dissonant ones), which is in line with theories of cognitive consistency (Brehm and Cohen, 1962; Festinger, 1957; Heider, 1946). A fundamental premise of these theories is that people will strive to reach internal coherence among their beliefs and feelings (to reduce the undesired tension of having dissonant beliefs/feelings). This means that when confronted with varying (unrelated) psychological elements, people will actively construct holistic representations that can account for their specific configuration. Strategies like altering, adding or changing the importance of elements can be employed during the process of reaching a stable representation (see Svenson (1992) for an overview of possible strategies). Unlike algebraic models like Anderson's Information Integration Theory (Anderson, 1996) or Bayes's Theorem, in which the individual cognitive elements are assumed to independently lead to (the computation of) a final judgment, cognitive consistency theories assume that premises and conclusions affect each other in a bidirectional manner (Simon et al., 2004). This also means that the meanings of individual elements are not invariant (as assumed in algebraic models), but arise from the particular wholes.

In line with the principle of bidirectional influence, we assume that noise annoyance is shaped by the frames, but in turn, is also constitutive of the frames. Hence, we do not assume causal

dominance of policy-related arguments over noise annoyance. Instead, we treat policy arguments and annoyance as elements, which together interact to form consistent frames with an intrinsic logic. It can be argued that it is unlikely that people will become annoyed by noise if that are not disturbed by it in any way and that, the other way around, people who have to interrupt a conversation due to the noise might not classify this as particularly annoying if the policy discourse would not legitimate such concerns. Our main objective is not to provide evidence of causal dominance one way or the other, but to show that the individual frames, due to criteria of internal consistency and external defensibleness, are limited in number as well as form.

Summarizing, it can be concluded that the discourse resonance theory contributes in understanding people's subjective evaluation of aircraft noise. However, several knowledge gaps still exist. Specifically, it is unknown (1) how the frames are distributed among the population of residents, and (2) whether and to which extent structural variables related to the individual influence this distribution. The conceptual model described in the next section is developed to fill these gaps.

6.2.4 Conceptual model

Based on the discourse resonance theory we hypothesize that the evaluative context of aircraft noise at Schiphol airport consists of four frames, three of which are linked to the policy discourse: 'mainport and environment' (consonance), 'don't complain' (dissonance) and 'free state Schiphol' (dissonance). More specifically, we predict that the majority of the population will use policy-related arguments to construct their evaluative frames of aircraft noise and expect that only a small portion of the population will be unaffected by the policy (autonomy). Based on the notion of feeling rules we hypothesize that each frame is associated with an 'appropriate' response in terms of feeling annoyed by aircraft noise.

To address the question why people end up in the particular frames as they do, we identify two variables which we hypothesize will predict frame membership. The first is the physical level of aircraft noise exposure. Previous research related to the noise-annoyance relationship has generally not provided explicit accounts for the underlying theoretical mechanism(s) involved (Fidell, 2003), but has consistently shown that noise exposure is empirically associated with people's reaction to noise (Fidell et al., 1991; Miedema and Oudshoorn, 2001; Quehl and Basner, 2006; Schultz, 1978). In the present study, we expect that the proportions of people subscribing to the varying frames will be related to the aircraft noise level. Specifically, we hypothesize that at low exposure levels people will mainly express themselves in the 'don't complain'-frame while at high exposure levels people will mainly adopt the 'free state Schiphol'-frame.

The second structural variable is an individual dispositional variable previously shown to be associated with noise reaction, namely noise sensitivity (Stansfeld, 1992; Van Kamp et al., 2004; Zimmer and Ellermeier, 1999). Research has shown that noise sensitivity is empirically unassociated with noise exposure (Job, 1988; Miedema and Vos, 2003). It can therefore be identified as a genuine determinant of noise reaction (and not as a possible reflection of noise reaction, since this would imply a correlation between noise exposure and noise sensitivity). Additionally, noise sensitivity has been shown to correlate with other aspects of a person's personality like neuroticism (Belojevic et al., 1992), adding to the evidence that noise sensitivity is a personal disposition. In this respect, a study among twin-pairs has also shown that noise sensitivity, with an estimated heritability of 36%, probably has a genetic component (Heinonen-Guzejev et al., 2005).

In sum, noise sensitivity can be viewed as a stable personality trait related to the individual, which, as such, should be largely unaffected by people's everyday communications about aircraft noise. We therefore hypothesize that noise sensitivity is, not an indicator, but a determinant of frame membership. Specifically, we expect that people with a general disposition to feel disturbed by sounds will express themselves in a frame which suits this disposition, in this case the 'free state Schiphol'-frame. The other way around, we expect that those not easily disturbed by sounds will (mainly) express themselves in the 'don't complain'-frame.

A third set of assumptions relate to the relationships between the determinants and indicators of the frames, which we hypothesize are mediated by frame membership. These assumptions reflect the idea that the frames are effective in capturing the full breadth of people's subjectivity in relation to aircraft noise. In other words, if no direct effects between the determinants and the indicators remain after accounting for the frames, it can be said that the frames indeed capture the relevant variance residing in the indicators.

In Figure 1 the full conceptual model is depicted. To summarize, we assume that people's subjectivity can be captured in a limited number of frames which exist in relation to the policy discourse. Conditional on the frame membership, we assume that the associations between the residual terms of the frame indicators (i.e. noise annoyance and concepts related to the policy discourse) are zero. This assumption reflects the idea that there are indeed a limited number of unobserved/latent categories (i.e. frames) that can effectively account for the observed relationships between the indicators. Additionally, we expect that frame membership will be associated with structural variables related to the individual. Specifically, we expect that aircraft noise exposure and noise sensitivity will (independently from each other) predict frame membership. Finally, we assume that the frames will fully mediate the direct relationships between the determinants and the indicators of the frames.

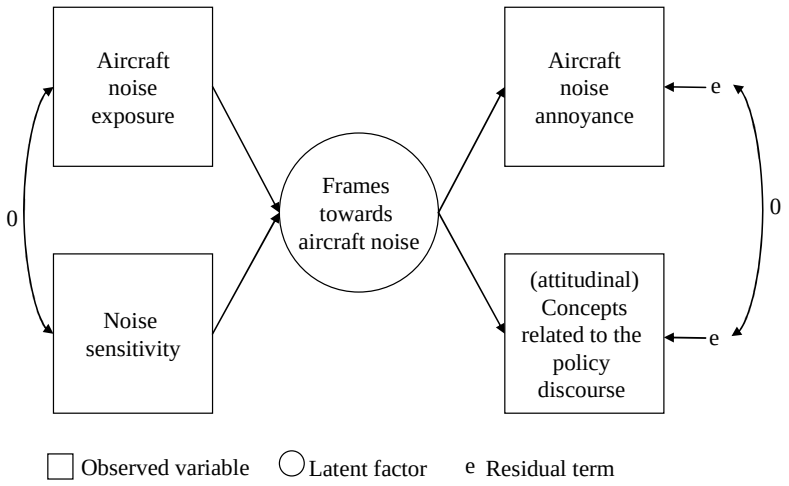

Figure 1. Conceptual model of aircraft noise annoyance

6.3 Method

6.3.1 Data

The data were gathered in a survey conducted in April 2008 among the population of residents living within the 45 L_{den} contour around Amsterdam Airport Schiphol. The survey represented a follow-up on a previous survey conducted two years earlier (in April 2006). To ensure representative sampling for this initial survey, we used data related to the numbers of people living in the municipalities within the 45 L_{den} contour around Schiphol. Based on these data and the total number of people within the 45 L_{den} contour (approximately 1.5 million people) we could calculate how many people per municipality needed to be included to arrive at an overall representative sample for the population within the 45 L_{den} contour. Proportional to the resulting figures varying numbers of residents were randomly approached within each municipality (7000 in total).

Those sampled were invited via a letter delivered at their home address to fill in an online questionnaire. With 646 useable responses the response rate was 9.2%. The mean sample age of 49.8 deviated slightly from the population mean of 46.7. Additionally, residents with better education and a higher income were slightly overrepresented. At the end of the questionnaire respondents could indicate whether they would be willing to participate in a second survey. In all, 505 people were willing and provided their e-mail address. These people were again approached in April 2008. 269 people responded positively. 15 respondents were excluded from the analysis because their sex and age did not match between the two surveys, and another 4 were excluded because they had moved to a location outside the 45 L_{den} contour. The final response group consisted of 250 (= 269 - 15 - 4) useable responses. Hence, the response rate for the second survey was 50.3%.

The low response rate can be problematic insofar as non-respondents differ from respondents on the variables of interest. In our particular case it is plausible that people who are exposed to higher levels of aircraft noise or who are more annoyed by the noise are also more inclined to participate in a survey about the airport. Comparisons between respondents and non-respondents for the second survey showed that respondents were not exposed to higher exposure levels than the non-respondents and that their average annoyance score did not differ from the non-respondents, thereby excluding the presence of response bias for the follow-up survey. However, this does not exclude the presence of response bias for the initial survey. In all, it is plausible that the people who are more bothered by noise are overrepresented in the final sample. This should be taken into account in the interpretation of the results.

6.3.2 Measures

Table 1 presents the used indicators and covariates of subjects' frames towards aircraft noise. The indicators were selected from three previous studies (Bröer, 2006; Kroesen and Bröer, 2009; Kroesen et al., 2008) in such way that they capture the full theoretical domain of the frames towards aircraft noise. Derived from open interviews with citizens (Bröer, 2006), these indicators represent people's natural and everyday communications about aircraft noise as much as possible. The first two indicators represent the domains of mainport and environment, capturing the essential features of the policy discourse. The next two items capture the attitudes towards Schiphol/aviation and complainants, two basic indicators of the dissonant frame 'don't complain'. The fifth and sixth indicator capture the features of the dissonant frame 'free state Schiphol': distrust in the government and feelings of powerlessness. The last indicator is reserved for aircraft noise annoyance. There are no indicators included which are related to autonomous frames. This is not necessary since these

frames are expected to display neutral positions in relation to the indicators described above. However, this does mean that we will not be able to distinguish between different autonomous frames, since they will all collapse into a single one.

Next, two inactive covariates are included. These variables do not contribute in the prediction of frame membership, but are merely included to aid in the interpretation of the different frames. The first inactive covariate is a second noise annoyance indicator. This item is the first of the standardized noise annoyance questions developed by Fields et al. (2001) and measures noise annoyance on an 11-point scale. This additional scale is included to compare the results with the previous studies of Bröer (2006) and Kroesen and Bröer (2009), which also used this scale. The second covariate is related to complaint behaviour. We expect that those in the 'don't complain'-frame will show the smallest probability of ever having lodged a complaint, while those in the 'free state Schiphol'-frame the highest.

Table 1. Indicators and covariates of residents' frames towards aircraft noise

No.	Indicator	Range
1	Schiphol is an engine of the economy.	[1='disagree', 2='neutral', 3='agree']
2	Aviation is a threat to the environment.	[1='disagree', 2='neutral', 3='agree']
3	Schiphol should be allowed to stay: Long live aviation!	[1='disagree', 2='neutral', 3='agree']
4	If people complain about aircraft noise they pursue their self-interest. They do not realize how important Schiphol is to The Netherlands.	[1='disagree', 2='neutral', 3='agree']
5	I trust the government to uphold the noise norms for Schiphol.	[1='disagree', 2='neutral', 3='agree']
6	I feel powerless in relation to the aircraft noise situation.	[1='disagree', 2='neutral', 3='agree']
7	I feel annoyed by aircraft noise.	[1='disagree', 2='neutral', 3='agree']
No.	**Covariate (inactive)**	**Range**
1	Aircraft noise annoyance (past 12 months)	[0='not at all annoyed', 10='very much annoyed']
2	Ever lodged a complaint about aircraft noise	[0='no', 1='yes']
No.	**Covariate (active)**	**Range**
3	Aircraft noise exposure in dB(A) L_{den}	[43.6-58.3]
4	Weinstein's sensitivity scale (sum score of 7 items)	[7-35]

The indicators were originally measured on scales from 1 (completely disagree) to 7 (completely agree). To reduce the number of response categories for the latent class analysis they were recoded by pooling the response categories into three levels (1-2→1, 3-5→2 and 6-7→3).

The third and fourth covariate are included as active covariates, because they are hypothesized to influence frame membership. The third covariate constitutes the physical level of aircraft noise exposure. This variable is represented by the noise exposure metric L_{den} dB(A). L_{den} (Level Day-Evening-Night) is an equivalent sound level of 24h expressed in decibels (dB) on the "A" weighted scale dB (A), which, in this study, is calculated for the period of a year. The "A" weighted scale most closely approximates the response characteristics of the human ear to sound. Sound levels during the evening (7-11 pm) and during the night (11 pm-7 am) are increased by a penalty of 5 and 10 dB(A) respectively. For every respondent in the sample, the level of noise exposure (a year average level based on the 12-month period preceding the survey) is calculated by the National Aerospace Laboratory (NLR) in the Netherlands. This was done by transforming the four-digit two-letter postal code of each respondent's residence into XY-coordinates, which are subsequently used to determine the level of aircraft noise exposure at the particular location.

Finally, noise sensitivity is measured via a subset of 7 items of Weinstein's noise sensitivity scale (Weinstein, 1978). This subset has previously been shown to form an uni-dimensional and reliable scale (Kroesen et al., 2008). In the present study this result is reproduced with a reliability coefficient of 0.87.

6.3.3 Method

Latent class analysis is used to reveal the (latent) classes that underlie the response patterns on the set of indicators presented in Table 1. The main idea of latent class analysis is that a discrete latent variable can account for the observed associations between the indicators, such that, conditional on the latent class variable, these associations become insignificant (Hagenaars and McCutcheon, 2002; Magidson and Vermunt, 2004; McCutcheon, 1987). This is generally called the assumption of local independence. The goal is to find the most parsimonious model, i.e. with the smallest number of latent classes, which can adequately describe the associations between the indicators. Given that we hypothesized the existence of a categorical latent variable (i.e. the four frames), latent class analysis is a suitable method to reveal these unobserved categories. Within the latent class model each class will represent a different evaluative frame of aircraft noise.

A latent class model has two kinds of parameters: the (unconditional) latent class probabilities and the (conditional) response probabilities. The latent class probabilities are the class prevalence estimates, which indicate the proportion of the sample assigned to each class (in this case to each frame of aircraft noise). The response probabilities indicate the percentages of class members responding positively (or negatively) to the indicators within the respective latent classes. The response probabilities are used to define each latent class.

Aircraft noise exposure and noise sensitivity are included as active covariates and are assumed to predict class membership. Their effects on class membership are estimated via a multinomial logistic regression model (Magidson and Vermunt, 2004). Aircraft noise annoyance (on an 11-point scale) and complaint behaviour are included as inactive covariates and will not affect the estimated models.

The software package Latent Gold is used to estimate the models (Vermunt and Magidson, 2005). This package is especially developed for latent class analysis. It uses a combination of the Expectation-Maximization and the Newton-Raphson algorithm to calculate the maximum likelihood estimates. In addition, the package can generate multiple sets of random start values to avoid local maxima and find the global maximum.

6.4 Results

6.4.1 Model selection

To assess the fit of the different models the chi-squared L^2 statistic can be used (Vermunt and Magidson, 2005). This statistic indicates the amount of discrepancy between the model-implied and the observed cell frequencies of the response patterns.

However, with $3^7 = 2187$ (7 indicators with 3 categories) possible response patterns and a sample size of $N = 250$ many response patterns are not observed. In the case of such sparse data testing model fit poses a problem because the L^2 statistic does not follow a chi-square distribution. To overcome this problem the bootstrap approach has been developed to estimate the p-value of the L^2 statistic (Langeheine et al., 1996; Magidson and Vermunt, 2004). This method is therefore used in the present study. Another approach to assess model fit in the case of sparse data is the use of an information criterion, which weighs both model fit and parsimony (i.e. the number of estimated parameters). For the present study we included the adjusted Bayesian information criterion (Sclove, 1987), which (in a simulation study) has been shown to perform well in determining to correct number of latent classes (Nylund et al., 2007). The model with the lowest BIC value indicates the best fitting model.

Table 2 presents the results of seven models in which 1 through 7 latent classes are successively specified. Since the main aim of the analysis is focused on validating the

measurement part of the model (the relationships between the latent variable and the indicators) these models are estimated without the active covariates. The results show that the bootstrap p-values of the models with three or more classes are insignificant at the desired level of significance (i.e. 0.05). The 95%-confidence interval of the bootstrap p-value of the 3-class solution, however, ranges from 0.034 to 0.078 and partly falls below the desired level of significance. In the 4-class model this interval lies entirely above the standard criterion of 0.05. Examination of the adjusted Bayesian information criterion also indicates that the 4-class solution is optimal. Based on these results, which align well with our theoretical argument, we conclude that the four-class model is optimal.

Table 2. Results from latent class models fit to the sample data

Number of classes	LL	Npar	L^2	*df*	Bootstrap p-value	S.E.	Adjusted BIC(LL)
1	-1776.0	14	1106.7	238	0.000	0.000	3585.1
2	-1568.4	29	691.6	223	0.002	0.002	3205.3
3	-1489.8	44	534.3	208	0.056	0.011	3083.5
4	-1460.2	59	475.2	193	0.080	0.011	3059.7
5	-1445.1	74	444.8	178	0.128	0.015	3064.7
6	-1435.1	89	424.9	163	0.056	0.010	3080.2
7	-1425.4	104	405.4	148	0.062	0.009	3096.1

LL = log-likelihood
Npar = number of model parameters
L^2 = likelihood-ratio chi-squared statistic
df = degrees of freedom
S.E. = standard error of the bootstrap p-value
BIC(LL) = Bayesian information criterion (based on log-likelihood)

6.4.2 Parameter estimates

Table 3 presents the profiles of the four-class solution. The parameters on which the (un)conditional probabilities are based (which not presented in the table) are all significant at $p < 0.05$, indicating that the classes differ in size as well as form. Below, the classes are discussed in terms of the unconditional and conditional response probabilities.

The first class compromising 32% of the sample can be identified as the dissonant frame ‘don’t complain’. Subjects in this frame express strong support for the mainport-argument. The majority is neutral towards the environmental argument, and a substantial portion even disagrees with it. All subjects in this frame are cheerful towards aviation. Nearly half of the subjects believe that complainants about aircraft noise pursue their self-interest because they do not appreciate the (economic) importance of Schiphol. Only a small portion distrusts the government to uphold the noise norms. Subjects in this frame do not feel powerless, nor do they feel annoyed by aircraft noise. On a scale from 0 to 10 the average annoyance score of subjects in this frame is 1.8.

The second class compromises 29% of the sample and can be identified as the consonant frame ‘mainport and environment’. The majority in this class supports the statement that Schiphol is an engine for the economy. Although the mainport-argument is dominant, a substantial potion also agrees with the statement that aviation is a threat to the environment. The majority is neutral toward Schiphol and towards complainants. Within this frame there is a considerable amount of distrust towards the government. Subjects are generally neutral towards the statements related to feelings of powerlessness and aircraft noise annoyance. The average noise annoyance score of subjects in this frame is 5.0.

The third class compromises 24% of the sample and resembles the dissonant frame ‘free state Schiphol’. Subjects in this frame express agreement with the statement that aviation is a threat to the environment and are neutral towards the mainport-argument. Subjects are strongly distrustful towards the government. They generally feel powerless in relation to the noise situation. The majority feels annoyed by aircraft noise. However, the average noise annoyance score of subjects, 6.1, is not extreme. This can be explained by the fact that the mainport-argument is not explicitly denied. Hence, economic benefits of Schiphol are, to some extent, acknowledged.

Table 3. Unconditional class and conditional response probabilities of the 4-class model

N = 250	**Class 1**	**Class 2**	**Class 3**	**Class 4**
Class size	0.32	0.29	0.24	0.15
Indicators				
Schiphol is an engine of the economy.				
Disagree	0.00	0.00	0.20	0.05
Neutral	0.11	0.44	0.57	0.79
Agree	0.89	0.56	0.23	0.16
Aviation is a threat to the environment.				
Disagree	0.42	0.03	0.07	0.00
Neutral	0.49	0.56	0.25	0.96
Agree	0.09	0.41	0.68	0.04
Schiphol should be allowed to stay: Long live aviation!				
Disagree	0.00	0.00	0.53	0.00
Neutral	0.00	0.71	0.46	0.77
Agree	1.00	0.29	0.01	0.22
If people complain about aircraft noise they pursue their self-interest.				
Disagree	0.09	0.25	0.83	0.01
Neutral	0.46	0.72	0.12	0.83
Agree	0.45	0.03	0.05	0.16
I trust the government to uphold the noise norms for Schiphol.				
Disagree	0.10	0.43	0.90	0.04
Neutral	0.46	0.54	0.05	0.86
Agree	0.44	0.03	0.05	0.10
I feel powerless in relation to the aircraft noise situation.				
Disagree	0.68	0.00	0.10	0.49
Neutral	0.22	0.63	0.17	0.51
Agree	0.10	0.37	0.73	0.00
I feel annoyed by aircraft noise.				
Disagree	0.86	0.13	0.13	0.59
Neutral	0.14	0.65	0.26	0.41
Agree	0.00	0.22	0.61	0.00
Inactive covariates				
Noise annoyance (0-10)				
Mean (S.D.)	1.8 (2.2)	5.0 (2.3)	6.1 (2.2)	3.0 (2.2)
Lodged a complaint				
No	0.92	0.75	0.60	0.88
Yes	0.08	0.25	0.40	0.12

The last class can be identified as an autonomous frame. This class is the smallest of the four with 15% of the sample being assigned to it. In this frame subjects are neutral towards all statements, providing no legitimization for feelings of powerlessness or annoyance. The average annoyance score in this frame is 3.0.

Both the unconditional and the conditional probabilities are in line with the expected patterns. Consistent with the studies of Bröer (2006) and Kroesen and Bröer (2009), the majority of the sample (85%) adopts the logic of the policy discourse to structure their evaluative frames of aircraft noise. It can therefore be concluded that the definitions of the frames as well as their sizes align well with our theoretic expectations.

Another interesting result is that the mainport-argument dominates the environmental argument. This dominance is manifested in three ways: (1) the greatest portion of the sample assigned to the 'don't complain' class, favouring further growth of aviation (2) in the consonant frame 'mainport and environment', support for the economic argument is greater than for the environmental argument and (3) none of the frames explicitly denies the mainport-argument. Related to this last point, we can observe that, the other way around, the 'don't complain'-frame does, to some extent, deny the environmental argument. In effect, we can observe a frame with an (extremely) low annoyance response ('don't complain'), but not an opposite frame with an (extremely) high annoyance response.

Finally, it can be observed that the frames are also predictive for complaint behaviour. Subjects in the 'don't complain'-frame have the smallest probability of ever having lodged a complaint about aircraft noise, while those in the 'free state Schiphol'-frame the highest.

6.4.3 Active covariates

In line with previous research, there is no significant correlation between the two active covariates, i.e. aircraft noise exposure and a person's general disposition to be sensitive to noise ($r = 0.05$, $p = 0.42$). In addition, as expected, both variables are significantly associated with frame membership (aircraft noise exposure, Wald statistic = 11.08, $p = 0.011$; noise sensitivity, Wald statistic = 34.50, $p = 0.000$). Finally, their inclusion leads to a good model fit ($L^2 = 2746.5$, $p_{bootstrap} = 0.228$) indicating that the latent class variable indeed mediates the effects of both variables on the indicators of the frames. Substantively this means that the latent variable is effective in capturing the relevant variance residing in its indicators.

In Figure 2 the relationships between the covariates and frame membership are plotted. It can be observed that at low noise exposure levels the 'don't complain'-frame is dominant. At high exposure levels the majority of the subjects is assigned to the frames 'free state Schiphol' and 'mainport and environment'. The autonomous frame decreases slightly with increasing noise levels. A plausible substantive explanation is that at high exposure levels people will feel forced to take an explicit position in relation to the policy discourse.

The relationship between noise sensitivity and frame membership shows a similar pattern. Subjects who indicate they are not sensitive to noise mostly belong to the 'don't complain'-frame, while those sensitive to noise mainly express themselves in the frames 'free state Schiphol' and 'mainport and environment'. The autonomous frame is relatively stable along the full range of noise sensitivity.

In line with expectations, it can be concluded that the distribution of the frames is dependent on two structural variables, one related to the individual's situational context (i.e. the level of aircraft noise exposure) and the other to a person's general disposition to feel annoyed by noise.

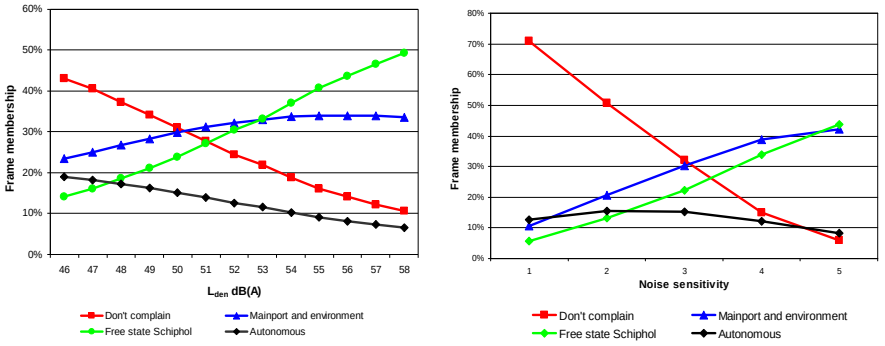

Figure 2. Relations between aircraft noise exposure in L_{den} dB(A) and frame membership (left) and noise sensitivity and frame membership (right)
Note: the range of the noise sensitivity scale [5-35] has been rescaled to the interval [1-5].

6.5 Discussion

In this section we will discuss the results in relation to previous attempts to explain individual differences in noise reaction, relate the findings to cognitive consistency theories, reflect on the adopted research method and discuss several limitations of the present study.

After accounting for noise exposure typically 70-80% of the individual variability in noise reaction remains (Job, 1988). Attempts to explain this variability have uncovered a range of factors which are empirically associated with noise annoyance. These factors can be categorized in personal variables, like a person's noise sensitivity (Stansfeld, 1992) or other personality traits, and social variables, like a person's attitude toward the noise source (Job, 1988). Typically, the attitudinal variables are found to be stronger determinants of noise reaction than the personal variables (Guski, 1999).

In this paper we have tested a model that provides a theoretical explanation for the strong associations between noise annoyance and the attitudinal (social) variables. We have hypothesized that they can be treated as part of an underlying factor, which consists of a limited number of categories. Specifically, we expected that the correlations between noise annoyance and social variables arise from a limited number of evaluative frames towards aircraft noise.

This conceptualization stands in contrast with previous models that aimed to explain individual variability in noise annoyance (see e.g., Alexandre, 1976; Kroesen et al., 2008; Staples et al., 1999). The left side of Figure 3 presents the general structure of these previous models. In words, this conceptualization assumes that variance in noise annoyance can be explained by noise exposure, personal variables and attitudinal variables, while controlling for the intercorrelations between these determinants. The present model, in contrast, assumes that a latent factor underlies both the attitudinal variables (in this case the arguments related to the policy discourse) and aircraft noise annoyance. Personal variables, on the other hand, are assumed to influence noise annoyance indirectly via frame membership. The present study has shown that these hypotheses can both be theoretically and empirically supported.

In effect, the present model provides a more insightful perspective on how social and personal factors actually influence subjective reaction to noise. Social factors (attitudes/arguments) do not 'cause' noise annoyance but operate discursively; they set limits on what can arguably be said and felt in a particular situation, resulting in a limited number of internally consistent and

socially 'viable' positions. In our case, for example, a frame legitimizing an (average) extreme annoyance response is not viable, because of the dominance of the mainport-argument. People would need to go to great length to rationalize such a position in relation to others. Personal factors, i.e. a person's personality, can be said to operate within a traditional cause-and-effect model. They (at least partly) determine in which of the existing socially viable perspectives a person ends up.

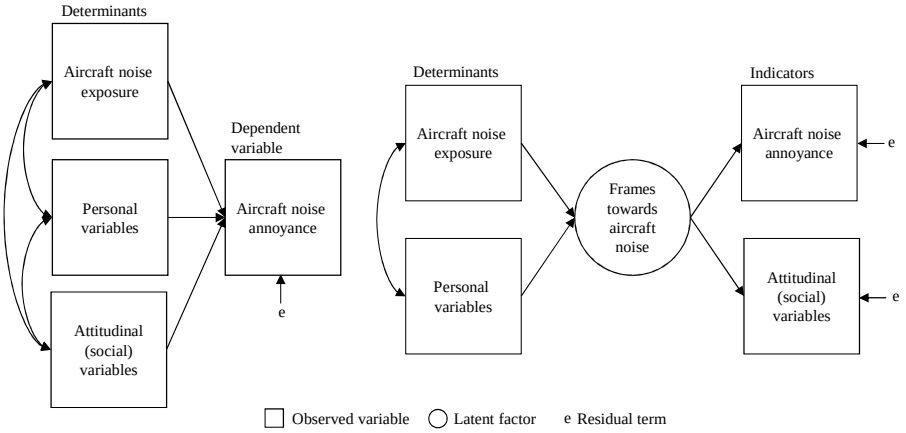

Figure 3. The general structure of previous conceptualizations to explain individual variability in noise annoyance (left) versus the conceptualization adopted in the present paper (right)

From the results of the present study two interesting deductions related to cognitive consistency theories can be made. First, in viewing the frames as outcomes of a process in which two dissonant cognitions - economic growth versus environmental protection - are integrated in coherent perspectives, the different strategies to reduce dissonance can be inferred. For example, in the 'don't complain'-frame the environmental argument is reduced in importance. The 'mainport and environment'-frame, which supports both arguments, uses the strategy of adding cognitions and feelings. In this frame dissonance is resolved by adding feelings of powerlessness and distrust in the government to effectively handle the problem of aircraft noise. These strategies can also be observed in the 'free state Schiphol'-frame, which prioritizes the environmental argument above the economic one and also adds feelings of distrust and powerlessness. In sum, different strategies (i.e. reducing the salience of arguments and adding cognitions/feelings) have been employed to reach internal coherence and consistency within the frames. A second inference is that the frames need not only be internally consistent, but they also need to be defensible in relation to each other. In theory, a frame denying the economic benefits of aviation can be internally consistent. However, it can be speculated that the reason that such a frame has not arisen is because such a frame would be difficult to uphold in relation to the other frames. Hence, in addition to the requirement of internal consistency (the main premise of cognitive consistency theories), external defensibleness (social viability) might be a second criterion for the (continued) existence of a frame.

On a methodological note, we can observe that latent class analysis is a successful bridge between other quantitative methods, like regression analysis, and qualitative methods, like Q-methodology (Brown, 1980), Grounded Theory (Glaser and Strauss, 1967) and other

interpretative methods. The reason is that, while being a quantitative method, it remains congruent with an important premise of most qualitative research methodologies, namely that meaning is relational (also called the 'principle of contextuality', see Brown, 1980). This means that the meaning attached to a certain response is not defined a priori, but arises from whole patterns of responses. For example, in relation to our study, the average annoyance responses in the 'don't complain' and the autonomous frame would, within a quantitative framework, be identified as instances of 'low annoyance'. Examination of the whole patterns of responses, within which this particular response occurs, however, reveals that the 'low annoyance' in the 'don't complain' frame is the resultant of a deliberate weighing of the benefits and costs of aviation, while in the autonomous frame, it is simply the resultant of a general indifference towards aircraft noise and the (noise) policy. By viewing meaning as relational a more profound understanding of the subject matter at hand arises, in this case being the people's subjective experience of aircraft noise. Additionally, latent class analysis still retains two (quantitative) advantages: (1) models can be estimated based on large probability samples and (2) (as a result) the effects of structural variables related to the individual (e.g. sex, age, personality traits, situational variables) can be estimated. In our case, resulting in knowledge about the distribution of the frames in the population of residents near Schiphol airport and how this distribution depends on aircraft noise exposure and noise sensitivity. It should be noted, however, that latent class analysis complements and does not substitute qualitative research. The appropriate indicators (derived from people's actual communications in the field) still need to be identified through qualitative enquiry. Additionally, qualitative methods can provide much richer descriptions of people's frames toward an issue.

Finally, the present study is characterized by several limitations and related directions for further research. The first is related to the low response rate (4.6%). A low response rate does not directly imply the existence of (non)response bias. However, given the topic of the present study (i.e. aircraft noise) it is likely that the low response rate did result in a biased sample of the population. Specifically, it can be expected that those who are more annoyed by noise are overrepresented. Related to the results, it can be argued that this overrepresentation may have led to an overestimation of the portion assigned to the "free state Schiphol"-frame. Additionally, the portion assigned to an autonomous frame may be underestimated, since these people may be expected to show no particular interest in the topic of the study. We do not believe, however, that the deviations between our estimates of the population parameters and the true population parameters are very large. Two pieces of circumstantial evidence can be brought forward to support this assertion: (1) it can be argued that, if there would indeed be a large sample bias, the 'free state Schiphol'-frame would likely be the largest frame (2) the overall average of annoyance in the sample (3.9) is approximately equal to the average found in a (large-scale) survey conducted around Schiphol airport in 1996/7 (4.0) (TNO and RIVM, 1998). In this survey the response rate was much higher (39% and N = 11,812) and (based on a non-response survey) the average annoyance score was corrected for selective (non)response (the uncorrected average annoyance score was 4.8).

A last critique and recommendation for future research relates to the development of the frames over time. The present study has shown that annoyance and policy arguments are empirically linked in coherent perspectives. However, since the study is based on cross-sectional data, it does not indicate which of these elements takes causal precedence. A qualitative panel study, preferably in a domain where shared meanings have not yet been established, might provide this answer. Additionally, a multiple group latent class model could be estimated (with groups representing different moments in time) to quantitatively assess qualitative changes in frames over time.

6.6 Conclusion and policy implications

The present study has provided an additional verification of Bröer's (2006) discourse resonance theory. Consistent with this theory we found that people develop their evaluative frames of aircraft noise in relation to the (dominant) policy discourse, and either entirely reproduce this discourse (consonance), or partly reproduce it and partly oppose it (dissonance). Only a small portion of the population derives its evaluative frame from another source than the policy discourse. According to their varying definitions of the noise situation, the frames are associated with appropriate degrees of annoyance response. In other words, the policy discourse shapes and thereby limits what can be legitimately said and felt about aircraft noise. The policy discourse can therefore be said to operate discursively. It does not determine in which frame a person ends up, yet it does determine which frames are socially viable. Within the resulting discursive space people cannot easily develop an idiosyncratic frame. Additionally, the present study has shown that frame membership is influenced by two structural variables related to the individual, namely aircraft noise exposure and noise sensitivity. These structural variables can be said to operate within a traditional cause-and-effect paradigm. They contribute in the determination of frame membership.

Finally, we would like to relate the findings to the policy context at Schiphol airport. The results could be used to suggest that policy makers and scientists should simply deny the problem of aircraft noise. We believe, however, that without a collective policy to deal with noise, people would resort to extreme frames to rationalize their (uncommon) position of opposition, which would probably go along with an extreme annoyance response. This would result in even more bipolarity in people's frames of aircraft noise than observed presently (i.e. 'don't complain' versus 'free state Schiphol').

However, we would argue that the present bipolarity can be further reduced. The underlying premise of the policy discourse is that the economic and the environmental goals can be achieved at the same time. Yet, even in the consonant frame 'mainport and environment' there exists considerable distrust towards the government to uphold the noise norms. Hence, it seems that people generally do not believe that the projected win-win situation between economy and environment can be achieved. As a result the debate continues along the line economy versus environment. What is good for the one is bad for the other. The fact that the majority of the people only reproduce a part of the discourse (economy or environment) further supports this contention.

In sum, the policy identifies aircraft noise as an important problem, but does not provide an effective framework to deal with it. So what would be an effective framework? Without denying the fact that new technology can lead to both economic and environmental gains, we believe that noise policy at airports should incorporate the logic of trade-offs. It should be recognized that, at least for the coming decades, technology will not be able to entirely solve the problem of aircraft noise. By making the trade-off between economy and environment explicit, the policy can move beyond its false assumption that we can have a no-annoyance society (Stallen and Van Gunsteren, 2002). We believe this would already provide relief from the unjustly aggravated tension between economy and environment.

Additionally, and perhaps even more important, is that the noise policy should recognize variety in local preferences. Presently, the policy falsely assumes that by providing collective protection against noise (i.e. collective noise limits) the (sum of the) existing individual preferences are adequately captured and addressed. However, the variability in noise reaction (after controlling for the noise exposure level) shows that humans are not passive receivers of noise. Preferences surrounding the airport should therefore also be preserved in their disaggregated forms. For example, in the present situation of applying strictly acoustical

criteria, a citizen's home may be eligible for state-funded insulation, while his neighbour's home is not. Yet, the person considered eligible may not be annoyed by noise, while his neighbour is. Neglect of such individual differences works against the way people experience noise (Bijstervelt, 2008; Smit and Van Gunsteren, 1997).

By preserving preferences in their disaggregated forms opportunities will arise for the aviation industry and local communities around the airport to adjust to each other's presence (Stallen et al., 2004). Whereas aggregated preferences like 'economy' and 'environment' will almost inevitably clash, disaggregated preferences can be exchanged against each other. Based on the principle of give-and-take transactions can be made on all kinds of issues, e.g. land-use policies, the determination of flight paths, the peak hour capacity of the airport, noise insulation policies, information provision, complaint handling and the night-time regime of the airport. Hence, in addition to making a trade-off on a national level, trade-offs should be made possible on a local level. The underlying idea is that mutual accountability will cultivate trust (Stallen et al., 2004). In other words, if the aviation industry and local communities are given space to adjust to each other's presence, people's confidence in the (noise) policy will be restored. In this connection it has been previously shown in a laboratory and field experiment that influencing people's attitudes towards the noise source in a positive way can lower noise reaction (Jonsson and Sörensen, 1967, 1970; Sörensen, 1970). Additionally, providing room for individual preferences also means providing residents with more opportunities to influence their exposure to noise, which, in turn, has also been shown to decrease noise reaction (Glass and Singer, 1972; Jue et al., 1984). To conclude, we believe that aircraft noise policy at Schiphol airport can benefit greatly from current insights in the psychology of noise annoyance.

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7. The Effects of Survey Context

Kroesen, M., Molin, E. J. E. and Van Wee, G. P. (2011) Measuring human response to aircraft noise: the effect of surveys context. *Journal of Environmental Psychology* (submitted)

Abstract

In applied research, noise annoyance is often used as indicator of subjective reaction to aircraft noise. The present study aims to show that the meaning which respondents attach to the concept of aircraft noise annoyance is partly a function of survey context. For this purpose a survey is conducted among residents living near Schiphol airport, the largest airport in the Netherlands. In line with the formulated hypotheses it is shown that varying contexts influence the response distribution of aircraft noise annoyance as well as the correlational patterns between aircraft noise annoyance and other relevant scales.

7.1 Introduction

Noise annoyance is one of the most extensively studied effects of exposure to aircraft noise in residential areas. Historically, the link between noise annoyance research and policy has been strong. Research in this area was generally initiated and funded by government agencies to provide a basis for their noise policies. Most efforts focused on establishing so-called exposure-response relationships which predict the percentages of 'highly annoyed' people in the population at varying (annual) energy equivalent noise levels (Fidell et al., 1991; Miedema and Oudshoorn, 2001; Schultz, 1978). To the present day, these exposure-response curves lie at the basis of noise regulation in many countries around the world.

The applied nature of noise annoyance research went along with a limited scope on human subjectivity. Noise annoyance was generally identified as the only relevant measure of subjective reaction to noise and little efforts have been made to explore and understand subjects' definitions (Job et al., 2001). The upside of this narrow focus, however, is that results of different surveys can be compared. Such comparisons generally show great variability in exposure-response relationships between different countries as well as over time (Guski, 2004; Van Kempen and Van Kamp, 2005). For aircraft noise, recent research confirmed that the present exposure-response function has shifted upwards compared to the European exposure-response curve, which is based on data from studies conducted (on average) 25 years ago (Babisch et al., 2009).

Numerous theoretical and methodological explanations have been provided for the observed upward trend. Theoretically, it can be explained by the present structure of the noise load, i.e. many low noise events, which differs from the structure of the past, i.e. few high noise events, and might be experienced as more annoying (Guski, 2004). Wirth and Bröer (2004) provide a sociological explanation. They theorize that the advent of a risk adverse society led to a decline in people's trust in the authorities which resulted in an increase in annoyance response. Brooker (2009) reviews several methodological explanations and shows that telephone surveys, compared to postal surveys and face-to-face interviews, and higher response rates tend to be associated with lower (aggregate) levels of annoyance response.

In this paper it is argued that the survey context may provide an additional explanation for the observed discrepancy. Context effects are usually defined narrowly as the effects of preceding survey items on the target item, although they can be defined more broadly by including the effects of the survey frame (i.e. sponsor, topic and stated purpose). The experiment of Hyman and Sheatsley (1950), which was later reproduced by Schuman and Presser (1981), is illustrative. In this experiment, subjects were asked whether American reporters should be allowed to report freely from the Soviet Union, and vice-versa, whether "communist" reporters should be allowed to report freely from the United States. When the item about communist reporters appeared first only 36% of the respondents endorsed the item, but when the item about American reporters appeared first, support for the item about communist reporters rose to 73%. According to Schuman and Ludwig (1983), a norm of even-handedness is evoked when an advantage given to the generally favoured party in a dispute prescribes comparability of treatment for the less favoured party.

While research in context effects has produced an impressive body of knowledge (Tourangeau and Rasinski, 1988), the authors are aware of only a single study that explored this issue in noise annoyance research (Stallen and Maris, 2004). In this study subjects in the experimental condition were primed by letting them read a newspaper article about an investigation of sleep disturbance near an airport. When asked to rate 15 hassles, these subjects rated the item "(briefly) woken up by a plane" more than twice as worrisome as subjects in the control condition (who had read an unrelated newspaper article). Subjects in

this experiment were students who (probably) were not affected by aircraft noise in their daily lives. Yet, given the size of the effect, it seems plausible that different contexts can significantly affect responses in surveys among affected populations.

This study investigates the influences of two different contexts on aircraft noise annoyance, the target item of this study. Our main aim is to show that the meaning which respondents attach to the concept of aircraft noise annoyance is partly a function of survey context. For this purpose a survey is conducted among residents living near Amsterdam Airport Schiphol. Respondents are (randomly) assigned to either one of two experimental conditions or a control condition. Based on a review of the literature, expectations are formulated related to the response distribution of the target item, but also about the strengths of the relations between the target item and other relevant scales. With respect to the response distribution, we expect that the typical context of aircraft noise annoyance used in present surveys about aircraft noise causes an increase in annoyance response as opposed to a neutral context. In establishing this effect, the secondary aim is to provide an additional explanation for the observed discrepancies between past and present exposure-response curves.

7.2 Theoretical background

7.2.1 Context effects

It is difficult to identify a general theory in the field of context effects, as acknowledged by several authors in this area (Groves, 1989; Smith, 1992). Much research is concerned with establishing empirical effects and not so much with the (often competing) theoretical explanations that could possibly underlie them (Smith, 1992). Lacking a general theory, much theories of the 'middle range' are developed to account for specific experimental results. An example is the theory of even-handedness discussed in the introduction.

One common theoretical thread in context effects research, however, is the notion that surveys in many ways resemble natural conversations. Following this analogy certain conversational rules can be assumed to apply. According to Grice (1975) such conversational rules (or maxims) can be deduced from a general principle, which he termed the cooperative principle. This principle entails that participants in a conversation recognize a mutually accepted direction and, as such, will engage in certain cooperative efforts in line with this common purpose. From this general principle Grice (1975) derived four maxims: (1) *quantity*: contributions should be informative, (2) *quality*: contributions should be true, (3) *relation*: contributions should be relevant and (4) *manner*: contributions should be clear, brief, and orderly.

Results of several experimental studies can be accounted for with reference to these maxims. An often-cited example is the experiment of Schuman and Presser (1981) who reported a contrast effect in which respondents were less likely to describe themselves as very happy when they had first answered a question about marital happiness. Bradburn (1982) explained this finding by arguing that respondents 'subtracted' their (generally happy) marriages from the overall happiness rating. In effect, the meaning of the general happiness item shifted from 'overall happiness' to 'overall happiness apart from your marriage'. Tourangeau (1984), in turn, proposed that this tendency to avoid redundancy reflects one of the Gricean principles of conversations, namely that each contribution should be informative (i.e. the maxim of quantity).

Another study that fits the framework of conversational rules is the experiment of Tourangeau and Rasinski (1988), which was inspired by the work of Schuman and Presser (1981). In this experiment subjects were asked to express their degree of support for an undefined measure, called the 'Monetary Control Bill'. In the control condition most subjects indicated their

neutrality/indifference towards this measure by selecting the 'don't know' category. However, when preceded by several items on inflation, subjects interpreted the 'Monetary Control Bill' as an anti-inflation measure and answered the question accordingly. This finding corresponds with the Gricean maxim of relation, i.e. that contributions should be relevant to the ongoing conversation. Having no reason to believe that the researcher is inquiring about a meaningless measure, subjects thus try to identify the intended meaning by using information provided by the context of the target item.

Apart from the more general theory of conversational rules, specific causes for contexts effects have been put forward. One that received much attention in context research is the notion of priming. The study of Stallen and Maris (2004), discussed in the introduction, already illustrated this mechanism. Generally, priming, for instance by a newspaper article, previous questionnaire items or by some other way, is believed to render specific beliefs (temporarily) more accessible. These activated beliefs can then 'spread' to the target item. For example, Tourangeau and Rasinkski (1988) showed that subjects who were primed with pro-abortion beliefs (questions about women's rights) were more likely to support abortion than subjects who were primed with anti-abortion beliefs (questions about traditional values). Although priming can result in a directional change on the target item, it is usually assumed that the interpretation of the target item remains unchanged. This point, however, is contestable and will be turned to later.

A second specific explanation underlying context effects in survey research is the notion of consistency. Although not originally meant to investigate context effects, the study of Simon et al. (2004) is illustrative. In a series of experiments, Simon et al. (2004) showed that subjects when provided with case material of a crime and asked to judge whether the suspect was guilty or not, aligned their evaluations of the evidence with their verdict. Hence, subjects who judged the suspect guilty would rate substantively unrelated pieces of incriminating evidence as more certain than acquitting evidence and, vice versa, subjects who judged the suspect not guilty would rate acquitting evidence as more certain than incriminating evidence. Simon et al. (2004) also found that these coherence-driven shifts to either side of the continuum (acquit/convict) occurred already before the final verdict, indicating that these shifts do not merely represent post-hoc justifications of the verdict. Different reasons have been suggested to explain why people strive to reach and/or maintain consistency among their beliefs. According to Festinger's dissonance theory, inconsistency leads to an undesired psychological tension (Festinger, 1957). In contrast, Billig (1987) draws attention to a social explanation; arguments that are inconsistent can easily be attacked by others.

In addition to formulating (general and specific) theories that can explain context effects, several researchers have been concerned with classifying known context effects in encompassing theoretical frameworks. Tourangeau and Rasinksi (1988) developed such a theoretical framework by organizing contexts effects along the different cognitive steps involved in answering an attitude question: interpretation, retrieval, judgment and response selection. In the interpretation phase respondents infer the meaning of a question and locate the relevant attitude structure. The experiments on general/marital happiness and the 'Monetary Control Bill' are illustrative of the possible context effects in this phase. In the general/marital happiness experiment the meaning of general happiness is shifted from 'general happiness' to 'general happiness apart from marital happiness' and in the 'Monetary Control Bill' experiment the meaning of the (meaningless) target item is inferred from the attitude structure invoked by the inflation items. During the retrieval phase respondents are believed to sample a selection of their beliefs. Priming, in this phase, can lead to an overrepresentation of certain beliefs at the cost of other existing beliefs. In the third phase, respondents use the retrieved information to render a judgment. This judgment can be affected

by previously established judgmental anchors or norms of even-handedness. Finally, respondents map their judgments on a response scale. According to Tourangeau and Rasinksi (1988) a judgment may undergo an 'editing process' in which the final answer is checked for consistency with prior answers.

7.2.2 Research objectives

To add to the current knowledge of context effects, we briefly turn to the related field of framing effects (for a recent review see Chong and Druckman, 2007). It is generally assumed that, by making some aspects of an issue more salient than others, framing alters the meaning of the issue under consideration. The experiment of Nelson et al. (1997) is illustrative. In this study subjects were exposed to either one of two frames on welfare policy, one which defined welfare as a give-away program for poor people who do not deserve it (the so-called recipient frame) and the other as an excessively expensive program that threatened the health of the economy (the so-called economy frame). Even though there was no difference in the average levels of support for welfare across the two conditions, support for welfare in the recipient frame was more strongly related to external attribution beliefs (e.g. society has failed to provide good schools) than in the economy frame. Hence, in the recipient frame the meaning of 'support for welfare' was aligned with the meaning induced by the frame, as a measure to help the poor. In the economy frame, on the other hand, external attribution beliefs were not associated with support for welfare since welfare policy was defined as a measure which threatened the economy.

Comparing the priming and framing experiments there seems to be a subtle difference in the assumed underlying theoretical mechanisms; priming is believed to render some beliefs more accessible, while framing is believed to alter the weight of the considerations that enter into the final judgment. It seems implausible, however, that an experiment can be designed which can show that these mechanisms lead to different effects. In fact, Chong and Druckman (2007) view the theoretical mechanisms as being essentially the same. Viewed in this light, the priming experiment of Tourangeau and Rasinkski (1988) can also be regarded as a framing experiment, in which the meaning of 'support for abortion' is inferred by respondents from either a women's rights frame or a traditional value frame. Hence, also in that experiment could different patterns of correlations have been expected between the target items and other relevant variables.

In line with research on framing effects the present experiment aims to show that placing a target item in different substantive contexts can lead to different interpretations of the target item, in this case aircraft noise annoyance. Contrary to research on framing effects, however, we show that a substantive context need to necessarily be represented by a story which precedes the measurement of the target item, but can also be represented by a block of preceding questionnaire items. While research on context effects has shown that previous questionnaire items can affect the interpretation of target items, like in the general/marital happiness experiment or the 'Monetary Control Bill'-experiment, the effects of placing a target item in substantively different contexts (similar to what is typically done in framing research) have not been investigated. The present study aims to fill this void.

In addition to a control condition, in which the target item is measured in isolation, the effects of two contexts are investigated. In the first experimental condition, aircraft noise annoyance is placed in the context of people's everyday communications about aircraft noise. This will be termed the natural-conversation context. The items in this context represent statements related to the topic of aircraft noise, which are sampled from open interviews with citizens living near Schiphol. This context is selected to assess whether aircraft noise annoyance in this context is indeed interpreted the same as in the control (no-context) condition. In the

second experimental condition, aircraft noise annoyance is placed in the context of other noise sources, termed the multiple-sources context. The items in this context cover a person's annoyance reaction to a range of sources: road traffic noise, railway noise, neighbour noise, etc.. This particular context was chosen for two reasons. In the first place, because it is common practice in surveys about aircraft noise to measure aircraft noise annoyance in this way, and secondly, because we expect that in this context the meaning of aircraft noise annoyance will differ from its ordinary (natural) meaning.

7.2.3 Hypotheses

Results from the study of Bröer (2006), Bröer and Kroesen (2009) and Kroesen, Molin, and Van Wee (2011) are used to formulate the specific hypotheses. Using an interpretative research method Bröer (2006) studied citizens' perspectives on aircraft noise. Being interested in the actual meanings people attribute to aircraft noise in their everyday lives, he found that people mainly use policy-related arguments to evaluate aircraft noise. At Schiphol airport, these policy arguments revolve around the (national) economic benefits and environmental costs of aviation. Follow-up studies of Bröer and Kroesen (2009) and Kroesen et al. (2011) quantitatively validated the results of Bröer's (2006) study. These studies revealed that the economic argument generally received greater support than the environmental argument. In effect, it was found that people generally do not indicate that they are very annoyed by aircraft noise, since such a response would be inconsistent with the widely held belief that aviation is associated with positive economic effects.

Based on the results of these past studies we expect to find a moderate average annoyance response in the no-context condition. Given that the natural-conversation context reproduces people's own communications about aircraft noise we expect to find the same average annoyance response in this condition. In the multiple-sources context, on the other hand, we hypothesize that, confronted with noise sources of which several are hardly audible in the residential environment, aircraft noise (as the dominant noise source) will, in contrast, be judged more annoying. In other words, given the context of these other noise sources, people will feel legitimized to express a more extreme annoyance response, something which, due to the dominance of the economic argument, is not legitimate in people's ordinary frame of reference.

Since our aim is to show that the concept of 'aircraft noise annoyance' can differ as a function of context, several hypotheses are formulated related to the patterns of correlations between the target item and other relevant scales. These correlations provide information as to how aircraft noise annoyance is interpreted in each context.

In the no-context and natural-conversation context we expect that the meaning of aircraft noise annoyance is the same. In the multiple-sources context, on the other hand, we expect a certain shift in the meaning attributed to aircraft noise annoyance. Specifically, we expect that asking subjects to rate multiple noise sources will result in a logical tendency to include more information about the physical exposure level (i.e. loudness and regularity) of each source vis-à-vis the other sources in the final judgments. Extending this line of reasoning we expect to find a stronger correlation between aircraft noise annoyance and noise sensitivity in the multiple-sources context than in the no-context and natural-conversation context.

Secondly, we expect that aircraft noise annoyance will be more strongly correlated with residential satisfaction in the multiple-sources context than in the other two contexts. This, because it is asked in relation to other aspects of the residential environment (i.e. the other noise sources) and therefore will be regarded as an attribute of the residential environment.

Thirdly, we assume that, since aircraft noise annoyance is empirically associated with beliefs about the economic benefits and environmental costs of aviation (Kroesen et al., 2011), it will also be correlated with two general socio-political orientations, namely individualism and egalitarianism. These orientations, which are derived from Cultural Theory (Douglas, 1978; Douglas and Wildavsky, 1982; Wildavsky and Dake, 1990), stress different principles of equality; individualism equality of opportunity and egalitarianism equality of condition. We expect that people who emphasize equality of opportunity will favour the argument that people are free to decide whether or not to live near an airport and, given that it is a free choice, assume that they will be less annoyed by aircraft noise. On the other hand, we expect that people who emphasize equality of condition will favour the argument that everybody has a right to a certain quality of life and, given that it is not simply a matter of free choice, assume that they will be more annoyed by aircraft noise. We hypothesize that when aircraft noise annoyance is taken out of its everyday *political* context of economy-versus-environment, as is the case in the multiple-sources context, the correlations between aircraft noise annoyance and these general political orientations will be weaker.

Table 1 summarizes the expected signs and sizes of the correlations between aircraft noise annoyance and the included dimensions (noise sensitivity, residential satisfaction, individualism and egalitarianism) in each of the three contexts.

Table 1. Expected signs and sizes of the correlations between aircraft noise annoyance and the dimensions

Dimension	No-context (control)	Natural-conversation context	Multiple-noise-sources context
Noise sensitivity	+	+	++
Residential satisfaction	-	-	--
Individualism	--	--	-
Egalitarianism	++	++	+

Finally, we are interested in the question whether people stick to the meaning of aircraft noise annoyance in their first-encountered context when aircraft noise annoyance is measured a second time in a different context later in the questionnaire. To investigate this, we will examine whether exposing subjects to other contexts later in the questionnaire will result in directional changes in the mean annoyance scores or in changes in the correlational patterns between the target item and the included scales. Since these analyses are explorative in nature no explicit hypothesizes are formulated a priori.

7.3 Method

7.3.1 Data

For the experiment it was necessary that aircraft noise was the dominant noise source. Therefore, a neighbourhood was selected (Amsterdam Buitenveldert) where the aircraft noise exposure level was relatively high. The annual noise exposure level in this neighbourhood ranges from approximately 50 to 65 dB(A) L_{den}.

In the selected neighbourhood 3000 letters were distributed at random locations. The letters invited citizens to fill in an online questionnaire. Over the period of a month (July 2010) 293 people filled in the online survey (141 males and 152 females), resulting in a response rate of 9.8%.

The mean sample age (53.7) is significantly higher than the mean age of the Dutch population (40.1). Yet, all age groups were sufficiently represented in the sample: 19.9% was younger than 35 years of age, 35.0% was between 35 and 59 years of age and 45.1% was 60 years old or older. Respondents with a higher education were also overrepresented: 34.2% had completed high school or a secondary vocational education, 37.9% had a higher educational degree and 27.9% had a university degree (in the Dutch population these percentages are 72.9%, 17.5% and 9.6% respectively).

The target item

In all conditions the target item, aircraft noise annoyance, was assessed with the standardized question of Fields et al. (2001): "Thinking about the last 12 months or so, when you are here at home, what number from 0 to 10 best shows how much you are bothered, disturbed or annoyed by aircraft noise?" In line with the recommendations the endpoints of the 11-point scale were labeled 'not annoyed at all' (0) and 'extremely annoyed' (10).

Control and experimental conditions

In the control condition, the question about aircraft noise annoyance was presented in isolation. In the natural-conversation context (the first experimental condition), subjects had to answer 12 statements measured on 7-point Likert-type scales. The statements were derived from open interviews with residents (Bröer, 2006) and, as such, represent people's own communications about the topic of aircraft noise. The statements are listed below:

- Schiphol should be allowed to stay: long live aviation!
- I trust the government to uphold the noise norms for Schiphol
- If people complain about aircraft noise they pursue their self-interest. They do not realize how important Schiphol is to The Netherlands.
- I believe that Schiphol always gets its way.
- The government does not live up to its promise to reduce the noise.
- I feel powerless in relation to the aircraft noise situation.
- We should be proud of our national airport.
- Aviation is important for the employment.
- Noise annoyance from aircrafts is an important problem.
- Schiphol should be relocated to the sea.
- Schiphol is an engine of the economy.
- Aviation is a threat to the environment.

We made sure that the numbers of positive and negative statements were in balance. After these statements the question about aircraft noise annoyance followed immediately on the same webpage.

In the multiple-sources context (the second experimental condition) aircraft noise annoyance was measured near the end of a matrix question[26], which (again using the standardized noise reaction question of Fields et al. (2001)) asked subjects to rate, from 0 to 10, how much they were bothered, disturbed or annoyed by the following noise sources:

- Road traffic slower than 50 km/h
- Road traffic faster than 50 km/h
- The supply of shops
- Neighbours

[26] Aircraft noise was not placed at the very end of the block to ensure that it would not receive undue attention.

- Helicopters
- Trains
- Trams/metro
- Aircrafts
- Companies/industry
- Construction and demolition activities (including renovation)

7.3.4 Questionnaire design

As discussed, to investigate whether respondents stick to the original meaning of aircraft noise annoyance in the first-encountered context, the choice was made to expose all respondents to each context in varying orders. Figure 1 visualizes the lay-out of the online questionnaire.

On the first webpage all respondents had to answer several background questions (sex, age, education level, length of residence). Next, respondents were randomly assigned to one of three routes. In the control condition, respondents answered the target item on three separate webpages, first in isolation (C1), then in relation to the other noise sources (C2) and finally in relation to the statements of other residents (C3). In the natural-conversation condition, respondents first answered the question about aircraft noise after answering the statements of other residents (NC1) and then in relation to the other noise sources (NC2). Finally, in the multiple-sources condition, respondents followed the reversed route, first answering the target item in relation to the multiple noise sources (MS1) and then in relation to residents' statements (MS2). After following the condition-specific routes, the routes converged again and all respondents answered the remaining part of the questionnaire.

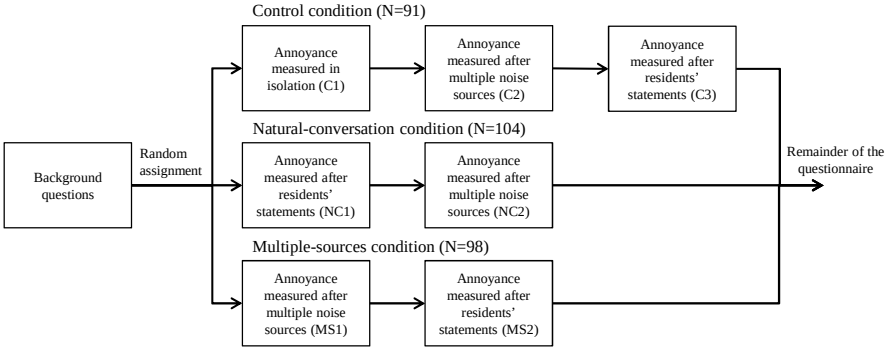

Figure 1. Structure of the online questionnaire
Note: each block represents a different webpage. Respondents were not allowed to scroll back.

In the experimental conditions respondents were not asked to answer the target item in isolation. Given that the no-context condition provides no additional information to respondents, we did not expect that this would influence the response. In addition, the choice to direct respondents in the control condition first to the multiple-sources context and then to the natural-conversation context is arbitrary.

7.3.5 Scales

To measure noise sensitivity, five items from Weinstein's noise sensitivity scale were used (Weinstein, 1978). A principal component analysis revealed that the items converged on a single underlying factor (see Table 2). To measure residential satisfaction items were drawn from a previously developed scale (Adriaanse, 2007). Again, principal component analysis revealed that the items formed a uni-dimensional scale. To measure the social-political orientations (individualism and egalitarianism) items were selected from two scales, which were initially developed by Wildavsky and Dake (1990) to test the hypotheses derived from Cultural Theory. The factor loadings of the items were sufficiently high, again indicating convergence. The reliability of the egalitarian scale, however, was poor. The correlational patterns of the two individual items with the variables of interest (aircraft noise annoyance) nevertheless showed similar patterns. We therefore choose to use both items to construct a composite scale. All scales were constructed by computing a sum score of the respective items.

Table 2. Scales, items and loadings

Scale	Items	Loading
Noise sensitivity (alpha=0.83)	I get used to noises without much difficulty.*	0.75
	I am good at concentrating no matter what is going on around me.*	0.72
	Sometimes noises get on my nerves and get me irritated.	0.75
	I find it hard to relax in a place that is noisy.	0.81
	I am sensitive to noise.	0.81
Residential satisfaction (alpha=0.86)	I am satisfied with my living environment.	0.89
	Living in this neighbourhood is not annoying.	0.80
	I feel at home in this neighbourhood.	0.84
	I don't feel an urge to move out of this neighbourhood.*	0.85
Individualism (alpha=0.69)	Continued economic growth is the answer to improved quality of life.	0.79
	In a fair system people with more ability should earn more.	0.76
	A free society can only exist by giving companies the opportunity to prosper.	0.82
Egalitarianism (alpha=0.55)	The government should make sure everyone has a good standard of living.	0.84
	I would support a tax change that made people with large incomes pay more.	0.84

* Item recoded

7.4 Results

7.4.1 Univariate distributions

With respect to the univariate distributions we expected that the mean annoyance score in the multiple-sources context would be greater than the mean scores in the no-context and the natural-conversation context. For the latter two contexts we expected to find equal mean scores.

Table 3 presents the univariate statistics of aircraft noise annoyance in the varying contexts. The sample distributions of aircraft noise annoyance for the first-encountered contexts (C1, NC1 and MS1) are presented in Figure 2. Analysis of variance reveals that the means of aircraft noise annoyance in the first-encountered contexts (C1, NC1 and MS1) differ significantly across the three conditions ($F = 8.8$, $p<0.000$). A post-hoc Bonferroni test shows, in line with expectations, that the means of the no-context (C1: $M = 4.6$) and natural-conversation context (NC1: $M = 4.7$) are not significantly different, but that both do significantly differ from the multiple-sources context (MS1: $M = 6.1$).

Examination of the distributions in Figure 2 shows that in the multiple-sources context, the extreme categories on the right side of the scale (9 and 10) are used more often than in the other two contexts. As a result, 43.3% of the sample in the multiple-sources context can be identified as 'highly annoyed' (defined as a person scoring 8 or higher), more than twice as much as in the no-context and natural-conversation context (in which these percentages are 16.5 and 16.3 respectively).

The results support the hypothesis that measuring aircraft noise annoyance in relation to other noise sources creates a context in which people feel legitimized to express a more extreme annoyance response. Extreme responses are not generally legitimized in the ordinary frames of reference, i.e. the no-context and natural-conversation context.

Table 3. Univariate statistics of aircraft noise annoyance in the different contexts

		N	Mean	Std. Dev.	% Highly annoyed
Control condition	C1	91	4.6	2.7	16.5
	C2	91	4.8	2.9	23.3
	C3	91	4.6	2.9	22.7
Natural-conversation condition	NC1	104	4.7	2.9	16.3
	NC2	104	4.9	3.2	25.0
Multiple-sources condition	MS1	98	6.1	3.0	43.3
	MS2	98	5.5	3.0	29.0

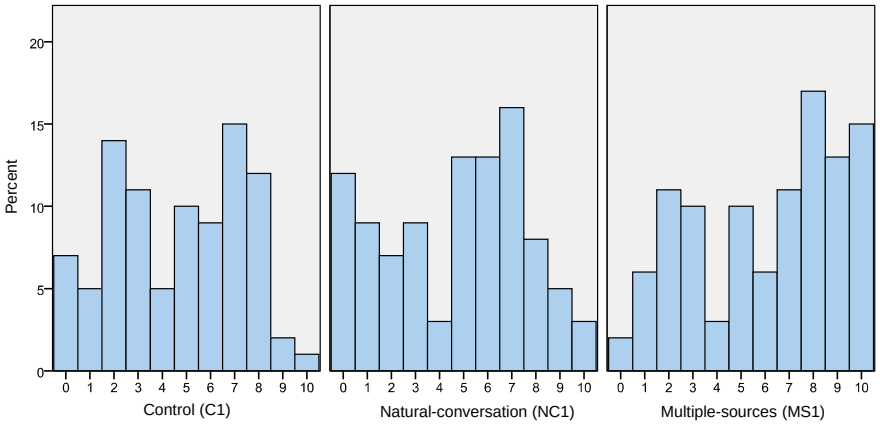

Figure 2. Distributions of aircraft noise annoyance in the three contexts

7.4.2 Bivariate correlations

We expected that the meaning people attach to the concept of aircraft noise annoyance is partly a function of context. To test this idea several hypotheses were formulated related to the correlations between aircraft noise annoyance and relevant scales. The correlations are presented in Table 4. Below we will only discuss the correlations between the scales and the first measurement of aircraft noise annoyance within each route (C1, NC1 and MS1).

As hypothesized, aircraft noise annoyance is more strongly correlated with noise sensitivity in the multiple-sources context than in the no-context or natural-conversation context. However, only between the correlations of the multiple-sources context and the natural-conversation context is the difference significant (at the 10% level).

Contrary to the expectations, the correlations between aircraft noise annoyance and residential satisfaction are of equal size in the no-context and multiple-sources context. In the natural-conversation context this correlation tends to be lower, but not statistically significant.

The scale of individualism is, as expected, negatively associated with aircraft noise annoyance. However, this correlation is only significant in the natural-conversation context. Unexpectedly, the correlation tends to be stronger in the multiple-sources context than in the no-context condition.

Finally, contrary to the expectations, the scale of egalitarianism is negatively associated with aircraft noise annoyance in the control (no-context) condition. In the natural-conversation context and multiple-sources context, this correlation is in the expected positive direction. The difference between the correlation in the natural-conversation context and the correlation in the control condition is significant at the 5% level.

The correlations indicate that aircraft noise is interpreted differently across conditions. However, only for noise sensitivity does the pattern follow the a priori formulated expectations. A remarkable finding is that the dimensions of individualism and egalitarianism correlate significantly with noise annoyance measured in the natural-conversation context, while these correlations are insignificant in the control condition. Contrary to the expectations aircraft noise annoyance is not a reflection of political preference in the control condition. This, however, is the case in the natural-conversation context. An explanation might be that, because people in the natural-conversation context are confronted with the whole structure of the economy-environment debate, they have to rely on the more general political values to rationalize their annoyance response. In other words, to take an explicit stance in the economy-environment debate requires that people use their political value-orientations. People's annoyance response then reflects the chosen position. In the control condition, on the other hand, people do not have to take such an explicit stance in the economy-environment debate. This explanation is also congruent with the lower correlations between aircraft noise annoyance and residential satisfaction in the natural-conversation context. As an expression of political preference aircraft noise annoyance is less viewed as an aspect of the residential environment.

The scales of individualism and egalitarianism are also more strongly related to annoyance measured in the multiple-sources context than in the control condition. This finding is more difficult to explain. It might be that, because people take more extreme positions in the multiple-sources context, they also rely more on their political value-orientations to legitimate these.

Table 4. Correlation coefficients between the aircraft noise annoyance variables and the four scales

		C1	C2	C3	NC1	NC2	MS1	MS2	NS	RS	IN	EG
Control condition	C1	1.00										
	C2	0.96*	1.00									
	C3	0.96*	0.95*	1.00								
Natural-conversation condition	NC1	-	-	-	1.00							
	NC2	-	-	-	0.92*	1.00						
Multiple-sources condition	MS1	-	-	-	-	-	1.00					
	MS2	-	-	-	-	-	0.91*	1.00				
Noise sensitivity	NS	0.36*	0.33*[a]	0.34*[b]	0.34*[c]	0.43*	0.50*[abc]	0.48*	1.00			
Residential satisfaction	RS	-0.35*	-0.30*	-0.37*	-0.28*	-0.29*	-0.36*	-0.39*	-0.42*	1.00		
Individualism	IN	-0.09	-0.06[d]	-0.06[e]	-0.25*[de]	-0.23*	-0.15	-0.18**	-0.11**	0.08	1.00	
Egalitarianism	EG	-0.06[AD]	-0.06[BE]	-0.07[CF]	0.27*[ABC]	0.24*[DEF]	0.11	0.09	0.04	0.00	-0.17*	1.00

* Significant at p<0.05
** Significant at p<0.10
Correlations with the same uppercase superscript are significantly different at p<0.05 (one-tailed)
Correlations with the same lowercase superscript are significantly different at p<0.10 (one-tailed)

7.4.3 Directional changes and consistency within the conditions

The changes in the means of aircraft noise annoyance within each condition are small (see Table 3). Moving from no-context to the multiple-sources context in the control condition, the mean annoyance score rises significantly from 4.6 to 4.8 ($t = -2.0$, $p = 0.046$) and then drops again to 4.6 in the natural-conversation context ($t = 2.2$, $p = 0.034$). In the natural-conversation condition, an equal, but insignificant rise of 0.2 is found in moving from the natural-conversation context to the multiple-sources context ($t = -1.8$, $p = 0.069$). The greatest difference (0.6) is found in the third condition in moving from the multiple-sources context to the natural-conversation context ($t = 4.5$, $p = 0.000$). Nevertheless, the reached mean score of 5.5 is still significantly higher than the mean scores in the other contexts.

The extremely high correlations between the annoyance variables (see Table 4) within each condition suggest that once the target item is answered in one context, it will not be reinterpreted when asked again in a different context. The patterns of correlations between the annoyance questions and the four scales, which are nearly equal within each condition, also confirm this conclusion.

Overall, the small changes in the means and the consistent correlational patterns indicate that the meaning of aircraft noise annoyance does not change within conditions. In other words, once respondents answer the target item in one particular context, they will not reinterpret it when presented in a different context later in the questionnaire.

7.5 Implications for validation research and policy

The present study shows that using the same instrument used in different contexts can lead to different interpretations of the measured concept. The natural-conversation context even showed that placing aircraft noise annoyance in the context of statements derived from people's own communications about this topic influenced the meaning attributed to it. This means that it is difficult, if not impossible, to define (in advance) the meaning of a concept like aircraft noise annoyance or any other measure of subjective reaction to noise. Instead, its meaning must be deduced after its measurement through examination of response and/or

correlational patterns. This view on measurement is complimentary to dominant conceptualizations of validity in the literature, which define validity either as a property of tests; a test should measure what a researcher *intends* to measure (Borsboom et al., 2004), or as a property of test score interpretations; the quantity and quality of evidence in support of the interpretation *intended* by the researcher (Messick, 1989). Both assume that the researcher can always define (on beforehand) the meaning of a concept or issue. This, however, is not always possible given that the researcher is often unaware of the actual meanings that are used by subjects in the field. In our opinion, researchers as well as research methods should be amenable to discover those meanings. To complement existing definitions, validity can be conceptualized as the degree of responsiveness of researchers and their methods to subjects' definitions of an issue.

The measurement of human reaction to noise for policy-related purposes is not value-free. Variations in question wording, answering scales and, as the present study shows, context can significantly affect the response distribution of a subjective measure. The selection of a particular method to measure human reaction to noise can therefore lead to drastically different policy implications. We believe that, given these limitations of exposure-response models, they should be used with more caution in the policy practice. Presently, these models are generally used to legitimate certain limits on the amount of aircraft noise we, as a society, are willing to accept. In our opinion, using exposure-response models to support such standards can have several perverse effects. For one, actors become focused on the means (i.e. the models and standards) instead of the ends (the negative/positive effects of aviation) (Tenbrunsel, 1999). For example, they can strategically draw attention to assumptions ('flaws') in the model that are disadvantageous to them or advantageous for the 'other' party, resulting in intractable discussions, which, in the end, result in declining levels of trust. An airport, which is regulated by noise norms, might also feel less responsible for aspects which are not explicitly regulated. In this respect it has also been shown that setting a norm can change an actor's decisional frame from an ethical evaluation (what is the right thing to do?) to an economic evaluation (what are the costs if the norms are transgressed?) (Tenbrunsel and Messick, 1999). Finally, the exposure-response model narrows the wide variety of problems and solutions that exist around any airport down to a single issue: more/less aircraft noise. This generally leaves the airport and the surrounding local communities little room for other positions than opposing ones (Stallen and Van Gunsteren, 2002).

All in all, given the fact that all models are limited, it seems unwise to let a single model (i.e. the exposure-response model) figure so prominently in the policy process. Doing so only leads to a continued discussion of its flaws. To improve noise regulation, options are to use a variety of models and criteria (in addition to energy-equivalent noise metrics) to assess the performance of an airport and to treat models and standards as a point of departure for negotiation instead of as ways to sanction the airport (and the airliners who use it) at the end of the line.

7.6 Conclusion and future research directions

In this paper we investigated the effects of different contexts on the measurement of aircraft noise annoyance. In line with the main aim, it is shown that varying contexts can alter the meaning of aircraft noise annoyance to the point that basically different concepts are being measured. As expected, we found an equal average annoyance response in the no-context and the natural-conversation context and a higher average annoyance response in the multiple-sources context. The correlational patterns confirmed our expectations with respect to the relationship between aircraft noise annoyance and noise sensitivity in each condition. For the other included scales (residential satisfaction, egalitarianism and individualism) the findings

were not in agreement with the hypotheses. The small changes in the means, as well as the consistency in the correlational patterns within each condition, support the conclusion that once respondents adopt a particular interpretation of aircraft noise annoyance they will not reinterpret the concept when asked again later in the questionnaire.

In line with the secondary aim of this study, we provided an additional explanation for the observed upward shift in exposure-response curves. The authors are aware of three (Dutch) large-scale studies that measured aircraft noise annoyance in relation to other noise sources (Breugelmans et al., 2004; Houthuijs and Van Wiechen, 2006; TNO and RIVM, 1998). The exposure-response relationships derived from these data are indeed significantly higher than the European exposure-response curve. A systematic comparison of studies that measured aircraft noise annoyance in isolation versus studies that measured aircraft noise in the context of multiple noise sources, can yield an estimate of the magnitude of the context effect. In line with the conclusion of Brooker (2009), the present study shows that the upward shift may not necessarily be caused by acoustical factors or changes in people's attitudes, but instead may be due to methodological artifacts.

Several directions for further research can be identified. An obvious one relates to the sample of the study, which is characterized by several limitations: (1) respondents are recruited from a single neighbourhood near Schiphol, (2) the response rate is low, and (3) older/higher educated people are overrepresented. To generalize the results to the population of residents living in the Schiphol region, a probability sample would need to be drawn from this population. In addition, any biases (e.g. a likely bias is that more annoyed people are overrepresented) could be decreased by increasing the response rate. These measures are also necessary if one is to establish the total effects of the investigated contexts on a general exposure-response relationship. Nevertheless, the present experiment has shown that the effects of different contexts can be quite large.

Future research might also concentrate on other context effects. For example, aircraft noise annoyance could be placed in the context of more general aspects of the residential environment (e.g. having nice neighbours) or in the context of other daily hassles (e.g. having a cold). Alternatively, the effects can be studied of the broader survey frame like the sponsor or the stated purpose of a study. It seems plausible that people will express a different response to aircraft noise measured in a survey of a university for scientific purposes than in a survey of a national institute for policy-related purposes. Finally, we would considerate it worthwhile to study the (experimental) data with more advanced analysis techniques, like latent class analysis. With the use of such models the response patterns of different groups of respondents can be revealed, which provide more detailed information as to how respondents actually interacted with the questionnaire and which strategies they employed. To conclude, we believe that there are many research objectives in the applied field of noise annoyance research which are related to the possible effects of context. Such research is scientifically relevant, but also needed to properly inform noise policy.

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8. Aircraft Noise and Residential Satisfaction

Kroesen, M., Molin, E. J. E., Miedema, H. M. E., Vos, H., Janssen, S.A. and Van Wee, G. P. (2010). Estimation of the effects of aircraft noise on residential satisfaction. *Transportation Research Part D*, 15, pp. 144-153.

Abstract

This study assesses the effects of aircraft noise on residential satisfaction, an important indicator of subjective well-being. A structural equation model is specified that estimates the relationships between objective variables, noise annoyance variables and residential satisfaction. Secondary data-analysis is used to estimate the model. The survey was conducted in 1996/1997 among the population living within a 25-km radius of Amsterdam Schiphol, the largest airport in the Netherlands. The effect of aircraft noise annoyance is found to be relatively small. In addition, the objective level of aircraft noise exposure is found to be a better predictor of residential satisfaction than its subjective counterpart. The most important determinants of residential satisfaction are found to be road traffic noise annoyance, age and neighbour noise annoyance.

8.1 Introduction

To assess the effects of aircraft noise exposure in residential areas its relationships with objective (e.g. high blood pressure, anxiety, depression) and subjective (e.g. annoyance, qualify of life) outcome indicators need to be studied. We assess the relative importance of aircraft noise exposure vis-à-vis other environmental stressors. This is done by studying the effects of aircraft noise exposure in a holistic framework that includes multiple determinant and criterion variables. Specifically, we investigate the relationships between aircraft noise exposure and two subjective criterion variables: aircraft noise annoyance and residential satisfaction. In addition, various personal and household variables as well as other noise-related subjective determinants of residential satisfaction, i.e. road, railway, construction and neighbour noise annoyance, are included in the analysis. The idea is that by studying the effect of aircraft noise exposure within such an integrated model, vis-à-vis other determinants and using multiple criterion variables like annoyance and residential satisfaction, its relative effect on subjective well-being can be properly assessed.

Residential satisfaction as the final criterion variable is selected because it can be identified as an important indicator of subjective well-being. It has been shown to be associated with other important constructs like life satisfaction (Fried, 1984), psychological well-being (Phillips et al., 2005) and perceived health (Kroesen et al., 2008b).

8.2 Model development

8.2.1 Theoretical background

Work investigating the determinants of residential satisfaction initially focused on objective attributes of residents. In this respect variables like tenure status (home-owner/rental), income, education, race, presence of children and the duration of residence, have been found to significantly correlate with measures of residential satisfaction (Amerigo and Aragones, 1990).

The sometimes weak relationships between objective characteristics and residential satisfaction, however, led to the belief that objective variables alone did not suffice as determinants of residential satisfaction. Galster and Hesser (1981) formulated and tested the idea that the effects of objective attributes, which they grouped into compositional, those relating to the individual household, and contextual variables, those relating to the physical conditions of the surrounding neighbourhood, are partially or wholly mediated via subjective assessments of more limited aspects of the physical or social environment. Indeed, they found both indirect and direct effects of the included objective attributes. Parkes et al. (2002) found, however, the influence of objective socio-demographic variables to be of little influence compared to subjective evaluations related to aspects like housing, crime, safety, neighbours, noise and appearance. This observation is also supported by the work of Lee and Guest (1983).

Overall, it can be concluded that the determinants of residential satisfaction include both objective attributes and subjective evaluations, both personal and environmental characteristics, and social and physical elements.

8.2.2 Model specification

The study concerns a secondary analysis of data gathered in 1996/1997. The variables present in this dataset are integrated into a single model based on the two theoretical notions: first, objective and subjective variables are both assumed to influence residential satisfaction and

second, objective variables can influence residential satisfaction either directly or indirectly via the subjective ones (Figure 1). Of the measurements in the survey, 18 personal background variables and six subjective variables are identified as relevant and included in the model to explain residential satisfaction. The subjective variables relate to annoyance from the following noise sources in the residential environment: aircraft, slow road traffic (<50 km/h), fast road traffic (>50 km/h), railway, construction/demolition/renovation activities[27] and neighbours.

Moving from the theoretical concept, we continue in an explorative fashion and do not hypothesize about individual effects a priori. Instead all possible relationships along the hypothesized causal direction (i.e. objective characteristics → subjective assessments → residential satisfaction) are estimated. Via deletion of the insignificant paths the most parsimonious model will be derived.

This strategy also ensures that a direct relationship between aircraft noise exposure and residential satisfaction is estimated. This relationship is included to account for possible pathways, other than through aircraft noise annoyance, through which aircraft noise exposure might influence residential satisfaction. Since there is evidence that the range of subjective reactions to noise is broader than annoyance (covering aspects like fear, anxiety, anger, disappointment, etc.) the existence of these pathways is plausible (Job et al., 2001). Through inclusion of a direct effect between aircraft noise and residential satisfaction these pathways are accounted for.

8.3 Method

8.3.1 Data

To estimate the structural equation model a dataset from a community survey conducted in 1996/1997 is used. Within this study a stratified random sample of 31,000 addresses was drawn from the population living within the 25-km radius around the airport (Figure 2). Stratification was necessary to adequately represent the full range of aircraft noise exposure. The strata were based on the combination of the distance from the airport and the level of aircraft noise exposure. In practice, this approach resulted in an over-sampling of people living close to the airport. To arrive at a sample which is representative for the population within the 25-km radius of Amsterdam Schiphol the observations were therefore re-weighted to take the stratified study design into account.

Approximately 1.5 million people aged 18 or over live in the survey area. The data were gathered via a postal questionnaire with a response rate of 39%.[28] Cases with more than 10% missing values are deleted. Of the remaining missing values of the variables used in the analysis, 1.2% of all entries, are imputed via the expectation–maximization algorithm of SPSS 14.0. The resulting dataset consisted of 10,746 complete cases.

[27] For the sake of brevity we will refer to this source as ‘construction noise’.
[28] For more detailed descriptions of this study see: TNO-RIVM (1998), Miedema et al. (2000) and Franssen et al. (2004).

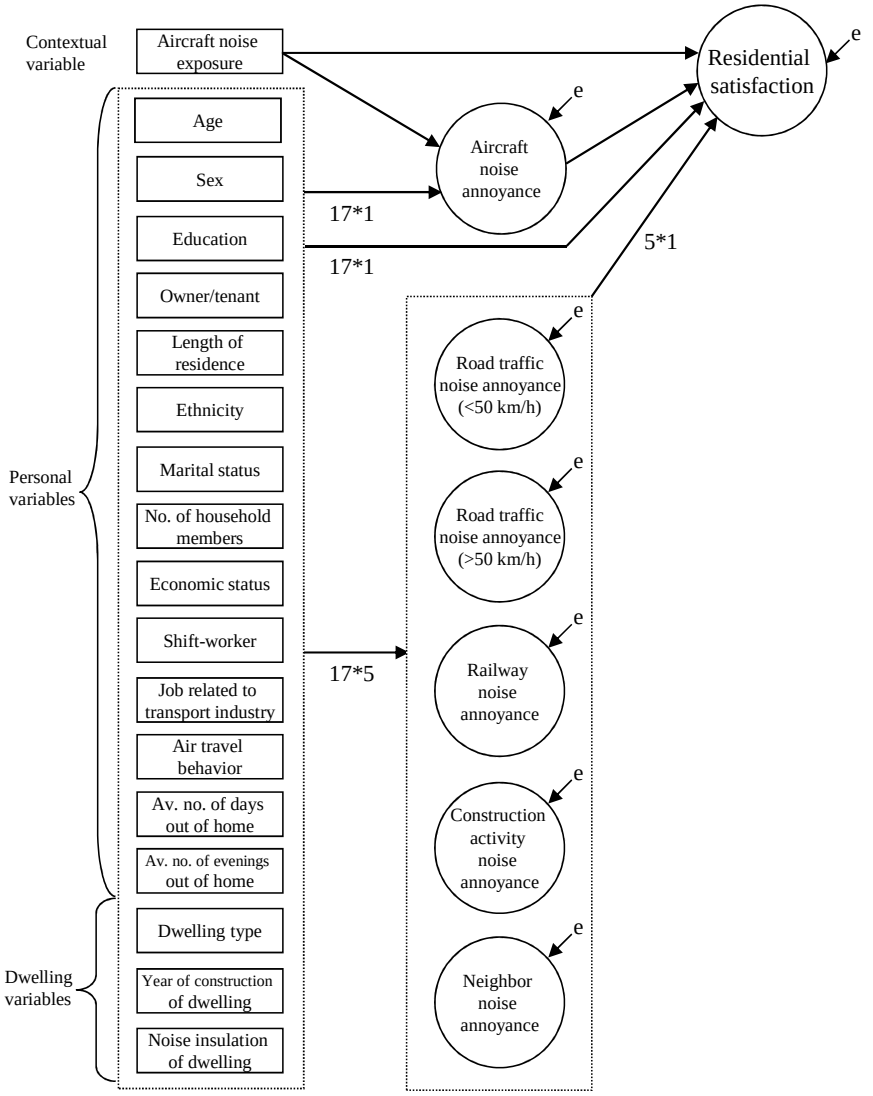

Figure 1. Theoretical model of the effects of aircraft noise exposure on residential satisfaction

8.3.2 Measures

Individual, household, dwelling and contextual characteristics

Table 1 shows the 18 objective variables and their re-weighted sample distributions. The variables cover a broad range of socio-demographic characteristics related to a subject's economic status and dependency on the aviation industry, household and dwelling characteristics and the level of aircraft noise exposure. Assuming that these variables are measured without errors they are directly included in the structural equation model as observed variables.

For age non-linear relationships with dependent variables in the model were expected (Miedema and Vos, 1999). Based on three categories (1: 'young' = 18-30 years, 2: 'middle-aged' = 31-55 years and 3: 'old' > 56 years), age was thus recoded into two indicator variables using the effect coding principle.

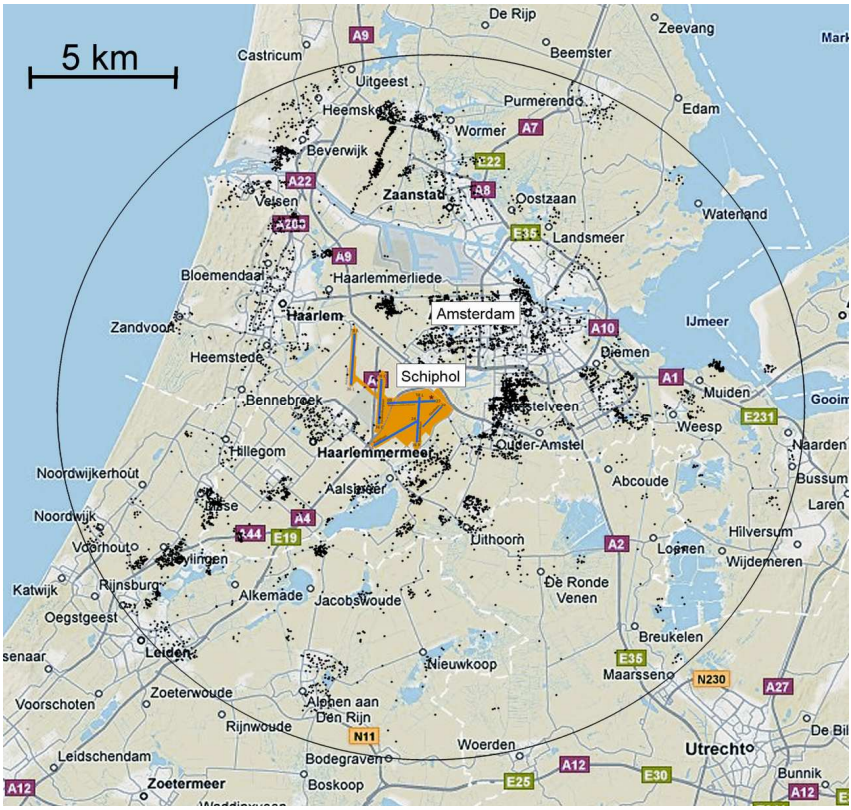

Figure 2. Survey area

All variables, except the level of aircraft noise exposure (Table 1), are self-reported. Using a method legally prescribed in the Netherlands (Rijksluchtvaardienst, 1996), the level of aircraft noise exposure around Schiphol airport was calculated by the Dutch National Aerospace Laboratory for all subjects in the dataset. These calculations are based on the actual flight data

(time, takeoff or landing, type of aircraft, flight path recorded by the flight tracking system) for each flight in the year preceding the survey. Here the L_{den} (i.e. level day–evening–night in dB(A)) is selected as a measure of the level of aircraft noise exposure.[29]

Measurement model

The noise-annoyance constructs are subjective in nature. To correct these constructs for structural and random measurement errors, they are measured indirectly via multiple items. This results in less biased estimates between the structural variables in the model.

For the measurement model six latent variables are defined, one for each noise annoyance construct in Figure 1. Each variable is operationalized using two items related to the following questions: (Item 1) 'How annoying or not annoying is the noise of the following sources according to you at home?' (response ranging from 0 = 'not at all annoying' to 10 = 'very annoying') and (Item 2) 'to what extent is your sleep disturbed by the following noise sources?' (responses ranging from 0 = 'not at all disturbed' to 10 = 'very much disturbed'). The model is specified assuming each set of two measures indicates its corresponding latent construct and allowing all latent constructs to correlate.[30]

Table 1. Re-weighted sample distributions of objective variables in dataset (N=10,746)

Observed variable	Range/Description	Freq.	%	Mean	S.D.
1. Age (years)	<20	160	1.5	46.2	15.7
	21-40	4279	39.8		
	41-60	3974	37.0		
	61-80	2039	19.0		
	>80	168	1.6		
	Missing	125	1.2		
2. Sex	Male	5668	52.7		
	Female	4992	46.5		
	Missing	86	0.8		
3. Education	No education	47	0.4		
	Primary school	468	4.4		
	Secondary school	4489	41.8		
	Higher education	3929	36.6		
	University	1408	13.1		
	Missing	404	3.8		
4. Dwelling ownership	Rental	4739	44.1		
	Owner-occupied	5887	54.8		
	Missing	120	1.1		
5. Length of residence (years)	0-10	5980	55.6	12.4	11.3
	11-20	2323	21.6		
	21-30	1368	12.7		
	31-40	879	8.2		
	Missing	196	1.8		
6. Ethnicity	Dutch	9871	91.9		
	Other than Dutch	585	5.4		
	Missing	290	2.7		
7. Marital status	Single	3453	32.1		
	Married/living together	7174	66.8		
	Missing	119	1.1		

[29] L_{den} is an equivalent sound level of 24 h expressed in decibels (dB) on the 'A' weighted scale dB(A). Sound levels during the evening (7 - 11 pm) and during the night (11 pm - 7 am) are increased by a penalty of 5 and 10 dB(A) respectively. This metric is also selected by the European Council to monitor and assess noise problems in its member states.

[30] It is estimated using the structural equation modeling software package Lisrel 8.8.

Table 1. (continued)

Observed variable	Range/Description	Freq.	%	Mean	S.D.
8. Household size (no. of household members)	1	2667	24.8	2.4	1.2
	2	4100	38.2		
	3	1461	13.6		
	4	1673	15.6		
	≥ 5	693	6.5		
	Missing	150	1.4		
9. Economic status	(part-time/full-time) employed	7891	73.4		
	Unemployed	2684	25.0		
	Missing	171	1.6		
10. Shift-worker (working in evening/night time so one is forced to sleep during the day)	No	9633	89.6		
	Yes	952	8.9		
	Missing	160	1.5		
11. Job related to air transport industry	No	9975	92.8		
	Yes	637	5.9		
	Missing	134	1.2		
12. Air travel behaviour	Did not fly in last two years	4550	42.3		
	Did fly in last two years	6137	57.1		
	Missing	58	0.5		
13. Average no. of days out of home per week	0	2616	24.3	2.9	2.2
	1	958	8.9		
	2	928	8.6		
	3	933	8.7		
	4	1020	9.5		
	5	3441	32.0		
	6	504	4.7		
	7	120	1.1		
	Missing	226	2.1		
14. Average no. of evenings out of home per week	0	3211	29.9	1.5	1.4
	1	2565	23.9		
	2	2468	23.0		
	3	1328	12.4		
	4	640	6.0		
	5	229	2.1		
	6	62	0.6		
	7	27	0.3		
	Missing	215	2.0		
15. Dwelling type (detachedness)	Flat or apartment	3832	35.7		
	Row house	5030	46.8		
	Semi-detached	816	7.6		
	Detached	781	7.3		
	Missing	288	2.7		
16. Year of construction of dwelling	Before 1900	699	6.5		
	1900-1944	2283	21.2		
	1945-1979	4572	42.5		
	1980 and later	2916	27.1		
	Missing	276	2.6		
17. Noise insulation of dwelling	No	6209	57.8		
	Yes	3540	32.9		
	Missing	997	9.3		
18. Aircraft noise exposure (dB(A) L_{den})	<50	805	7.5	53.7	2.6
	50.1-55.0	6793	63.2		
	55.1-60.0	3017	28.1		
	60.1>	131	1.2		

The results show that the measurement model provides a reasonable fit to the data.[31] The modification indices indicate that model can be improved through specification of additional

[31] Since the chi-square statistic is sensitive to sample sizes over 500 and thus expected to be significant indicating a lack of fit, we included the indices independent of sample size to evaluate the fit of the model. These

correlations between the second items of the latent variables, namely those relating to the 'sleep disturbance' questions. Theoretical justification for these correlations lies in evidence that people vary in their sensitivity to be awakened by noise (Anderson and Miller, 2007), causing the additional structural covariation between these items. After specification of these 15 correlations and re-estimation, the model fit improved significantly with all indices showing an acceptable fit.[32]

Based on the model fit results and evidence of construct validity, present in terms of convergent and discriminant validity (not presented), one may conclude that the measurement model is well specified.

Residential satisfaction

Finally, we will focus on the operationalization of the main dependent variable, residential satisfaction. This variable also represents a subjective evaluation but it was not included in the measurement model because only one item suitable to proxy this concept was available (making it impossible to define a multiple item latent variable). This item related to the question: 'how satisfied are you with living in this residential environment?' The re-weighted sample distribution in response to this question was: 8.9% extremely satisfied, 29.2% very satisfied, 50.4% satisfied, 8.4% not so satisfied, 2.0% dissatisfied and with the remainder missing.

Since only one indicator of residential satisfaction is available it is not possible to provide an estimate for its reliability. Instead of assuming its reliability to be 100%, however, the item is assumed to be measured with the same reliability as the average reliability (Cronbach's alpha) of the six noise-annoyance constructs, an assumption more likely to reflect its true reliability. The reliability is taken into account by including the item in the model as an observed variable of a corresponding latent variable and fixing its error variance at (1 - 0.767) multiplied by the variance of the observed item (Kelloway, 1998).

8.4 Results and discussion

8.4.1 Estimation of the full structural equation model

The objective characteristics, as directly observed variables, the noise-annoyance constructs, as indirectly observed latent variables, and residential satisfaction, as a single-indicator latent variable, are included in the structural equation model as seen in Figure 1. All objective attributes, the exogenous variables, are allowed to correlate. As a result, the effects of each on endogenous variables later in the causal chain are controlled for the effects of all other exogenous variables. Similarly, at the level of the noise-annoyance constructs, which are endogenous, and thus have error terms, the error terms of these variables are allowed to correlate. Again to ensure that the effect of each noise annoyance variable on residential satisfaction is controlled for the effects of all other noise annoyance variables.

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are the root mean square error of approximation (RMSEA) (Browne and Cudeck, 1993), which measures the discrepancy between the model implied and observed covariance matrix per degree of freedom, the standardized root mean residual (SRMR) (Bentler, 1995), which measures the mean of the squared residuals (the differences between the sample and model-implied covariance matrices) divided by the standard deviations of the respective manifest variables, and the comparative fit index (CFI) (Bentler, 1990), which provides a comparison between the specified model and a baseline model with zero constraints. A well-fitting model is defined as having values below 0.06 and 0.08 for RSMEA and SRMR respectively and a CFI value greater than 0.95 (Hu and Bentler, 1999). The parameters obtained are S-B scaled $\chi^2 = 2848.53$, $Df = 39$, RMSEA = 0.082, CFI = 0.944, SRMR = 0.0290.

[32] S-B scaled $\chi^2 = 142.96$, $Df = 24$, RMSEA = 0.021, CFI = 0.998, SRMR = 0.0102.

The first step is to estimate a fully saturated structural model in which all paths between structural variables are estimated; an estimation of 139 structural parameters. To arrive at a more parsimonious model, all insignificant estimates are deleted. Considering the large sample and the increased chance of finding a significant relationship due to the large number of parameters, the conventional alpha level of 0.05 is lowered to 0.001. This criterion leads to the deletion of 73 insignificant paths.[33]

The standardized effects between the predictors, the six noise-annoyance constructs and residential satisfaction are presented in Table 2 in descending order based on their effect on residential satisfaction. For residential satisfaction, the effects are decomposed into direct and indirect effects.

8.4.2 Effects of aircraft noise on residential satisfaction

A surprising result is that the total effect of aircraft noise exposure ranks higher than the effect of aircraft noise annoyance. In addition to an expected indirect effect via aircraft noise annoyance a large direct effect remains. Hence, with respect to aircraft noise the objective physical condition is a stronger predictor of residential satisfaction than its subjective counterpart. As has been suggested before, a plausible explanation is that aircraft noise annoyance does not capture all negative feelings in response to aircraft noise (Job et al., 2001). The remaining strong direct effect provides additional evidence for this assertion.

In relation to the other noise-related constructs we find that the effect of aircraft noise annoyance, is smaller than the effects of slow road traffic noise annoyance (<50 km/h), and neighbour noise annoyance, but larger than the effects of fast road traffic noise annoyance (>50 km/h), railway noise annoyance, and construction noise annoyance.

The results indicate that, in comparison to other environment effects, aircraft noise is not a strong predictor of residential satisfaction. Since the analysis is based on a representative sample of residents living within the 25-km radius of a large international airport, this finding may be seen as remarkable. The relatively weak link between aircraft noise and residential satisfaction has also been confirmed in a previous study among residents around Schiphol airport (Marsman and Leidelmeijer, 2001). Stallen and Van Gunsteren (2002) explain this finding by speculating that annoyance caused by aircraft noise is part of a different, more political domain of frustrations than residents' feelings about their residential quality.

[33] The re-estimated model shows an acceptable model fit (S-B scaled χ^2 = 1090.52, *Df* = 217, RMSEA = 0.019, CFI = 0.993, SRMR = 0.0134).

Table 2. Standardized total effects on dependent variables (all sign. at p<.001) and proportions of explained variance

	Direct effects on noise annoyance constructs						Effects on residential satisfaction			
	Aircraft noise annoyance	**Road traffic noise annoyance (< 50 km/u)**	**Road traffic noise annoyance (> 50 km/u)**	**Railway noise annoyance**	**Construction noise annoyance**	**Neighbour noise annoyance**	**Direct**	**Indirect**	**Total**	**Rank**
Road traffic noise annoyance (< 50 km/h)	-	-	-	-	-	-	-.254	-	-.254	1
Age (young) → age1	-.119	.090	0	.036	.190	.260	-.072	-.063	-.135	2
Age (middle-aged) → age2	.204	.182	.077	.070	.120	.210	.051	-.104	-.053	
Age (old) → -age1 + -age2	-.085	-.272	-.077	-.106	-.310	-.470	.021	.167	.188	
Neighbour noise annoyance	-	-	-	-	-	-	-.180	-	-.180	3
Aircraft noise exposure	.307	0	0	.035	0	0	-.123	-.021	-.144	4
Dwelling ownership (owner-occupied)	.066	0	0	0	0	-.108	.127	.016	.143	5
Year of construction of dwelling	-.057	-.142	0	0	-.120	0	-.138	.039	-.099	6
Dwelling type (detachedness)	.041	0	.093	0	-.175	-.236	.061	.035	.096	7
Length of residence	-.043	0	0	0	0	.107	-.072	-.017	-.089	8
Air travel behaviour (did fly in last 2 years)	-.068	0	0	0	0	0	.072	.004	.076	9
Aircraft noise annoyance	-	-	-	-	-	-	-.064	-	-.064	10
Av. no. of evenings out of home per week	0	0	0	0	.070	0	.054	0	.054	11
Road traffic noise annoyance (> 50 km/u)	-	-	-	-	-	-	-.048	-	-.048	12
Shift-worker (yes)	.030	0	0	0	.037	.044	-.034	-.010	-.044	13
Household size	0	-.103	0	0	-.079	-.100	0	.044	.044	14
Marital status (married/living together)	.059	.102	0	0	0	.076	0	-.043	-.043	15
Railway noise annoyance	-	-	-	-	-	-	-.040	-	-.040	16
Education	.118	.037	0	0	.140	.071	0	-.030	-.030	17
Economic status (unemployed)	0	.059	0	0	.093	.069	0	-.027	-.027	18
Noise insulation of dwelling (yes)	-.065	0	.041	0	0	-.054	0	.012	.012	19
Sex (female)	0	0	0	-.034	.064	.043	0	-.006	-.006	20
Job related to air transport industry (yes)	-.036	0	0	-.047	0	0	0	.004	.004	21
Av. no. of days out of home per week	0	0	0	0	-.109	0	0	0	0	22
Ethnicity (other than Dutch)	0	0	0	0	0	0	0	0	0	22
Construction noise annoyance	-	-	-	-	-	-	0	-	0	22
Percentage of variance explained	17.2%	6.1%	1.6%	1.1%	17.6%	21.6%			24.4%	

0 = Non-significant (fixed at zero)

8.4.3 Effects of personal background variables

After road traffic noise annoyance, age is the main determinant of residential satisfaction. In line with previous work the effect shows that as one grows older one is most positive about the residential environment, but the direct effect of age on residential satisfaction is curvilinear, whereby the middle-aged class is most satisfied with their residential environment. Age also has six indirect effects with residential satisfaction via the noise-annoyance constructs. The effects of age on aircraft, road traffic and railway noise annoyance are also curvilinear, with those in the middle class age reporting most annoyance, a result that has been previously established for aircraft noise annoyance (Miedema and Vos, 1999). The causal mechanism involved might be that, because of a relatively high level of daily mental workload, the adaptive resources of middle-aged people are pushed to the limit by the presence of noise.

The effect of dwelling ownership indicates that home-owners are more satisfied than tenants. Evidence for the existence and significance of this effect has been provided in the past by Parkes et al. (2002), Lu (1999) and Galster and Hesser (1981), and has been explained by incentives for home-owners to maintain their properties at a higher standard and to join organizations that protect their collective interests (Rohe and Stewart, 1996). The indirect effects of dwelling ownership run through aircraft noise annoyance and neighbour noise annoyance. A theoretical justification for the positive effect on aircraft noise annoyance might be that home-owners are concerned about property devaluation due to the aircraft noise, a factor shown to affect the negative appraisal of aircraft noise (Kroesen et al., 2008a). However, the validity of this explanation is questionable since this mechanism would also apply to the other transportation noise sources for which no effects are found on the respective noise-annoyance constructs.

The effect of year of construction of the dwelling shows that people in older properties generally have a higher degree of residential satisfaction. This is consistent with a study of McHugh et al. (1990) who reason that older neighbourhoods are more established in a community sense and are in better locations relative to jobs and services. In contrast, newer neighbourhoods contain more fluid populations and weaker community ties. The indirect effects of year of construction though aircraft, road traffic moving at over 50 km/h, and construction noise annoyances, result in a positive contribution to residential satisfaction. A possible explanation is that newer houses are generally better insulated.

The dwelling type has a positive indirect and direct effect on residential satisfaction. The positive sign of the total effect is consistent with previous research (Marans and Rodgers, 1975). A plausible explanation for the direct effect is that, moving along the dimension of detachedness, the houses are generally bigger resulting in higher levels of housing satisfaction, which, in turn, leads to greater residential satisfaction (Parkes et al., 2002). The indirect effects between dwelling type and residential satisfaction run through aircraft, road traffic (>50 km/h), construction and neighbour noise annoyance. For neighbour noise annoyance an obvious explanation is that higher detachedness leads to lower proximity to neighbours which decreases the perceived noise caused by them.

Length of residence has a negative effect on residential satisfaction. This is inconsistent with some studies that provide evidence of a positive effect (e.g. Marans and Rodgers, 1975), although others offer a significant negative effect including Onibokun (1976) and Lu (1999). Additionally, a part of this negative effect is mediated through neighbour noise annoyance. Living longer in one place increases the annoyance from neighbour noise.

Air travel behaviour has a direct effect on residential satisfaction and a very small indirect effect. Individuals who have flown in the previous two years are more satisfied with their

residential environment. The indirect effect via aircraft noise annoyance can be explained by the fact that use of the airport leads people to be less annoyed by noise (Miedema and Vos, 1999).

The remaining relationships have a relatively small effect and are less relevant. The effects will therefore not be discussed. Overall, it can be concluded that the signs and sizes of most of the remaining effects are intuitively correct and in line with previous research findings. There is one remaining specific finding which is remarkable. This finding relates to the effect of noise insulation, which is relatively small and only affects residential satisfaction via aircraft, road traffic moving over 50 km/h and neighbour noise annoyance. This finding is potentially interesting because a subset of individuals in the sample even received government funded noise insulation measures especially designed to mitigate the effects of aircraft noise.

8.4.4 Percentages of explained variance

The percentages of explained variance indicate how well the endogenous variables in the model are predicted. These figures are presented in the bottom row of Table 2. 24.4% of the variance in residential satisfaction is explained, which is reasonably high considering the range of other variables, not included in the study; e.g. safety, air quality, housing attributes, neighbourhood appearance/services, social network, and accessibility.

Related to the noise annoyance variables, the objective variables can explain substantial portions of variance in the variables aircraft noise annoyance, construction noise annoyance and neighbour noise annoyance. The objective variables are unable to explain substantial portions of the variance in road traffic noise annoyance and railway noise annoyance.

Nevertheless a large amount of variance in aircraft noise annoyance remains unexplained, which can probably be attributed to the existence of so-called non-acoustical factors not included. These have, next to the noise exposure level, been shown to affect aircraft noise annoyance. Examples include the attitude towards the noise source authorities and the level of perceived control (Kroesen et al., 2008a). These social-psychological variables are also likely to play a role in the explanation of the other noise-annoyance constructs in which also large portions of variance remain unexplained.

8.5 Conclusion

This study looked at the effects of aircraft noise on residential satisfaction around Amsterdam Schiphol within a holistic framework that included exogenous objective variables relating to the individuals, the dwellings and the context, as well as the mediating role of subjective noise annoyance variables. The analysis shows that the most important determinants of residential satisfaction are road traffic noise annoyance age and neighbour noise annoyance. Unexpectedly results include a strong direct effect between aircraft noise exposure and residential satisfaction that remains after accounting for the indirect relationship via aircraft noise annoyance. This is consistent with the idea that aircraft noise annoyance is unlikely to fully capture all negative reactions in response to aircraft noise. Additionally, the effect of sound insulation is very small, indicating that it only marginally increases residential satisfaction.

Following Marans (2003) the study provides a holistic analysis into the relationships between objective attributes and subjective perceptions and evaluations of the residential environment. In applying this perspective, insights are gained into the relative importance of different variables in relation to residential satisfaction, an important indicator of subjective well-being. These insights can be valuable in the design and planning of measures that affect residential quality.

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9. Policy Actors' Response to 'Non-Acoustic Factors'

Kroesen, M., Huys, M. G. and Stallen, P. J. M. (2009) Cultural theory and aircraft noise policy in the Netherlands. *Environment and Planning C – Government & Policy* (submitted).

Abstract

Smit and Van Gunsteren (1997) have applied Cultural Theory to understand the enduring disputes about aircraft noise reduction measures at Amsterdam Airport. They argue that the dominant policies are, and had been for some decades, responding essentially to the hierarchical and egalitarian way of life. Typically, the individualistic way of life is marginalized. This also keeps down making proper use of new insights in non-acoustical determinants of aircraft noise annoyance. In the present study individuals actively involved in the Amsterdam-Airport noise discussions and representing all major stake-holding groups are asked to evaluate (by Q-sorting) a wide variety of policy-relevant statements. Some of these statements reflected noise policy preferences as they would go with the individualistic way of life. Results from the Q-sort analyses provide evidence of the marginalized position of individualistic preferences within the larger policy frame. Additional analyses of verbal reports by respondents offer further insights into the reasons for this marginalized position.

9.1 Introduction

Aviation, aside from being a global industry with global economic impact, also has significant negative local impacts, like air pollution, 3rd party risks and noise. In this paper we focus on the latter impact. In the case of Schiphol airport, the largest airport in the Netherlands, the problem of aircraft noise was first identified in the 1950s (see Bröer, 2006). In the decades to follow a particular constitution of aircraft noise policy has developed: aircraft noise was defined and dealt with in a way fitting both the post-war trust and the growing distrust in regulated development of industrial activity. The resulting 'bias' has been characterized by Smit and Van Gunsteren (1997) using cultural theory. In their view the ruling constitution of aircraft noise policy can be classified as an alliance between the *hierarchical* and *egalitarian* way of life. Biased towards these ways of life, they argue, the *individualistic* way of life is presently excluded.

Because cultural theory holds that variety is necessary for the successful management of (environmental) problems (Schwartz and Thompson, 1990), wider problems should be expected. Stated in the words of Thompson et al. (1990, p. 96) 'those regimes that have largely excluded a particular cultural bias lose the wisdom attached to that bias, and thus inevitably pile up trouble for themselves.' As for the case of Schiphol troubles have indeed been piling up: the policy debate is characterized by strong controversy (Van Eeten, 2001a; Teisman et al., 2008), large-scale deliberative processes fail to leave a recognizable imprint on the policy (Van Eeten, 2001b) and distrust is widely spread among political actors (Derksen et al., 2006) as well as among the general public living in the vicinity of the airport (Interview NSS, 2006). Finally, the number of complainants at Schiphol is much greater than at other European airports with similar noise-footprints (ADSE and Strategem, 2006).

In this paper we explain these problems by the strong alliance of the *hierarchical* and *egalitarian* way of life, an alliance which leaves no room for local actors to negotiate with each other. Inclusion of the individualistic way of life in the noise-policy constitution, which does provide room for the aviation sector and local communities to adjust to each other's presence, can help to address the particular problems of polarization and distrust. In addition, when dealing with the human response to aircraft noise, the individualistic way of life is also complementary to the present policy. Recent insights in how aircraft noise is appraised by people show that annoyance is not merely a function of acoustic factors but also of certain non-acoustic factors, which are social-psychological in nature (Stallen, 1999). This means that at similar noise levels one resident can be extremely annoyed while the other does not even perceive the sounds of aircrafts. Policies that specifically target this large variation in the subjective reaction to noise can therefore be successful. Because of their individualistic orientation such policies can be regarded as complementary to the present policy constitution.

Smit and Van Gunsteren (1997) made several policy recommendations that address the individualistic way of life in aircraft noise policy. A more recent proposal by Stallen et al. (2004) was also triggered by the opportunities of including the individualistic pattern. Over the years the ideas and concepts discussed in these proposals have found their way to policy-related documents. However, their resonance seems to have been limited; the ideas and concepts have not been institutionalized in specific policies. It seems that the ideas have been assimilated by policy actors but that no true accommodation has taken place. In other words, the ideas are internalized as extensions of existing perspectives and not as one or more fully grown autonomous perspectives. The aim of the present paper is to assess the validity of this expectation. Via an explorative study, using the Q-method, we assess in which way the ideas and concepts of Smit and Van Gunsteren (1997) and Stallen (2004) have resonated among individuals involved in Schiphol-noise policy. In turn, we hope that this can provide us with

insights into the reasons behind the present marginalized position of the individualistic way of life.

The remainder of this paper is structured as follows. First, in line with Smit and Van Gunsteren (1997) we introduce cultural theory and show how the problems of polarization and distrust came about. Next, we discuss their proposal to include the individualistic way of life, as well as the more recent proposal by Stallen et al. (2004). In section 9.3 we present the Q-study and reveal actors' perspectives on future noise policy. In section 9.4 we will discuss the results and speculate on the reasons behind the marginalized position of the individualistic way of life. Section 9.5 presents the conclusions.

9.2 Aircraft noise policy at Schiphol airport

Cultural theory contends that there are four viable ways of life: the fatalistic, the hierarchical, the individualistic and the egalitarian (Douglas and Wildavsky, 1982). These four arise from the ways we choose to organize our social life. The dimensions of 'grid' and 'group' have been introduced by Mary Douglas to identify these viable ways of organizing (Douglas, 1978). According to her these two dimensions adequately capture the variability of an individual's involvement in social life. The group dimension "refers to the extent to which an individual is incorporated into bounded units. The greater the incorporation, the more individualistic choice is subject to group determination" (Thompson et al., 1990, p. 5). The grid dimension, on the other hand, "denotes the degree to which an individual's life is circumscribed by externally imposed prescriptions. The more binding and extensive the scope of the prescriptions, the less of life that is open to individual negotiation" (Thompson et al., 1990, p. 5). The combination of these two dimensions (high/low) results in four viable ways of life: the fatalistic, the hierarchical, the individualistic and the egalitarian (see Table 1).

Table 1. The four ways of life

Dimensions of sociality	**Group**	
Grid	**Low**	**High**
High (prescribed)	Fatalistic	Hierarchical
	View on nature: nature is capricious	*View on nature*: nature is perverse/tolerant, nature has limits
	Idea of fairness: none	*Idea of fairness*: equality before the law
	Allocation of blame: fate	*Allocation of blame*: blame those who violate the rules (avoid system blame by diffusing responsibility)
	Preferred form of governance: no consistent preference (opportunistic)	*Preferred form of governance*: command and control, decision making by representation
	Safeguarded object: personal survival	*Safeguarded object*: order
Low (prescribing)	Individualistic	Egalitarian
	View on nature: nature is benign/robust	*View on nature*: nature is fragile
	Idea of fairness: equality of opportunity	*Idea of fairness*: equality of condition
	Allocation of blame: blame incompetent individuals	*Allocation of blame*: blame the system, us versus the "bad guys"
	Preferred form of governance: market, majority vote	*Preferred form of governance*: decision making by consensus, small is beautiful.
	Safeguarded object: freedom of exchange	*Safeguarded object*: survival of the group

To preserve their respective way of life, each has developed a distinctive cultural bias, i.e. a coherent set of preferences, values and beliefs. Hence, the viability of a way of life depends upon the mutually supportive relationships between these cultural biases and the respective patterns of social relations. For example, in Risk and Culture Douglas and Wildasky (1982) show how egalitarians accomplish to maintain group cohesion (high group) without behavioural rules, coercion or overt leadership (low grid), through adoption of beliefs about external threats like global warming and pollution ('outside evils'). In similar vein other preferences, attitudes and behaviours are deduced from the four types of social organization. In line with Smit and Van Gunsteren (1997) Table 1 shows five of these: view on natures, ideas of fairness, allocations of blame, preferred forms of governance and safeguarded objects.

Although quantitative investigations have largely failed to validate cultural theory's main premises (Marris et al., 1998; Dake, 1992; Sjöberg, 1996), it has been successfully applied in qualitative studies as a heuristic device to identify competing arguments, to generate competing problem solving scenarios and to assess the learning capacities of institutions (Mamadouh, 1999). In line with Smit and Van Gunsteren (1997) we use cultural theory largely as a heuristic tool, and make no claims in terms of its integral empirical validity. In addition, we apply cultural theory to the level of a policy domain, in this case being the domain of aircraft noise-policy at Schiphol airport. In the following we will discuss the active ways of life and directly link them to the noise policy at Schiphol.

9.2.1 The hierarchical way of life and its role in aircraft noise policy

The encompassing goal of the hierarchical way of life is to create and maintain social order; a society in which all parts are oriented towards the whole. Every member has his or her place, securely bounded and stratified with many grid constraints to guide behaviour. In a hierarchy nobody's knows personal glory (for such personal rewards would tear it apart) nor personal blame (blame is diffused so the integrity of the system as a whole remains unquestioned). The hierarchy has the tendency to turn political problems into administrative ones. In this, it always faces the paradox of having to incorporate new laws, which arise out of unsystematized interaction among living forces, as if these were mere extensions of the original system. In all, the implicit political strategy is one of compromise. To ensure that each part has a place in (and remains subjected to) the whole goals are multiple and ambiguous, no overriding objective is defined. This also ensures that goals can be retrospectively rationalized whenever one happens to be accomplished or de-rationalized when one lies beyond its reach (to avoid system blame). To secure its long term future the hierarchy is committed to rules and traditions. As a result, it fails to appreciate dangers that stem from the environment. The hierarchy takes risks because it cannot see them (Douglas & Wildavsky, 1982).

The hierarchical way of life is clearly discernable in aircraft noise policy at Schiphol. Here, ever since the 1950s, the Dutch central government has positioned itself as the exclusive caretaker for the problem of aircraft noise. Supported by a strong belief in the malleability of society the political problem of aircraft noise was transformed into a technical problem: the prevailing belief was that, given the right (spatial/technical) interventions, aircraft noise (annoyance) could be controlled. Maps were used to draw noise contours and acceptable limits were set by experts, effectively masking the normative decisions being made (Bröer, 2007). To ensure the necessity for order those exposed to aircraft noise were conceptualized as passive and weak. Procedural planning (i.e. centralistic control), in which acoustic experts played a dominant role, was subsequently brought forward as the best way to protect these people (Stallen and Van Gunsteren, 2002).

In sum, aircraft noise policy is strongly hierarchical. The political problem was turned into an administrative one. The view on nature as being generally tolerant but not without limits, supports the argument that specialized experts ("the right man in the right place") are necessary to find and define these limits.

9.2.2 The egalitarian way of life and its role in aircraft noise policy

If the sole political culture of aircraft noise policy would be effectively captured by the hierarchical one, it would be unexplainable why the policy focused on this (long-term) environmental risk in the first place (since it would not be congruent with anything in its codified past). As mentioned previously, the egalitarian way of life *is* able to perceive long-term environmental dangers. Its role in the constitution of the noise policy is also clearly visible and will be turned to next.

The egalitarian way of life is self-defined in its opposition to larger social systems (e.g. hierarchies), thereby also maintaining a strong group boundary. Yet, in contrast to the hierarchical way of life, the egalitarian one does not impose restrictions on behaviour. Participation in this organization is voluntary and decisions are reached via consensus; every member is equal. This way of life does not use internal prescriptions, but recruits and keeps members within its group boundaries through the identification of external pressures. Hence, for its survival a morality distinct from society's mainstream morality needs to be upheld. Therefore, whereas the hierarchical way of life tries to evade system blame, egalitarians try to emphasize it. Nature conceptualized as fragile helps to point an incriminating finger at established authorities (government and businesses) who exploit nature for their self-interest and increase inequality (Douglas and Wildavsky, 1982).

Risks associated with (large-scale) technological development are typically underappreciated by established institutions (i.e. the bureaucracy and the market) and therefore provide a fertile breeding ground for egalitarian groups to capitalize upon (Stallen and Van Gunsteren, 2002). As a symbol of modernity an airport can become an easy target for activists. This can also be observed in the history of Schiphol. Between 1960 and 1990 the development of the Schiphol airport went along with fierce opposition of small and radical local groups (Bröer, 2006).

9.2.3 Aircraft noise policy: an alliance between the hierarchical and egalitarian way of life

A hierarchy has little concern over which goals eventually make it to the policy agenda (just as long as they support a need to create order). Hence, a typical hierarchical response is to incorporate the egalitarian goals into its system of thought, thereby avoiding system blame, and devise procedures and rules to handle them, subjecting them to order. However, faced with the contradictory goals of economic growth and environmental protection, a convincing story was needed to allow their co-existence on one agenda. The storyline of ecological modernization (Hajer, 1995; Mol and Spaargaren, 1993), introduced in the 1990s, proved to be convincingly enough to (temporarily) resolve the tension. This story replaced the zero-sum logic by a positive-sum logic, i.e. the belief that (through technological innovation) economic and environmental goals could be simultaneously achieved. The result has been termed the "mainport and environmental discourse" by Bröer (2006)[34]. In effect, the 'sting' from the

[34] The term mainport was introduced in the political field in the 1980's and initially applied to the port of Rotterdam. Later it was also applied to Schiphol airport, since it aligned well with the, already used, concepts of 'hub' and 'gateway'. The mainportdiscourse combines the identification of several external forces (internationalization, liberalization and the development of hub-and-spoke networks) with the necessity of a strong national strategy (concentration and large

environmentalists discourse was taken out (Hajer, 1995) and a strong alliance between the hierarchical and egalitarian way of life was created. Left without a clear external pressure (environmental goals were explicitly incorporated by the central government), small local groups lost their momentum. Instead, a place at the table was created for national (more hierarchical) environmental groups like Friends of the Earth.

In sum, the central government appropriated the care for environment by subjecting it to rules and norms (hierarchy) based on the egalitarian motive of equality of condition (protection of the weak). The view of nature underlying this strategy is also a mix of the hierarchical and egalitarian way of life: the present environmental load (i.e. the amount of aircraft noise) is conceptualized as balancing on the edge of what is acceptable. In addition, noise policy strongly relies on science to draw the line between what is and what is not acceptable. Both the hierarchical and the egalitarian worldview support this dependency (Smit and Van Gunsteren, 1997). In the hierarchical worldview the expert is the one who holds the authority to make this decision, he is 'the right man in the right place'. Within the egalitarian worldview science also plays a key role, not as the monopolistic keeper of knowledge, but as bringer of bad news (the 'shaggy prophet'). Finally, nature conceptualized as fragile also enforces a strong preference of both ways of life for prevention and foresight. This further adds to the dependency on science, which is believed to be able to provide complete knowledge of the future.

9.2.4 Results of aircraft noise policy: polarization and distrust

The coalition between the hierarchical and egalitarian way of life proved to be convincingly enough for both proponents and adversaries of the airport. However, given that it concerns a marriage between two different (and partly opposing) ways of life, the coalition is not without its internal contradictions and failures.

An important internal contradiction relates to the view on nature. The hierarchical way of life can tolerate aircraft noise, so long as it stays within certain limits. Yet any amount of noise is already too much for the egalitarian way of life. Given that both views are legitimate in the policy discourse there is a strong base for *potential* polarization. This risk for polarization materializes when the central government institutionalizes the conflicting views. Driven by the hierarchical spirit to create order the opposing views are rigidly encoded in collective claims like mainport and environment (i.e. noise norms). Given that actors only have the means to express themselves in terms of these aggregated claims the outcome is always a point on a predefined one-dimensional scale (mainport vs. environment, growth vs. no growth, more vs. less noise), resulting in a win-lose situation. There are no transactions possible between these aggregated claims, only a trade-off is possible. Since the 'game' is perceived as such, actors are encouraged to take extreme positions. The result is strong controversy and polarization (Van Eeten, 1999; 2001a).

Another weakness of the coalition results from its strong reliance on science. The institutions of the coalition are based on anticipation (under the principle of "better safe than sorry") and therefore assume complete knowledge (Smit and Van Gunsteren, 1997). For example, the zoning system to control aircraft noise is based on forecasts for the demand for air travel. However, on multiple occasions, the future proved to be more uncertain than the forecasts would account for on beforehand.[35] As a result, failing to anticipate the future, the system

infrastructure development) in order to bring about national economic prosperity (or, in other words, to create 'engines of the economy') (Bröer, 2006).

[35] The most striking example is a calculation error made in 2003. Due to this error the noise norms were set at levels that would make further growth impossible. Correction of the error, which entailed setting the norms at a higher noise level, went along with fierce protests of opponents of the airport. The correction was seen as an intentional relaxation of the norms.

became exposed to critique. Egalitarians stand ready to blame it: the institutions are corrupt. (The love-hate affair between the hierarchical and egalitarian way of life becomes apparent when egalitarians subsequently plea for more rules and regulations to prevent future failures.) When the institutions fail, for example those that are put in place to control noise, accountability is lost and trust in the policy declines (Stallen en Van Gunsteren, 2002). As is observed in (recent) publications distrust is widely spread among political actors (Derksen et al., 2006) as well as the general public (Interview NSS 2006).

In sum, the mainport and environment discourse, a derivate of the hierarchical-egalitarian coalition, started out as a powerful story to unify actors around the airport, but has led to *polarization* and repeated system failures, which fostered *distrust* among the involved actors. Taken together, actors are frustrated by the little room the policy constitution leaves them.

9.2.5 The individualistic way of life and its possible role in aircraft noise policy

The individualistic way of life is the last of the three active ways of life.[36] The individualistic social context is one in which every person is an entrepreneur whose aim is to optimize profit. To pursue his best strategies the individual desires a measure of autonomy, he needs to be neither restricted by group boundaries nor guided by specific rules of behaviour. Within the individualistic way of life every person is his own lord and master, free to negotiate and make bargains with others. Competition is the preferred social model and equality of opportunity the accompanying social ethic. Blame is allocated to those who are incompetent. A view of nature as benign provides a moral justification for the individual's desire for freedom and experimentation. Risks are conceptualized as opportunities. Without the danger of loss, there would be no prospect of personal reward and hence no scope for entrepreneurs (Douglas and Wildavsky, 1982).

Since each way of life has the ability to see things differently cultural theory claims that the key to good governance is to find an appropriate balance between the different political cultures. Over the years several proposals to include the individualistic way of life in the constitution of aircraft noise policy have been published. Below the proposals of Smit and Van Gunsteren (1997) and Stallen et al. (2004) are discussed.

Smit and Van Gunsteren (1997) make a demarcation between national and local noise policy. In terms of the national noise policy, they argue, the government has indeed a role to play. Providing general noise limits for the airport safeguards certain public values. However, they warn against the tendency of the central government to make her preferred cultural bias, the hierarchical one, also absolute for local policies. Among other measures, Smit and Van Gunsteren (1997) discuss the noise insulation program to illustrate this. This program is also strongly hierarchical in nature. Residents are considered eligible for insulation measures based on the same acoustic criteria used to set general noise limits for the airport. In addition, residents have no say in how and to which extent the measures are applied; they have to passively submit themselves to the system. According to Smit and Van Gunsteren (1997) this goes against the way people experience aircraft noise, which is not so much determined by these objective acoustics measures, but, to a similar extent, by people's attitudes towards the source, the trust they have in the noise policy and their perception of individual control. These so-called *non-acoustical factors* can account for a third of the variation human reaction to

[36] The fatalistic way of life is inactive; it does not try to control or manipulate the other ways of life. Instead, it is being controlled by the other ways of life (Thomson et al., 1990). Since the fatalistic way of life has no explicit agenda it is not considered as a way of life that can enrich the noise policy constitution. This does not mean to say, however, that the fatalistic way of life is useless. It helps to define the other ways of life, which can only exist in opposition to a fatalistic way of life. In addition, it can buffer the other ways of life. Should the other ways of life fail people can resort to the fatalistic way of life.

noise (Guski 1999).[37] According to Smit and Van Gunsteren (1997) this subjective side of noise annoyance legitimates more emphasis on the individualistic way of life in noise policy. Residents should not be treated as passive and weak, but as autonomous and active individuals who should be given opportunities to influence their exposure to noise. Their specific recommendation is that any compensational scheme (like insulation programs) should offer residents a range of options that, if necessary, can be tailored to accommodate specific individual preferences.

The insight in non-acoustic variables moderating the effects of noise on humans, exemplifies the limitations of the hierarchical-egalitarian tradition in noise policy. The hierarchical-egalitarian alliance prefers one stimulus-response model (e.g. noise→annoyance), as this model implicitly aims to capture the aggregate of all individual preferences. The variation in human response, after accounting for acoustic influences, already undermines this claim. In addition, the fact that these non-acoustic factors consist of beliefs about individual control, further adds to this critique, indicating that the inclusion of the individualistic way of life has potential benefits in terms of noise policy.

The proposal of Stallen et al. (2004) takes the ideas of Smit and Van Gunsteren (1997) in relation to the institutional setting around Schiphol. Non-acoustic factors imply individual variation. If such variation is to be taken seriously more room should be provided for local policies that can address variety. As mentioned before, the present noise policy institutionalizes the two conflicting views, i.e. that aircraft noise is acceptable and that aircraft noise is not acceptable, at the same time. Through these institutions the hierarchical-egalitarian coalition emphasizes the legitimacy of both viewpoints, but at the same time, tries to keep the (political) conflict under the surface. Within the individualistic orientation this one-dimensional conflict would preferably be 'out in the open' and have, not one, but multiple dimensions. Hence, instead of institutionalizing (and denying) a single conflict, Stallen et al. (2004) argue that multiple conflicts should be generated and, subsequently, be played out against each other. This would create a fertile breeding ground for entrepreneurs (individualists) to form and formulate multiple interests and exchange them against those of other actors.

To accomplish this in the policy practice at Schiphol Stallen et al. (2004) previously developed an innovative governance model. They argue that the central government should reconsider which collective political decisions are to be made on a central level and which goals and policies can be developed regionally, i.e. by local governments, citizens groups and the aviation sector. When certain decisions and policies can be allocated to regional actors, room becomes available for them to articulate their interests in multiform ways (instead of two opposing interests growth/no growth). Subsequently, a process of giving-and-taking between the formulated objectives via a multitude of mutual transactions can take place. These transactions can be made on all kinds of issues, which, in the present situation, are *unjustly* 'fixed' by central regulations, e.g. land-use policies, the determination of flight paths, the peak hour capacity of the airport, noise insulation policies, the night-time regime of the airport, house moving schemes, policies that enhance the overall environmental quality in the region of Schiphol, policies for complaint registration and handling, information provision (also for those who are moving into the affected area), etc. Within this model regional governments and the aviation sector can hold each other accountable. By providing Schiphol and its environment (local governments and citizens) the means to adjust to each other's presence, a social context that enhances trust can be created. Within this social context aircraft noise may not necessarily be reduced, but can become much less annoying. To facilitate these

[37] Another third can be attributed to acoustic factors and the last third to unknown factors and/or measurement errors (Guski, 1999).

transactions Stallen et al. (2004) advocate the creation of regional institution with an administrative mandate. They use the term *regional transaction model* to define this new governance model. In addition, this new institution can also become a platform for learning. Based on the principle of trail-and-error (the individualistic mode of learning), room can be provided for experimentation. This would also relief the coalition from its strong dependency on science to support the anticipatory mode of policy making.

Smit and Van Gunsteren (1997) contend that the inclusion of the individualistic way of life goes along with certain risks and uncertainties for those involved. Within the individualistic way of life one should accept that one does not always know what is going on, that meanings are still open and that the best way forward is undefined. Many would feel uncertain without the stable policy base provided by the central government. Yet, Smit and Van Gunsteren (1997) emphasize that a great many shades are possible between the different ways of life, without violating the criterion of sufficient stability and order of the hierarchical government.

9.3 Research focus and method

In this section we will reveal policy actors' viewpoints on future aircraft noise policy at Schiphol. Our interest lies in knowing how participants' beliefs interacted with the insights in *non-acoustic factors* and Stallen et al.'s (2004) *regional transaction model*, which we treat as concrete triggers/manifestations of proposals to include the individualistic way of life into the noise policy constitution at Schiphol. Given that the hierarchical-egalitarian coalition excludes the individualistic way of life we can expect that actors are not favourable towards ideas which are derived from it. On the other hand, if the dissatisfaction with the present policy is indeed great enough actors may be sensitive to a new perspective that can unlock the present debate.

Hence, we can identify two possible reactions to the new ideas: assimilation or accommodation. The former entails that the ideas are internalized as extensions of existing perspectives while the latter entails that the ideas form a coherent independent perspective. To support our aim of revealing the actors' reactions towards the new ideas we made the following substantive and methodological choices:

1. We define a 'coherent independent perspective' as one in which both the insights in non-acoustic factors is emphasized and the implementation of a regional transaction model is supported.
2. We use the study of Van Eeten (1999; 2001a) as a reference point for the existing perspectives. Van Eeten (1999) previously investigated the arguments in relation to the future development of Schiphol airport. He revealed two diametrically opposed policy arguments, one pro-growth and the other anti-growth. Van Eeten showed that the resulting polarization suppressed three other policy arguments that could possibly enrich the policy agenda: (1) societal integration of a growing airport, (2) ecological modernization of the aviation sector and (3) sustainable solutions to a growing demand for mobility.
3. In line with Van Eeten (1999) we also use Q-methodology to reveal actors' perspectives.[38] Q-methodology allows researchers to assess actors' holistic 'frames of mind' on an issue (Brown, 1980). As a result, Q-methodology has the advantage of providing the subjective context of a particular response. In our case, this allows us to better discriminate between instances of assimilation and accommodation. For

[38] The Q-method has been successful in revealing perspectives on a range of public policy topics (Ellis 2004; Ellis et al. 2007; Pelletier et al. 1999; Steelman and Maguire 1999) and, in the field of policy analysis, comes recommended as a method to gain an in-depth understanding of policy issues (Durning 1999).

example, an actor may support the regional transaction model, but may do so for reasons other than the true line of thought expressed in the proposals of Smit and Van Gunsteren (1997) and Stallen et al. (2004). Since Q-methodology can reveal the subjective context of each response the underlying motivations for expressing a particular response can be traced back.

4. We use statements from policy-related documents (i.e. research reports and policy advices) as the communicative context of the present Q-study. The statements in these reports represent the 'state-of-the-art' of our knowledge about noise and its effects as well as ways of dealing with it. In addition, this concourse also covers more general views about the airport and its development, which are needed to compare the perspectives to those of Van Eeten (1999). Lastly, the statements cover conclusions as well as recommendations. Both are needed to identify whether the new ideas exist as a coherent independent perspective: actors must emphasize the *conclusion* that non-acoustic factors are relevant and support the *recommendation* to implement a regional transaction model.

In the following we discuss the selection of statements (Q-sample), the selection of participants (P-sample) and the analysis procedures.

9.3.1 Q-sample

Over the years numerous policy-related documents about aircraft noise and Schiphol have been published. Reports, which were recently published within the framework of Schiphol's policy evaluation (2004-2006), were included in this study. The main aim of the evaluation was to study the effectiveness of Schiphol's legal framework and the related technical system to control aircraft noise. However, additional research also covered a broad range of other issues like experiences from actors in the field, best practices from abroad, ways to measure aircraft noise in practice, and also a study investigating the social-psychological determinants of human response to aircraft noise.

Schiphol's policy evaluation was finalized in 2006. The published reports of Schiphol's policy evaluation are presented in Table 6 in appendix A. Several other reports are added to this list: (1) the final report of the process commission, which was set up to guarantee the neutrality/objectiveness of the evaluation, (2) policy advises of independent research councils (think tanks) and (3) research reports from parallel projects.

In total 190 conclusions and recommendations are sampled from the included documents. In an inductive manner we structured this sample into five themes: social-psychological, economic, political-administrative, legal and technical-acoustical. The distribution of statements over these themes is presented in Table 2. At the cost of the technical-acoustical theme we oversampled statements from the social-psychological and political-administrative theme. The subjects covered in these themes, i.e. related to the insight in non-acoustic factors and to general political views about the airport respectively, were crucial in light of our aim. The strategy to oversample these themes was meant to prevent missing or misinterpreting relevant responses on these topics.

The final Q-sample consists of 41 statements and can be found in Table 5. Statements 2, 8 and 9 relate to the insights in non-acoustic factors and statements 20 and 35 relate to Stallen et al.'s (2004) proposal for more regional cooperation and the implementation of a regional transaction model.

Table 2. Distribution of statements over the five themes

Theme	Total sample	Selection	%
Social-psychological	33	11	33
Economic	22	5	23
Political-administrative	20	8	40
Legal	17	4	24
Technical/acoustical	98	13	13
Total	190	41	22

9.3.2 P-sample and procedures

Given constraints on the available resources the choice was made to administer the Q-sorting task via the internet. The application Flash-Q was used for this purpose (Hackert and Braehler, 2007). Based on the authors' network of relations complemented with contact information of relevant stakeholders gathered via the internet a list of 310 e-mail addresses was composed. In the selection process we made sure that all relevant actor groups were sufficiently represented. An e-mail with an invitation to participate in the Q-study was send to the selected actors. In all, 45 actors performed the Q-sorting task and filled in a small questionnaire afterwards.

The response rate was relatively low, 14.5%, but more or less identical for all actor groups (see Table 3). This means that all relevant actor groups are sufficiently represented in the final sample. Based on the assumption that an actors' position is the most relevant variable influencing an actors' viewpoint (as captured in the theorem "where you stand depends on where you sit"), we were fairly confident that all existing viewpoints would be revealed.

Table 3. Actors groups, selection and response

Actor group	Selection	Response	Response rate (%)
National governments (Ministry of Transport (V&W), Ministry of Environment (VROM) and Ministry of Economic Affairs (EZ))	31	4	12.9
Regional governments (municipalities and provinces)	50	7	14.0
Aviation industry (Schiphol Airport, Royal Dutch Airlines, Martinair, Air Traffic Control, Airport Coordination Netherlands)	41	7	17.1
Universities	60	10	16.7
Regional Consultation Committee Schiphol (CROS)	27	3	11.1
Interest groups (Friends of the Earth, Dutch Aviation Platform)	9	2	22.2
Research institutes (consultancy groups, research councils and planning agencies)	70	7	10.0
Other	22	5	22.7
Total	*310*	*45*	*14.5*

We wanted to give actors the opportunity to evaluate the different insights on their own merits as much as possible. We therefore choose to formulate the condition of instruction such that it was focused on Schiphol's long-term future, i.e. a context not constrained by present institutions. The exact formulation was: "Given the following conclusions and recommendations from (scientific) research reports and policy advises, which, do you think,

are most relevant for Schiphol's aircraft noise policy on the long-term?" Subjects sorted the 41 statements on an 11-point scale from -5 (least important) to +5 (most important).[39]

In the interview after the Q-sorting task, subjects were asked to motivate the extreme positions (+/-5) and provide information on their background.

9.4 Results

Factor analysis (centroid extraction method) of the rank-orderings and varimax rotation[40] revealed that eight factors satisfied the criterion of having two or more significant loadings (Brown 1980). Table 4 shows the proportions of explained variance and number of factor exemplars. It can be concluded that there is one strong factor (A) with 12 exemplars, 3 intermediate factors (B, C, and D) with 5 or 6 factor exemplars and 4 smaller factors (E-H) with only 2 exemplars. However, given that we did not select a random sample, these figures should be taken as merely indicative.

The Q-sorts of the factor exemplars, i.e. those persons that *solely* and *significantly* loaded on a factor, were merged into factor arrays. The factor arrays, presented in Table 5, can be regarded as the idealized Q-sorts of fictive persons loading 100% on the respective factors.

Table 4. Proportions of explained variance and number of factor exemplars

Factor	EV (%)	Factor exemplars
A	14	12
B	10	6
C	8	5
D	9	5
E	4	2
F	4	2
G	4	2
H	4	2
≥ 2 sign. loadings		7
Zero sign. loadings		2
Total		*45*

Table 5 presents the factors arrays of the first four factors (A through D). Because these four represent the most dominant positions in the total set of eight perspectives, the discussion is limited to these only. In the following an interpretation of the perspectives is provided, which especially focuses on the response to the insights into non-acoustic factors and the regional transaction model proposed by Stallen et al. (2004).

[39] Subjects were forced to conform to the following distribution (score, number of statements): (-5, 2), (-4, 3), (-3, 4), (-2, 4), (-1, 5), (0, 5), (1, 5), (2, 4), (3, 4), (4, 3), (5, 2).

[40] The PQ method software of Schmolck (2002) was used for this purpose.

Table 5. Factor arrays

No.	Statement	Factor A	B	C	D
1	The choice for a mainport inevitably leads to noise annoyance, pollution and risks.	3	-2	2	-2
2	Noise annoyance increases when people's expectations differ from actual developments.	3	3	1	3
3	Lack of trust and recognition play a role in the experience of noise.	3	1	-1	5
4	Based on the "test for equivalence" it can be concluded that the Schiphol legislation satisfies the criterion of equivalence.	-2	-2	-4	-4
5	The levels of noise and risk in the vicinity of Schiphol stayed within the set maxima stated in the transition articles.	-1	-2	-3	-5
6	The portion highly annoyed is considerably higher than predicted from the EU dose-response curves for environmental noise.	-2	3	-3	-2
7	It is conceivable that due to constantly changing flight patterns there is also a constant over-reaction to the noise.	-1	0	-1	0
8	Non-acoustic factors add significantly to the degree of annoyance.	1	-3	-2	5
9	Investing in the restoration of trust could contribute to reducing the degree of annoyance.	1	-3	-1	4
10	A clear and comprehensible future vision of the central government, including clarity about the consequences for residents around Schiphol, is very important.	5	-1	3	4
11	More than 75% of the residents is positive towards Schiphol and 50% is positive towards further expansion of Schiphol.	2	-4	0	-3
12	The majority of the residents finds that the norms and regulations provide little guarantees for protection against noise.	0	3	-2	3
13	The current legal system is experienced as technocratic, which according to some parties contributes to the creation of distrust among residents around Schiphol.	1	-1	0	4
14	An important disadvantage of the Schiphol act is the deficient legal protection for residents.	-4	4	-3	1
15	The noise norms set in the control points will provide the protection envisioned in the Schiphol act, now and in the future.	-2	4	-4	-5
16	Continuous Descent Approach (CDA) could reduce the level of aircraft noise, especially in residential areas further away from Schiphol.	2	1	2	0
17	There does not seem to be a sustainable balance between the space for the mainport Schiphol and the negative effects of aircrafts operations on the environment.	-3	4	-1	1
18	The instruments of the Schiphol policy provide insufficient possibilities to optimize the use of Schiphol.	2	0	1	-1
19	It is of great importance that a legal system is developed that more directly controls the effects of air traffic to and from Schiphol.	-3	5	1	2
20	A regional transaction model in the form of a public-private contract or a functional administration at the regional level could provide a structural contribution to the restoration of trust.	-5	-4	1	1
21	Research into policy for the mid-long term future of Schiphol is important and should be focused on a structural revision of Schiphol's policy and the related legal framework.	3	0	3	2
22	Concentration of the effects of air traffic can contribute to enlargement of the capacity of Schiphol and more predictable air traffic.	0	0	0	0
23	Not allowing Schiphol to grow any further would lead to a competition disadvantage for airliners operating from Schiphol which, in turn, would cause the Netherlands to become a less attractive environment for corporations.	4	-5	0	-4
24	The legal framework for the noise norms should provide space for further development of the airport and challenge the aviation sector to reduce noise through innovation.	4	-3	4	-1
25	Concerning the capacity of the airport the noise norms are most restrictive.	4	-3	-5	-2
26	Because the aviation sector grew little in the period of the evaluation of the Schiphol policy, little can be said about the effectiveness of the Schiphol legislation.	-4	-2	-4	-3
27	Research into a sub-hub scenario in which Schiphol assumes a smaller size is of great importance.	-5	2	2	1
28	It is a good option to strengthen the current noise norm system based on calculations with actual measurements of noise.	-1	2	-3	-2
29	Air traffic which is not essential for the mainport function of Schiphol should be displaced to other airports.	-4	2	5	1
30	In favour of a strong economy Schiphol should be allowed to grow at the current location within the limits of noise and risk.	5	-5	2	-1
31	Strict and legally enforceable noise norms provide the best guarantee for residents to prevent exposure to too much noise.	-2	5	-1	-1
32	Currently the calculated noise levels structurally underestimate the actual noise levels, creating a wrong picture about noise exposure in the environment of Schiphol.	-3	3	-2	-1
33	We should constantly look for ways to reduce noise exposure from aircrafts (e.g. quieter flight procedures). A knowledge center can play an important role in this.	1	-1	4	0
34	The slot coordinator should be given more power to maximize its capability to selectively allocate slots.	-1	1	4	-3
35	The policy of the national government should be focused on enhancing the cooperation between Schiphol and regional actors (citizens and local municipalities).	0	-1	1	3
36	When innovations are implemented it should be clear how the gains are distributed in terms of improved environment and increased capacity.	0	1	5	2
37	Growth of Schiphol should not come from messing around with the noise norms. Growth should arise from innovation.	-1	2	3	3
38	The developments to which Schiphol airport and its home carrier are exposed are global and can hardly be influenced by the Dutch national government.	1	-4	0	-4
39	A factor that makes the work of CROS (Commission Regional Dialogue Schiphol) so difficult is that the given margins in which CROS has to operate are very small.	-3	0	-5	0
40	A painful fact about the distrust among residents is that nobody wants to believe that the double-sided goal has proven to be tenable in the last years.	0	1	-2	2
41	With a better mutual adjustment of air traffic and land-use a substantial reduction of noise annoyance is possible, even with a continued growth to 600.000 aircraft movements in 2020.	2	-1	3	-3

9.4.1 Perspective A: Government, live up to your choice for the mainport Schiphol!

Within this perspective actors believe that the future policy should provide room for growth of the airport (statement 30) and actors emphasize the necessity of this growth for the Netherlands in terms of its attractiveness for international corporations (23). It is therefore important for future policy that this growth is not restricted by the noise norms (24). Continued growth within the set noise limits remains an important principle (30).

Options like a sub-hub scenario, in which Schiphol would function as a regional airport instead of a major hub (27), or relocation of air traffic to other airports (29), are strongly ruled out. To address the noise problem spatial-technical solutions like Continuous Descent Approach (16) and an optimized configuration of flights paths vis-à-vis land-use (41) are considered moderately relevant.

Within this perspective great importance is attached to a clear vision on Schiphol from the national government. Since the choice for a mainport inevitably leads to annoyance, pollution and risks (1) it is important that such consequences are clearly communicated towards residents (10). Actors in this perspective do not believe in the importance of strict and enforceable noise limits for future noise policy (31), nor in the ability of such limits to optimize the use of Schiphol (18). On the contrary, they value the conclusion that research on policy for the mid-long term is important and that it should be focused on a structural revision of Schiphol's policy and the related legal framework (21).

In sum, actors in this perspective strongly value conclusions that stress the importance of Schiphol for the national economy and the necessity of growth. They do not appreciate statements that accentuate the effectiveness of noise limits. Instead, since the choice for a mainport has already been made on a national level, actors in this perspective believe that the main solution is to clearly communicate this choice to residents.

Non-acoustic factors

Perspective A acknowledges the relevance of non-acoustic factors related to the experience of aircraft noise (2 and 8) and of trust in particular (3). The following remark of a subject subscribing to this perspective is illustrative:

(related to statement 3) "The biggest problem with aircraft noise around Schiphol is perception. The amount of noise is the same or less compared to other mainports in Europe, but this is experienced differently by those living in the vicinity of the airport. This is probably due to the distrust and/or bad news coverage, through which the perception of noise is much higher than the actual noise."

Although actors acknowledge the 'non-acoustic factors' insight they interpret it strategically. They use it to emphasize that efforts of the aviation industry in the Netherlands have been more than sufficient and that the relatively high portion of complainants is caused by bad news coverage/distrust. In other words, residents' response is irrational given the objective noise levels.

Even though the non-acoustic factors are acknowledged enhanced cooperation between Schiphol and its environment (i.e. citizens and municipalities) (35) or the installation of a regional transaction model (20) as means to address the lack of trust are not valued as important strategies:

(related to statement 20) "I do not belief deliberative models are the solution. In my experience the syrupy of the present policy (and the lack of policy) is a direct consequence of the current deliberative models."

(related to statement 20) "The restoration of trust does not come about by creating an additional regional administrative organ or something like that, it results from being consistent in saying what you do and doing what you say."

(related to statement 39) "Not the small margins of CROS (Commission Regional Dialogue Schiphol) are the problem, but the absence of a clear underlying policy is the problem. […] In my opinion citizens are sufficiently represented and protected via our democratic polity."

The last two remarks clearly show that actors within this perspective believe distrust is best dealt with by making clear choices on a national level and acting accordingly. This belief is strengthened by their bad experiences with regional deliberative efforts.

9.4.2 Perspective B: Government, live up to your choice for environmental protection!

Concerning future policy this perspective does not attach importance to statements stressing the economic benefits of Schiphol nor to those stressing the necessity of growth in favour of a strong economy (23, 24 and 30). In this respect perspective B is opposite to perspective A.

According to this perspective strict and enforceable noise norms remain important (15) and provide the best guarantee to protect residents against too much aircraft noise exposure (31). However, actors do underline the importance of a new legal system that controls the environmental effects of aviation more directly (19). The actual measurement of aircraft noise, in addition to the current practice of calculation, is also considered relevant for improving the present legal system (28 and 32). A possible negative outcome of a technical/hierarchical system, i.e. distrust among residents, is not considered relevant (13).

Research into a sub-hub scenario (27) and displacement of air traffic to regional airports (29) are options that are considered mildly relevant. Overall, actors in this perspective are indifferent about the importance of research focused on a structural revision of Schiphol's policy (21).

Within this perspective great importance is attached to the conclusion that presently there is no sustainable balance between the mainport and the environment (4). The conclusion that the global developments to which Schiphol airport and its home carrier are exposed can hardly be influenced by the Dutch national government is considered irrelevant (38).

In sum, this perspective does not consider the economic benefits of aviation as a relevant point of departure for future policy. In addition, the present legal system can be improved (e.g. by measuring noise), but its core (i.e. strict and legally enforceable noise norms) should be retained. Strict enforcement of the aircraft noise norms is necessary to secure a sustainable balance between economy and environment.

Non-acoustic factors

This perspective does not belief that the non-acoustic factors are relevant (8 and 9). On the contrary, several actors subscribing to this perspective express downright criticism, as illustrated by the following remark:

(related to statement 8) "This is chatter of professor Stallen. He thinks the experience of noise is 'all in the head', in other words, it is all due to residents. […] He does not live under a flight path."

Actors feel attacked by the notion that noise annoyance is a social-psychological construct, as if they do not experience real (objective) nuisance. They have internalized the definition of noise as a collective acoustic problem and reject a problem definition in which residents' subjectivity and the social relationship between the source and those exposed play a role. In

their view, such a problem definition would relief the government (and the aviation industry) from their task to protect residents against 'real' aircraft noise.

In line with the mainport perspective (A) a regional transaction model is not regarded as a relevant element of future policy (20). The same goes for government policies to enhance cooperation between Schiphol and its environment (35). This position can be explained by the low importance actors attach to non-acoustic factors, but also by their strong belief in the central administrative model:

(related to statement 31) "This is the only thing we can hold on to. Otherwise, they can do what they want."

The criticism towards the hierarchical model expressed by other actors is fenced off by the following response:

(related to statement 13) "So long as it works a noise norm system does not have to be understood by everybody."

In sum, actors expect little from a regional approach. Within their perspective the technical administrative model is viewed as the only thing they can hold on to, a necessary evil.

9.4.3 Perspective C: mainport and environment: a solvable problem (innovation and selectivity)

In this perspective some importance is attached to the conclusion that Schiphol should be able to grow in favour of a strong economy (30), yet it is indifferent about the implied causality between development of Schiphol and the Dutch settlement climate for businesses (23).

Within the perspective (technological) innovation is an important element to achieve both economic and environmental goals. The recommendations that the noise norm system should challenge the aviation sector to innovate (24), that growth of Schiphol should not come from messing around with the noise norms but arise from innovation (37) and that we should continuously search for options to reduce the noise production of aircrafts (33) are considered important. Actors in this perspective are optimistic about the abilities of technology to reduce the negative effects of aviation. In addition, it should be clear how gains from innovations are allocated to either side of the dichotomy (i.e. economy versus environment) (36).

This perspective also underlines the importance of selectivity measures. Emphasis is placed on the recommendations that air traffic unrelated to the mainport function should be displaced to regional airports (29) and that the slot coordinator should be given more possibilities to selectively allocate slots (34).

Within this perspective little importance is attached to the conclusion that the present noise norms function effectively to protect residents against noise (15). Instead, it stresses the relevancy of research focused on a structural revision of Schiphol's policy (21).

In sum, to reconcile the tension between economy and environment this perspective seeks the future of Schiphol's policy in possibilities to promote technological innovation and selectivity.

Non-acoustic factors

This perspective is indifferent about the relevancy of non-acoustic factors for future policy (8 and 9). However, unlike perspective B, this does not relate to their unwillingness to subscribe to a subjective problem definition, but is derived from a position that human subjectivity lies outside public policy's reach, as illustrated by the following remark:

(related to statement 8) "This is indeed true, but in terms of policy useless knowledge."

Hence, actors' emphasis on the technocratic logic to resolve the tension between economy and environment creates a context in which human subjective variation is irrelevant. In line with this belief, actors are also indifferent about more regional cooperation (35) or a regional transaction model (20).

9.4.4 Perspective D: Aircraft noise as a social problem (trust and transparency)

In accordance with perspective B this perspective attaches little importance to the conclusion that a growth stop would lead to a degradation of the Dutch settlement climate (23).

This perspective is built around the insight into the role of non-acoustic factors (7). Acknowledgement of the relation between trust and noise annoyance (3) and efforts to restore trust (9) are seen as important elements of future policy. As one actor describes:

(related to statement 3) "This "soft" side of annoyance is more and more supported by empirical research. Listen to people, do something with their input, be honest and transparent, and then trust will slowly return."

This perspective expects little from the existing norms to control aircraft noise (15). On the contrary, it stresses the relevancy of the conclusion that the technocratic system might be the very driver behind the creation of distrust among citizens (13). As another actor remarks:

(related to statement 3) "People do not trust Schiphol, the aviation sector or the policy. By definition, this causes stress, the feeling of not be taken seriously. Without trust there can be no healthy policy."

The emphasis on the non-acoustic factors also manifests itself in the importance this perspective attaches to the recommendation that the government should stimulate the cooperation between Schiphol and the regional actors (35). However, even in this perspective actors are not convinced about the added value of a regional transaction model for future noise policy (20).

The conclusion that growth should originate from innovation instead of adjusting the noise norms is considered moderately relevant (37), as is the conclusion that is should be clear how gains from innovations are distributed over the two sides of the dichotomy (36).

In sum, this perspective places the social side of aircraft noise in the core of the future policy. Trust, transparency (in communication) and cooperation are keywords. The present technocratic system forms an obstacle to realize these principles. Yet, the regional transaction model of Stallen et al. (2004) is not regarded as a promising alternative.

9.5 Discussion

Now we turn back to our research aim, which was to understand how the ideas and concepts related to the inclusion of the individualistic way of life (i.e. non-acoustic factors and a regional transaction model) were received by actors involved in noise policy at Schiphol. Specifically, we identified two ways the new ideas could be received: (1) actors could assimilate them, which would mean that the ideas would function as part of existing perspectives, or (2) actors could accommodate to them, which would mean that the ideas would exist as one or more coherent independent perspectives. The former response can be classified as an instrumental interpretation and the latter as a substantive one.

Based on the results we can conclude that the insight in non-acoustic factors is largely used instrumentally. For perspective A the non-acoustic factors confirm that Dutch people, compared to other Europeans, are somehow more (politically) sensitive to noise. Hence, even

though the Dutch aviation industry performs relatively well in terms of actual noise exposure levels, residents' response is irrational. It confirms the belief that they have to satisfy opponents that can never be satisfied enough. For actors in perspective B, it proves that the government and the aviation industry are trying to find ways to relief themselves from efforts to reduce actual noise levels. They interpret perspective A's emphasis on perception as the result of the belief that the noise problem is not real, that it is all in people's heads. Actors adhering to perspective B are offended by this notion, and advocate control over actual aircraft noise instead of the clever management of people's perceptions. Perspective C is indifferent in relation to the insight in non-acoustic factors. Actors in this perspective acknowledge their existence but do not consider them relevant in terms of policy. Finally, perspective D does provide a substantive interpretation of the insight in non-acoustic factors. Taking local actors more seriously in the policy process is considered relevant and the government should provide more room for regional cooperation.

Turning to Stallen et al.'s (2004) regional transaction model we can observe that actors' response is relatively invariant; none of the four perspectives attaches great importance to this model. For perspectives A and B, the regional transaction model is considered least important for future policy. Perspective C is indifferent towards a regional transaction model. Actors in this perspective would probably not oppose such a model, but do not expect any benefits from it. Lastly, perspective's D response towards a regional transaction model is unexpected. Given that this argument revolves around the insight in non-acoustic factors, its indifference towards this model is contrary to the expectations.

Overall, we can conclude that perspectives A, B and C have clearly assimilated the ideas of Smit and Van Gunsteren (1997) and Stallen (1999). Perspective D accommodates the ideas, but still this perspective does not seem to go all the way. In the following we provide two possible explanations for these results.

9.5.1 Polarization leads to instrumental interpretations

We can observe that perspectives A and B reproduce the dichotomy between pro-growth (mainport) versus anti-growth (environment) of the airport. Although we did not find two diametrically opposed (i.e. bipolar) arguments as the study of Van Eeten (1999) revealed, the correlation between the factor scores of perspectives A and B, -.52, still indicates the presence of strong opposition. Hence, a decade after the study of Van Eeten (1999), Schiphol's policy debate is still characterized by polarization. Actors are still accustomed to formulate their objectives within the central governments frame of the problem, i.e. mainport (growth) versus environment (collective noise norms). Within this frame there is no room for the formulation of individual and situational-specific preferences.

Due to the polarization we can observe how actors on either side of the dichotomy (perspectives A and B) are creative in molding the insight in non-acoustic factors to fit and perpetuate their respective arguments. Actors in perspective A view residents' reaction to noise as irrational. Such reaction can best be dealt with if the government assumes a more leading role. The central government should clearly state its mainport ambitions and make fewer promises in terms of the environment. Actors in perspective B, on the other hand, view the emphasis on non-acoustic factors as a way to draw attention away from what really matters: the physical noise load. In turn, they advocate for strict rules and regulation to control actual noise. Both arguments, more leadership (centrality) and more rules (bureaucracy), strengthen the hierarchical-egalitarian coalition.

Ironically, instead of resolving the polarization, the insight in non-acoustic factors leads to the exact opposite result; it becomes part of (and strengthens) the controversy. A substantive interpretation is hindered by an instrumental one.

9.5.2 The hierarchical-egalitarian coalition caused previous failures of attempts to include the individualistic way of life

In terms of cultural theory we can conclude that perspectives A and B are strongly rooted in the hierarchical-egalitarian coalition. For perspective A aircraft noise is tolerable, for perspective B aircraft noise is intolerable, both views are legitimated by the hierarchical and egalitarian part of the coalition respectively. In addition, both perspectives have hierarchical tendencies. Emphasizing that the collective decision for a mainport has already been made by majority vote, factor A argues for more leadership of the central government: the government should emphasize that aircraft noise is acceptable. From an egalitarian viewpoint (emphasizing the need for more protection of residents) perspective B argues that the government should retain (and improve) the rules and regulations to control noise. These centralistic institutions are necessary evils to control the profit seeking (self-centered) behaviour of the aviation industry. Hence, both sides call upon the central government to act according to their respective viewpoints. In turn, the government can only respond by capturing the opposing wishes in more rules and procedures, which reinforce the hierarchical-egalitarian conceptualization.

Since regional governments and the aviation industry both look at the central government to grant their opposing wishes, they have no reason to deal with each other. Moreover, when initiatives for more regional deliberation do emerge actors are given no room to effectively interact with each other. This is illustrated by Schiphol's recent history, in which three major interactive policy rounds have been organized (concluded in 1995, 1999 and 2006) (Huys, 2006; Mayer, 2005). Even tough much variety is generated during these processes the ideas do not find their ways into policy. Van Eeten (2001b) has identified this problem as the 'missing link' between such deliberative efforts and established institutional lines. With cultural theory we can particularize this conclusion and explain the negligible impact as the marginalization of the individualistic way of life by the hierarchical-egalitarian coalition. The 'prescribing' variety of individual entrepreneurs cannot be incorporated into a hierarchical system which is already prescribed. This tension is also visible in the experiences of the Regional Consultation Committee Schiphol (CROS), in which regional governments, citizens and the aviation industry participate. This institution is unable to accomplish its aim to reduce noise annoyance because it has to operate within the small bandwidth left by the (central) rules and regulations to control noise (Stallen, 2006).

As a result actors generally have negative experiences with participatory processes, resulting in a critical attitude towards regional deliberation. Hence, given that the outcomes of deliberative processes fail to leave an imprint on policy (Van Eeten 2001b), actors dismiss the regional transaction model as just another forum for talk. This reason can also account for perspective's D unexpected response towards the regional transaction model.

Overall, the results of our analyses can be described as follows. First, actors on either side of the dichotomy (arguments A and B) are creative in molding the insight in non-acoustic factors to fit and perpetuate their respective arguments. Ironically, instead of resolving the polarization, it has led to the exact opposite result; it became part of (and strengthened) the controversy. The instrumental interpretation hinders a substantive one. Second, a shift towards a more individualistic orientation in noise policy is not only hindered by the controversy created around the insights in non-acoustic factors, but also by actors' emphasis on centrality and technocracy, the main principles of the hierarchical-egalitarian coalition. Within this context, a regional transaction model as envisioned by Stallen et al. (2004) is perceived as just another forum for talk. This belief is strengthened by the negative experiences of previous deliberative efforts, which, in turn, can be explained by the marginalization of the individualistic way of life by the hierarchical-egalitarian coalition. In

Figure 1 the two feedback loops that reinforce the hierarchical-egalitarian coalition are schematized.

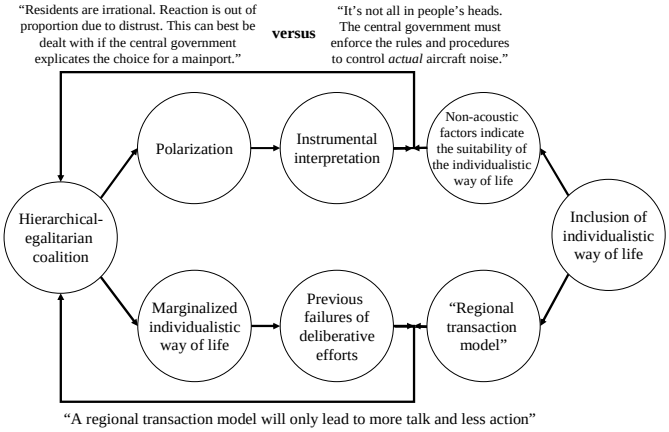

Figure 1. Two feedback-loops that reinforce the hierarchical-egalitarian coalition

9.6 Conclusion

In line with Smit and Van Gunsteren (1997) this study applies cultural theory to elucidate the potential benefits of including the individualistic way of life in the constitution of aircraft noise policy at Schiphol. The insight in non-acoustic factors triggered their proposal to provide more opportunities for local actors to influence their exposure to noise. Stallen et al. (2004) applied this insight to the institutional setting of the airport and advocated for the implementation of a regional transaction model as a forum for regional actors to formulate their interests and facilitate transactions. Via Q-methodology actors' perspectives on future noise policy are revealed with a specific focus on the insight in non-acoustic factors and the proposed regional transaction model. The perspectives show that due to polarization the insight in non-acoustic factors becomes part of the controversy as another issue on which it crystallizes. In addition, we have shown that the hierarchical-egalitarian coalition enforces itself through the exclusion of the individualistic way of life. Due to this exclusion the potential gains of regional deliberative processes have never been realized. In effect, actors do not consider a regional transaction model as proposed by Stallen et al. (2004) as a viable way forward. Overall we can conclude that the ideas inspired by the individualistic way of life are assimilated and that little accommodation has taken place.

In relation to this study we have identified two (research) directions that we may want to pursue in the future. The first is to report the results of this study and the (speculative) discussion back to the actors in the field. This strategy can validate our research and, hopefully, lead actors to reflect on the policy practice at Schiphol. A second direction is to further investigate the effectiveness of a regional transaction model as a way of dealing with aircraft noise. For this purpose a game can be designed with which the policy practice around Schiphol can be simulated. This game can be played under two different conditions: one in which there are no possibilities for transactions among regional actors (the aviation industry and regional governments), representing the present policy context, and the other in which these possibilities are present, representing a possible future context. Results can indicate whether polarization and distrust do indeed arise under the first condition, and whether the

regional transaction model can successfully be implemented as a means to address distrust and, more general, as a way to effectively deal with aircraft noise.

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Appendix A

Table 6. Research documents used to derive the Q-sample

Main documents	Author	Year
Research approach policy evaluation Schiphol	Ministry of Transport, Public Works and Water Management and Ministry of Housing, Spatial Planning and Environment	2004
Evaluation of the Schiphol policy - final report*	Ministry of Transport, Public Works and Water Management and Ministry of Housing, Spatial Planning and Environment	2006
Research reports		
Test for equivalence old versus new legislation (motion Baarda et al.)	Advanced Decision Systems Airinfra Ltd., DHV Group, and National Aerospace Laboratory	2006
Opinion of the Environmental Impact Assessment Committee on test for equal protection	Environmental Impact Assessment Committee	2006
Opinion of the Aircraft Noise Expect Committee on test for equal protection	Aircraft Noise Expert Committee (Eversdijk et al.)	2006
Schiphol experienced by residents	National Institute for Public Health and the Environment and RIGO Research and Advice	2006
Residents about Schiphol	Interview NSS	2006
Two years experience with Schiphol policy	Bijnsdorp Communication Projects (BCP)	2006
Cleaner air, cleaner aircrafts, more aircraft emissions	Advanced Decision Systems Airinfra Ltd.	2006
Schiphol act and two airport decrees a good solution for the objections and a suitable system?	NovioConsult Van Spaendonck Ltd.	2006
Mainport development in the framework of the policy evaluation Schiphol	SEO Economic Research	2006
The effect of policy on noise annoyance and external safety	National Aerospace Laboratory	2006
Learning experiences from abroad	ADSE and Strategem	2006
Growth possibilities of Schiphol within the environmental limits	To70 - Aviation and Environment	2006
Response Council for Housing, Spatial Planning and Environment: "more market for the mainport"	Council for Housing, Spatial Planning and Environment	2006
Response Council for Transport, Public Works and Water Management: "storms clear the sky"	Council for Transport, Public Works and Water Management	2006
Improvement proposals - initial exploration	To70 - Aviation and Environment	2006
Assessment and weighting of improvement proposals	Ministry of Transport, Public Works and Water Management and Ministry of Housing, Spatial Planning and Environment	2006
Research into the effects of the improvement proposals	To70 - Aviation and Environment	2006
Process committee for the evaluation of the Schiphol policy		
Process committee evaluation Schiphol policy - final report	Process committee (Derksen et al.)	2006
Policy advices		
Advice Transport, Public Works and Water Management Inspectorate	Transport, Public Works and Water Management Inspectorate	2006
Advice Housing, Spatial Planning and Environment Inspectorate	Housing, Spatial Planning and Environment Inspectorate	2006
Advice Environmental Impact Assessment Committee	Environmental Impact Assessment Committee	2006
Advice Council for Transport, Public Works and Water Management: "it's no use hiding…"	Council for Transport, Public Works and Water Management	2005
Results from parallel/associated research projects		
Trends in noise exposure around Schiphol over the period 1990-2004 in KE and LAeq	Advanced Decision Systems Airinfra Ltd., DHV Group, and National Aerospace Laboratory	2005
Antecedents of the experience of Schiphol - a qualitative study among residents around Schiphol	RIGO Research and Advice	2005
Loud; but clear! (enforcement system for the outer area around Schiphol and noise measurements for enforcement and information provision)	Aircraft Noise Expect Committee (Eversdijk et al.)	2006
Noise capacity within the noise enforcement points	To70 - Aviation and Environment	2006
The environmental around Schiphol 1990-2010, facts and numbers	Netherlands Environmental Assessment Agency	2005
Effectiveness of the spatial planning policy instruments	Advanced Decision Systems Airinfra Ltd.	2005
Mainport Schiphol - background document	Ministry of Transport, Public Works and Water Management, Ministry of Housing, Spatial Planning and Environment and Ministry of Economic Affairs	2005
Four perspectives on Schiphol - policy scenario assessment	Ministry of Transport, Public Works and Water Management, Ministry of Housing, Spatial Planning and Environment and Ministry of Economic Affairs	2006
Mainport Schiphol: selectivity in aviation – background and options	Ministry of Transport, Public Works and Water Management and Ministry of Housing, Spatial Planning and Environment	2006
Options for Schiphol, balance between the inner and outer area	Netherlands Environmental Assessment Agency	2006

* Document available in English via the web: http://www.evaluatieschipholbeleid.nl/download/16102006/eindrapport_engels.pdf (accessed September 2009).

10. Conclusion and Reflection

This thesis empirically tested two previously developed theories which account for the prevalence of aircraft noise annoyance: the psychological stress theory as applied to the concept of annoyance by Stallen (Chapter 2) and the discourse resonance theory developed by Bröer (Chapters 4 and 5). Two studies were conducted to address a specific limitation of the first study (Chapters 3 and 4) and two to test specific ideas derived from the discourse resonance theory (Chapters 6 and 7). Finally, policy actors' responses to non-acoustic factors were investigated (Chapter 9). Below the main findings of the thesis are summarized in relation to the formulated research questions.

10.1 Conclusions study 1: Testing a theory of aircraft noise annoyance

Does the psychological stress theory fit with the empirical relationships between acoustic factors, non-acoustic factors and aircraft noise annoyance?

Based on previous work of Stallen (1999), the first paper conceptualized subjective noise reaction as a form of psychological stress. Noise annoyance, according to this model, arises when a stressor (like aircraft noise) is perceived as such and when the abilities to cope are perceived to be insufficient. These pathways are termed primary and secondary appraisal respectively (see Figure 1). While the first pathway is commonly assumed to exist, also in a-theoretical models (see e.g. Guski, 1999), the addition of the second pathway is theoretically innovative. It means that one may be behaviourally disturbed by sounds, but not annoyed if the coping resources are perceived to be sufficient. Related to aircraft noise, the noise management by the source (e.g. the airport operator) or beliefs about the social and economic impacts of aviation, may significantly increase or decrease coping potential and therefore indirectly influence annoyance response.

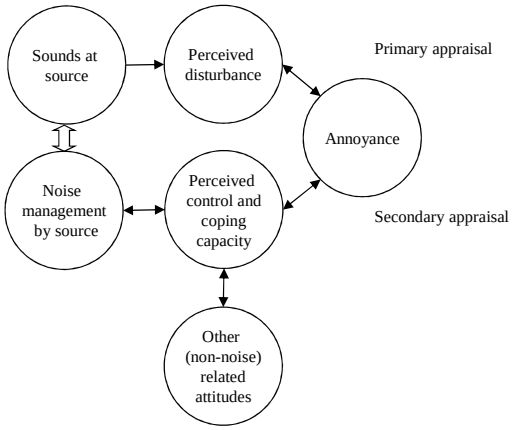

Figure 1. A theory-based model of aircraft noise annoyance

Unlike previous correlational studies or explorative models, the model of Stallen (1999) provided the theoretical mechanisms which supported the relationships between non-acoustic factors and noise reaction. The first study aimed to operationalize and empirically test this model. The conceptual model was translated into a structural equation model (Bollen, 1989) and data were gathered from residents living in the vicinity of Amsterdam Airport Schiphol in the Netherlands (N=646) to estimate it. The specified model could adequately reproduce the observed correlational structure in the data providing empirical support for the theoretical model of Stallen (1999) on which it was based. To summarize, the psychological stress theory could account for the empirical relationships between acoustic factors, non-acoustic factors and aircraft noise annoyance. The first research question can therefore be answered positively.

10.2 Conclusions study 2: Determining the direction of causality

Which non-acoustic factors can explain changes in aircraft noise annoyance over time?

Can aircraft noise annoyance explain changes in non-acoustic factors over time?

A typical critical question in relation to the estimated structural equation model is whether the assumed causal order between the variables is correct. Since all model variables are measured at one point in time it is difficult to argue in favour of one causal order over another. In the second paper the question of temporal order is empirically address. Not via the traditional use of an experiment, but via the use of panel data. Panel data contain measures of the same variables from the same respondents observed repeatedly over time. The specified two-wave panel model is depicted in Figure 2.

The basic idea of the panel model is to explain variation in aircraft noise annoyance (at the second measurement: T2), while controlling for the stability of aircraft noise annoyance (path P1), the initial overlap between the social-psychological factors and aircraft noise annoyance (correlation C1) and the influence of unmodelled ‘third’ variables and/or synchronous effects in the period between the two measurements (correlation C2) (Finkel, 1995). If the effect of a social-psychological factor on aircraft noise annoyance at T2 (path P4) is significant over and above the effect of P1, it can be inferred that the factor accounted for some change in aircraft noise annoyance and that it is a causal predictor of aircraft noise annoyance. The reversed hypothesis (path P3) is also tested.

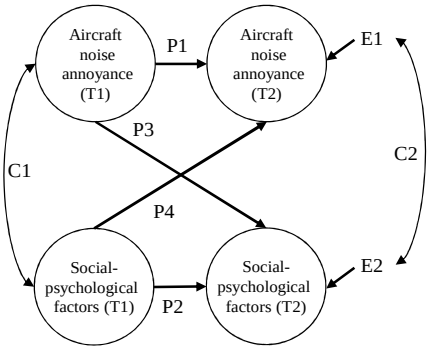

Figure 2. A cross-lagged panel model to explain aircraft noise annoyance

To estimate the model the same respondents were approached a second time two years later using the exact same questionnaire. This resulted in 250 useable responses. Unexpectedly, none of the paths from the social-psychological factors to aircraft noise annoyance were significant. Hence, the social-psychological factors at T1 did not contain any information which could predict how people's annoyance response changed within the period between the two measurements. Yet, two effects were significant the other way around: (1) from 'aircraft noise annoyance' to 'concern about the negative health effects of noise' and (2) from 'aircraft noise annoyance' to the 'belief that noise can be prevented.' Hence aircraft noise annoyance measured at time 1 contained information that could effectively explain changes in these two variables at time 2, while controlling for their previous values.

The study was not able to reveal any significant effects from the social-psychological factors to aircraft noise annoyance. Three empirically supported reasons could be identified to explain this result: (1) the high stability of aircraft noise annoyance ($r = 0.80$), (2) the strong overlap between aircraft noise annoyance and the social-psychological factors at T1 (the C1's) and (3) the strong overlap between the error terms of aircraft noise annoyance and the social-psychological factors at T2 (the C2's). In summary, the results of the second study indicated that establishing the direction of causality between aircraft noise annoyance and other social-psychological factors in the field remains a difficult project, even with the use of panel data.

10.3 Conclusions study 3: Annoyance as a reflection of a general attitude

Can a common factor account for the empirical associations between aircraft noise annoyance and non-acoustic factors?

To what extend is aircraft noise annoyance a reflection of this common factor?

Temporarily suspending the issue of causality the third study focused on the correlational structure of the data at hand. Typically, only effects between non-acoustic factors and annoyance are reviewed and not the associations among non-acoustic factors. However, the high correlations among several of the social-psychological determinants and between these factors and aircraft noise annoyance suggested the presence of a common underlying factor (Edwards, 2001). These determinants should then be considered as reflections of noise reaction and not as possible causes. If this conceptualization would hold with the data it could also be assessed to what extent noise annoyance formed an accurate reflection of the underlying concept of interest, which was termed general noise reaction (GNR).

In Figure 3 the model is visualized. In addition to aircraft noise annoyance, activity disturbance and anxiety/fear related to the noise source were included as reflections of GNR. Aircraft noise exposure, as a determinant, and mental and physical health, as consequences of GNR were included to validate the model. The data to test the model originated from a field survey conducted near Frankfurt airport (N = 2,312) and fitted the specified structure well. GNR as a second-order factor could successfully account for the associations between the dimensions and the consequences and mediate the effects between aircraft noise exposure and the dimensions/consequences. It turned out that aircraft noise annoyance was a strong reflection of GNR, but did not capture all the variance relevant in the prediction of the outcome variables (i.e. mental and physical health).

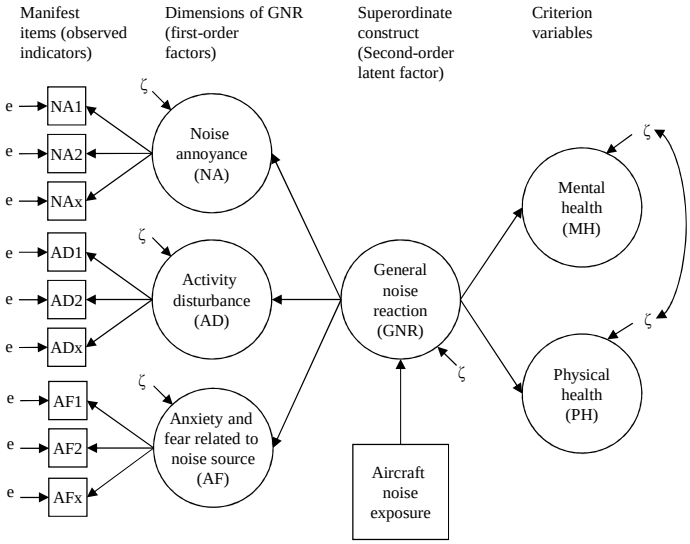

Figure 3. Aircraft noise annoyance as a reflection of general noise reaction

10.4 Reflective intermezzo: from structural to functional models

Although the model in Figure 3 provided useful insights in its own right, it did not provide an answer to the issue of causality. It merely showed that alternative conceptualizations could fit the data just as well. It seemed that a cause-and-effect perspective could not deliver on its promises in a field setting. Turning to the literature this concern was not unfounded. Specifically, the usefulness of the cause-and-effect perspective has been questioned on two fundamental points.

The first relates to its assumption that the structural categories and relationships as defined by the researcher can adequately capture the functional categories and relationships as used by the subject (Brown, 1980; Brown, 2002). Within the cause-and-effect perspective the gathered data can only be explained by the imposed structural categories. Interpretations therefore inevitably return to the researcher's conceptions (Brown, 1980), leaving the question whether these categories indeed overlap with the functional concepts used by subjects to give meaning to reality unaddressed. A second and related criticism attacks the usual assumption within the cause-and-effect perspective that a between-subject relationship can support a within-subject causal statement. As reasoned by Borsboom et al. (2003) between-subject relationships are not necessary indicative of individual processes, which is also confirmed in empirical research where interindividual and intraindividual structures have been shown to differ.

These criticisms are best illustrated with an empirical example. Suppose a researcher is interested in the relationship between aircraft noise annoyance and the belief that aviation is important to the economy. After administering two questions to measure these concepts, he finds the relationship depicted in Figure 4. It is readily apparent that the assumptions of bivariate normality and linearity are violated in this particular case. Apart from these statistical concerns, however, is the theoretically problematic interpretation of this correlation as a functional and within-subject causal process. The correlation is a characteristic of the population and not of any individual. In other words, if a particular individual would move from left to right on the scale 'Schiphol is an engine of the economy' it does not automatically mean that he or she would become less annoyed by aircraft noise. It might even be that for that individual the process is actually reversed. Hence, within the cause-and-effect perspective the only valid interpretation of the data is structural and between-subject in nature, following the a priori conception of the relationship as X causes (or less ambitious: correlates with) Y in the population. Given that this interpretation was already conceived of from the beginning of the research, it is not really informative.

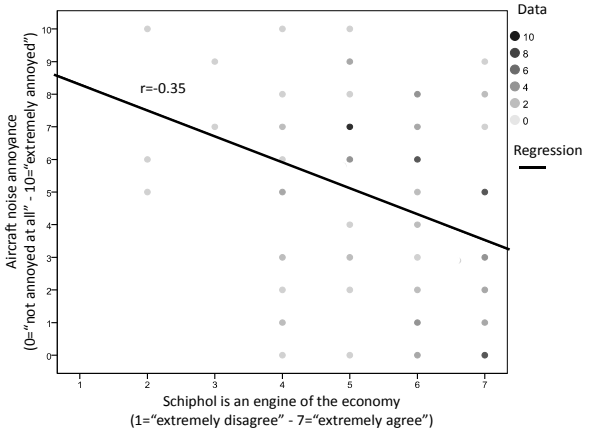

Figure 4. A structural and between-subject interpretation of the relationship between two concepts (N = 91, data from no-context condition of study 6, Chapter 7)

How can the functional within-subject structures then be revealed? Borsboom et al. (2003) propose time series analysis. Apart from the increased time it takes to administer the same test to a single subject (as opposed to administering one test to multiple subjects), this approach runs into trouble with constructs that are relatively stable over time (as learned from the second study in Chapter 3). In the end, variation is necessary to estimate a model. Brown (1980) proposes a more straightforward solution, namely the direct examination of subjects' response patterns. This involves dropping the notion of causality altogether and simply examining the ways in which respondents functionally draw relationships between the concepts. Related to the example above, a latent class analysis reveals two consistent response patterns. The class centroids and the percentages of the sample assigned to each class are presented in Figure 5. A latent class model is statistically equivalent to the correlational model, in the sense that both can account for the observed correlation in the data. The difference is that in the latent class model this correlation is the by-product of (in this case) two distinctive types of persons. There is no residual correlation between the two variables within each class.

The latent class model provides information about the within-subject relationship between aircraft noise annoyance and the belief that Schiphol is an engine of the economy. For example, the subjects in the largest class only slightly agree with the statement that Schiphol is an engine of the economy and relate this position to a moderate annoyance response. On the other hand, the subjects in the smallest class strongly agree with the statement that Schiphol is an engine of the economy and relate this position with a low annoyance response. The within-subject patterns provide functional information; they reflect the actual thought that is occurring for the people belonging to a particular class (Brown, 2002).

The researcher can directly examine the patterns and provide an interpretation of their intrinsic logic. Although this approach might run into the critique that multiple interpretations may account for the data and/or that these interpretations are themselves subjective in nature, the interpretations are nevertheless constrained by the ways subjects related the concepts in their perspectives. In our case, for example, there is neither a class of subjects which disagrees with the statement that Schiphol is an engine of the economy nor one which expresses extreme annoyance. Hence, subjectivity is discursively constrained, meaning that the space of what can and cannot be legitimately said or felt in a particular situation is limited (Edwards and Potter, 1992).

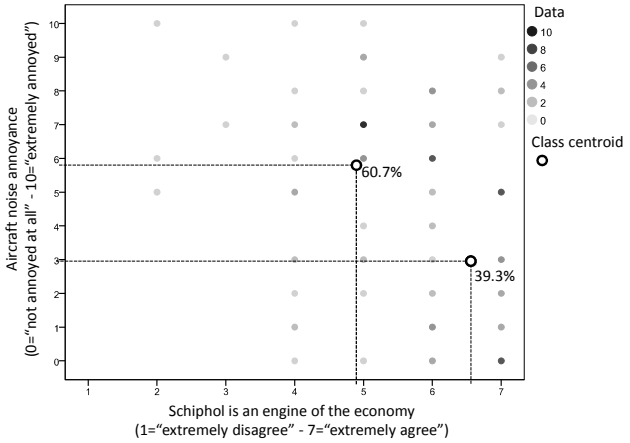

Figure 5. A functional and within-subject interpretation of the relationship between two concepts (N = 91, data from no-context condition of study 6, Chapter 7)

In contrast to the structural interpretation (in terms of X causes or correlates with Y) the functional interpretation reveals how subjects actually think and feel about a topic. This is because information about the means is preserved. A correlation coefficient, on the other hand, is based on deviation scores, whereby differences in means are lost (Brown, 1980). As Brown (1980, 2002) notes, a functional interpretation, as a result, has the ability to surprise the researcher in ways not envisioned on beforehand. Related to the present case two clusters are revealed which are positive towards aviation and not extremely annoyed by noise. A surprising finding indeed given that the subjects in this example were sampled from a neighbourhood (Amsterdam Buitenveldert) where aircraft noise exposure levels are relatively high. Finally, note also that the latent class model by-passes the problems of normality and linearity; the model relies on neither of these assumptions.

To summarize the foregoing line of reasoning: (1) structural between-subject interpretations are problematic because they do not refer to functional categories and relationships nor to individual causal processes (which they implicitly claim to do), (2) functional within-subject interpretations do not have these drawbacks and reveal how subjects actually think and feel about a particular topic and (3) quantitative data-analysis techniques can be used to reveal the within-subject structures. The fourth study proceeds from this line of reasoning.

10.5 Conclusions study 4: Policy, frames and annoyance

Which frames of aircraft noise can be quantitatively revealed?

Are frames informed by (noise) policy?

How do the frames influence aircraft noise annoyance?

Instead of estimating between-subject correlations, the aim of the fourth study was to reveal the within-subject structures. These structures were termed 'frames', defined as interrelated sets of beliefs and feelings, including annoyance. The research follow-up on the work of Christian Bröer, who previously applied an interpretative approach to investigate the meanings which people attach to aircraft noise (Bröer, 2006). Bröer found three policy-related frames of aircraft noise and several autonomous definitions. The aim of the fourth study was to quantitatively objectify these frames. Q-methodology was used for this purpose (Brown, 1980).

The study relied on the work of Bröer (2006). For one, the functional categories that people use in their daily lives to evaluate aircraft noise were sampled from the qualitative material gathered by Bröer (through open interviews, new paper articles, complaint letters, etc.). Second, the research followed Bröer's hypothesis that the policy discourse formed a dominant source of arguments which structured people's frames. In other words, it was assumed that people's evaluations of aircraft noise revolved around policy-related arguments.

Figure 6 conceptualizes the assumed model. In contrast to the previously described structural models, this model is functional: it captures the ways people use categories and draw relationships between them to interpret aircraft noise. It does not introduce any structural meanings on beforehand; instead the meanings are derived from a direct examination of the patterns people develop to make sense of aircraft noise. The model resembles the conceptualization in Figure 3. However, it deviates in the important respect that the latent variable in Figure 6 is assumed to be categorical in nature, while the (second-order) latent variable in Figure 3 is continuous. Hence, whereas the relationships between GNR and its dimensions can only be interpreted as structural and between-subject, the relationships between the frames and the indicators can be interpreted as functional and within-subject.

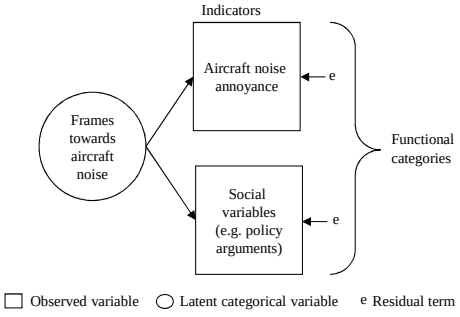

Figure 6. A functional model of aircraft noise annoyance

240 statements were derived from the qualitative material of Bröer and reduced to a theoretically representative set of 48. The 48 statements were rank-ordered by 43 subjects living in a single neighbourhood near Amsterdam Schiphol (Amsterdam Osdorp). A single neighbourhood was selected to ensure that the physical aircraft noise exposure level remained approximately constant, such that all variation could be attributed to individual differences. The rank-orderings were correlated and factor-analysed to identify similarly patterned orderings. This revealed five consistent patterns (see Table 1). As hypothesized three of these (A, B and C) were substantively linked to the policy discourse. Finally, as expected each frame was associated with a fitting level of annoyance response.

Table 1. The means and standard deviations of the standardized noise annoyance item for each frame

	Noise annoyance (0-10)		
Frame	**Mean**	**Std. dev.**	**N**
A Long live aviation!	1.43	1.45	14
B Aviation: an ecological threat	6.00	2.37	15
C Aviation and the environment: a solvable problem	4.00	1.00	3
D Aircraft noise: not a problem	2.50	0.71	2
E Aviation: a local problem	6.33	3.21	3

10.6 Conclusions study 5: Policy, structural variables and annoyance

What is the distribution of frames within the population?

What is the effect of structural variables on the distribution of frame membership?

While the Q-method was effective in revealing people's functional frames of aircraft noise, it did not provide an integral framework to investigate both structural and functional categories. This is because the Q-method can only deal with a limited sample size. As a result, no inferences could be made related to the distribution of the frames in the population or the influence of structural variables on frame membership. In the fifth study latent class analysis was applied to address these remaining questions. The latent class model is visualized in Figure 7.

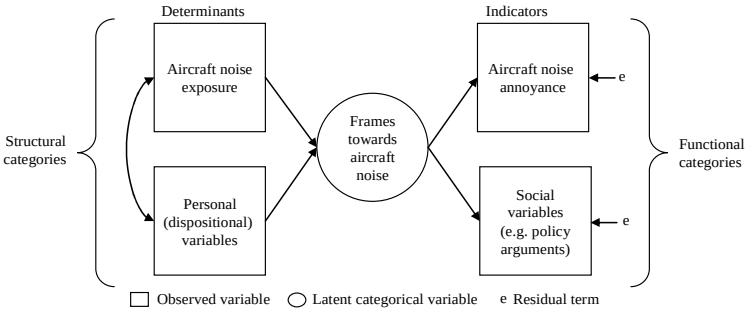

Figure 7. A structural and functional model of aircraft noise annoyance

Unlike functional categories, the meaning of the structural variables can be fixed on beforehand. For example, an objective variable like the aircraft noise exposure level can be identified as a structural category. Its influence can be assessed within the traditional cause-and-effect perspective as a characteristic of the population. Personality traits, like noise

sensitivity were also identified as structural. Three reasons supported this classification: (1) noise sensitivity is (unlike the social variables) empirically unrelated to aircraft noise exposure[41], (2) in the qualitative material of Bröer (2006) noise sensitivity never surfaced as a functional category to give meaning to aircraft noise[42] and (3) there is evidence that noise sensitivity has a genetic component supporting the notion that it is an objective variable. These reasons supported the conceptualization of noise sensitivity as a structural variable, which, as such, could be treated within the traditional cause-and-effect perspective.

The latent class model was estimated based on the same dataset as the second study (the panel model). The model could adequately reproduce the frames revealed by the Q-study. Moreover, in line with expectations, aircraft noise exposure and noise sensitivity were found to significantly influence frame membership.

10.7 Conclusions study 6: The effects of survey context

What is the influence of survey context on the response distribution of aircraft noise annoyance?

What is the influence of survey context on the meaning of aircraft noise annoyance?

In the sixth study a theorized consequence of the model in Figure 7 was tested. If the idea holds that policy arguments discursively constrain human subjectivity with regard to aircraft noise, it can be assumed that the evaluation of aircraft noise will be different if it is placed in a context other than its 'natural' (policy-related) context. An often-used context in surveys about aircraft noise, is the one of multiple noise sources. In this context aircraft noise annoyance is measured in a matrix question alongside other noise sources such as road traffic, railway traffic and neighbours. Confronted with noise sources of which several are hardly audible in the residential environment, it was expected that aircraft noise (as the dominant noise source) would, in contrast, be judged more annoying than in a natural context. In other words, given the context of these other noise sources, people would feel legitimized to express a more extreme annoyance response, something which, due to the dominance of the economic argument (Figure 5), is not legitimate in people's ordinary frames of reference. Data to test this idea were gathered using an online survey among citizens living in the neighbourhood of Amsterdam Buitenveldert (N = 293).

In line with the formulated hypotheses it was shown that varying contexts influenced the response distribution of aircraft noise annoyance and the meanings subjects attached to the concept of aircraft noise annoyance. A higher average annoyance response was observed when aircraft noise annoyance was measured in relation to other noise sources than when measured in isolation. In addition, when aircraft noise annoyance was measured in the context of multiple noise sources it was more strongly related to noise sensitivity than when measured in isolation. Other hypotheses related to the correlational patterns between aircraft noise annoyance and the included scales, however, could not be confirmed.

10.8 Conclusions study 7: Aircraft noise and residential satisfaction

What is the relative effect of aircraft noise exposure on residential satisfaction?

What is the relative effect of aircraft noise annoyance on residential satisfaction?

[41] Since the distribution of frame membership is dependent on the noise level and noise sensitivity is not associated with the noise level, it is unlikely that noise sensitivity is a functional category in people's frames.

[42] This might be due to the fact that people will not readily blame themselves as the cause of annoyance. Be that as it may, however, noise sensitivity as a category is not used to endow aircraft noise with meaning.

Compared to previously described studies, the seventh study took a relative independent position. Its aim was to assess the relative strength of the relationships between aircraft noise exposure, aircraft noise annoyance and residential satisfaction. Indirectly, this model also tested an assumption derived from the previous models, namely that if aircraft noise annoyance (partly) represents a political attitude, it would be regarded less as a negative evaluation of the living environment and therefore be less strongly related to residential satisfaction than annoyance by other noise sources (e.g. like traffic or neighbour noise).

To test this idea, a structural equation model was estimated which included both objective background variables and subjective evaluations of other noise sources (i.e. road traffic noise, railway noise, neighbour noise, etc.). The model is visualized in Figure 8. Data from a survey conducted by TNO and RIVM in 1996/7 (N = 11,812) (TNO and RIVM, 1998) were used to estimate the model.

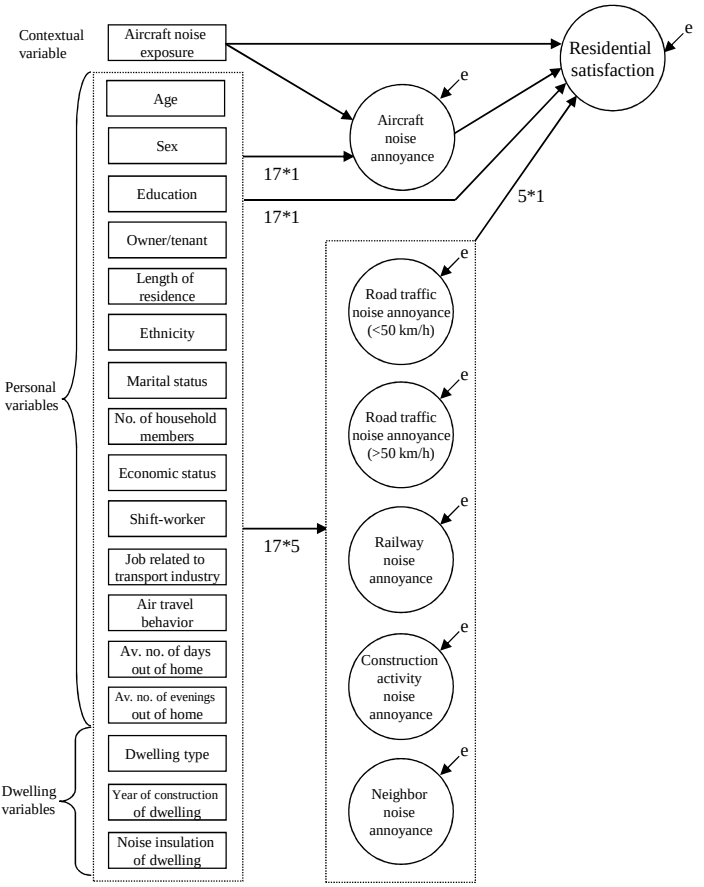

Figure 8. Assessing the effects of aircraft noise exposure and annoyance on residential satisfaction within a holistic framework

The relatively weak relationship between aircraft noise annoyance and residential satisfaction provided indirect evidence for the idea that this concept represents a political

statement/frustration rather than a negative aspect of one's living conditions. In addition, a relatively strong direct effect between aircraft noise exposure and residential satisfaction remained after controlling for aircraft noise annoyance. This confirmed a finding of the third study (Figure 3), namely that aircraft noise annoyance does not capture all relevant variance resulting from exposure to aircraft noise.

10.9 Conclusions study 8: Policy actors' response to 'non-acoustic factors'

How do policy actors involved in the Schiphol-debate integrate the insights in non-acoustic factors in their perspectives on future noise policy?

In the final study, policy actors' response to 'non-acoustic factors' is examined. To this purpose conclusions and recommendations derived from research reports published in the framework of the Schiphol evaluation (2006) are sorted by a representative sample of actors involved in Schiphol-noise policy. In effect, actors' perspectives on future (noise) policy are revealed including their stance towards non-acoustic factors and Stallen's proposal of a regional transaction model (Stallen et al., 2004). The findings show that the two largest perspectives express opposing views; the first advocating continued growth of aviation and the second stringent norms to control aircraft noise. Within these perspectives knowledge about the social-psychology of annoyance is used instrumentally and interpreted such that it strengthens the original arguments. The third perspective takes a technocratic stance; it emphasizes selectivity and innovation to resolve the growth-noise debate. In effect, it is indifferent to non-acoustic factors. The fourth perspective *does* provide a substantive interpretation of non-acoustic factors. According to this perspective the restoration of trust must be a central element of future noise policy. Yet, even in the fourth perspective actors are not enthusiastic about a regional transaction model. Unsurprisingly, the first three perspectives are critical towards such an institution. It is regarded as a just another forum for talk with no obligations. Given that the national regulations effectively determine the development of aviation, actors believe nothing can be gained from regional transactions.

While Stallen's emphasis of non-acoustic factor and his proposal for a regional transaction model (*with* mutually binding obligations) where meant to relief the unproductive tension between the collective claims of growth and noise, the insights in non-acoustic factors became part of and strengthened the controversy. Led by instrumental interpretations policy actors did not interpret the insights on their own merits. In sum, the centralistic orientation of Schiphol noise-policy proves to be self-enforcing.

10.10 General reflection

In this thesis two previously developed theories, namely the psychological stress theory and the discourse resonance theory, have been quantitatively tested. While both theories aimed at explaining and understanding aircraft noise annoyance, their operationalization was based on different research traditions; the verification of the psychological stress theory with a model of structural equations followed the typical hypothetico-deductive approach, whereas the verification of the discourse resonance theory with Q-methodology and latent class analysis can be characterized as post-positivist. As such, the formulated theories and adopted methodologies reflect two different research traditions in the social sciences. The former generally characterized as being in search of universal laws and context-independent truths, while the latter as being in search of particular and context-dependent knowledge.

These traditions have been compared by numerous authors with respect to their relative merits. Flyvbjerg (2006), for example, argues in favour of a social science that is more reflexive and context-dependent, instead of one which tries to develop general predictive

theory. Based on the observation that the social sciences have not succeeded in producing context-independent theory, Flyvbjerg (2006) argues that this activity should be reserved for the natural sciences, which, unlike the social sciences, is able to develop 'hard' theory. In line with this argument Flyvbjerg (2006) advocates the use of the case-study method, which due to its proximity to reality, is able to generate context-dependent knowledge.

Although a shift to using more context-sensitive methods in the social sciences is indeed desirable, I believe this shift need not necessarily be accomplished through an increased use of the case-study method. Instead, it can also be achieved within a quantitative framework. Both Q-methodology and latent class analysis proved to be sensitive to the actual viewpoints of the actors involved. Even though these can be identified as quantitative methods, they provided context-dependent knowledge of the studied phenomenon.

Hence, whereas previous comparisons of positivistic and post-positivistic traditions generally lead to contrasting quantitative and qualitative methods, both traditions can actually be given shape within a quantitative framework. In this respect, it is interesting to compare the actual operationalizations of both traditions given that the research subject and quantitative nature of the research are kept constant. Here, two interesting observations can be made.

As expected, the positivistic approach aimed but eventually failed to provide a universal predictive theory of aircraft noise annoyance. For example, the model (see Figure 1) can easily be criticized on the account that the relationships between factors are wrongly specified. Given that the same data can lend support to different structures there is basically no way of knowing which of these structures is actually 'true'. The post-positivistic approach did not aim to test a universal theory, but instead aimed to reveal the context-dependent meanings subjects in the field attributed to aircraft noise. While this approach succeeded in this aim, it also indicated the existence of several invariant truths. For example, it showed that what is communicated about a particular subject is limited in scope and that people, from this limited 'concourse', develop viewpoints which are again constrained, both in number and form. Surprisingly, these 'invariant truths' are revealed by providing the possibility for 'context' to enter into the model. Hence, by letting go of the desire to find a universal theory, several universal truths are actually revealed!

A second observation relates to the presence of researcher and confirmation bias within the positivist and post-positivist operationalizations. The case-study method and other interpretative methods that fall within the post-positivist tradition are often criticized for being biased towards the researcher's preconceived notions. Flyvbjerg (2006) counters this critique by arguing that proximity to the field often leads to falsification of the researcher's preconceived notions. He adds that the question of subjectivism applies to all methods, both quantitative and qualitative. In this respect, he argues that the choice of categories and variables for a quantitative or structural study is often led by arbitrary subjectivity, which, unlike the case-study method, will probably survive during the investigation because researcher is never corrected by subjects 'talking back'.

With respect to the present thesis, the latter point indeed applies to the structural equation model estimated in the first study. As mentioned before, interpretations of the relationships within this model invariably return to the researcher's preconceived notions (see paragraph 10.4). With respect to the former point we can observe that the quantitative operationalizations of the post-positivist tradition (i.e. the Q-method and latent class analysis) allow subjects to construct their own meanings. While this is partly achieved through proximity to the field (similar to the case-study method), the main reason relates to the way the data is gathered and analysed (i.e. examining the within-subject patterns). In addition, while researchers using qualitative methods may be captured by a (dominant) particularity in the field, perhaps disconfirming the researcher's original ideas but nonetheless providing only

a partial picture of the studied phenomenon, quantification provides an objective frame of reference (i.e. the factors or classes) from where interpretation can proceed. In effect, it has a greater chance of also revealing the marginalized perspectives (Brown, 1980).

While these 'observations' are part of the common sense in the Q-methodology community, they are not widespread in the social sciences. Despite the fact that Q-methodology has come to be regarded as an accepted method appearing in such volumes as the Sage handbook of qualitative research in psychology, quantitative techniques which adopt a positivist logic (such as structural equation modeling) still dominate the scene. Perhaps in the long run, the inferiority of these methods will lead to a shift to post-positivistic methods like Q-methodology. However, while results of a Q-study are generalizable to a population of perspectives, results of a SEM study (which may not be very surprising or meaningful) can be generalized towards a population of people. Given that latter type of generalizability is so engrained in the social sciences as an important aim to strive for, positivistic quantitative method which appeal to this aim remain persuasive. It is therefore not altogether certain that a shift will occur.

In this respect, the present thesis has made an important contribution by illustrating how, with the use of latent class analysis, the results of a Q-study can be generalized towards a population of people. As a result, information can be gained about the distribution of frame membership and how structural variables influence this distribution. However, apart from these substantive gains, the methodological gain is that the results of the latent class analysis lend further credibility to the results of the Q-study. For example, since the latent class analysis revealed the same perspectives, it confirmed an important assumption of the Q-method, namely that (so long as subjects are theoretically sampled) a sample size of 40-50 is enough to reveal all perspectives towards a given topic. In addition, given that latent class analysis supports both types of generalization it may serve the purpose of supporting the shift towards the use of post-positivistic quantitative techniques in the social sciences.

To summarize, the main contribution of this thesis lies in providing quantitative tests of two theories of aircraft noise annoyance. Secondly, it illustrated that advanced statistical techniques can be applied to formalize the post-positivistic tradition in a quantitative way, something which is a commonplace in the relatively closed scientific community around Q-methodology, but not widely acknowledged within the social sciences. Thirdly, it made an important contribution by illustrating how, with the use of latent class analysis, both types of generalization (i.e. towards the populations of perspectives and people) can be supported, which may support the shift towards the increased use of post-positivistic quantitative techniques in the social sciences.

10.11 Future research directions

Several Chapters in this thesis concluded with a description of research directions that were deemed worthwhile to pursue in the future (Chapters 2, 4, 5, 6 and 7). These will not be reiterated here. Three interesting directions, however, can be added to the list.

Maris et al. (2007a; 2007b) showed that the fairness of the procedures that precede exposure to noise influences people's reaction to noise. A fair procedure led to a decrease in the average annoyance response (compared to a neutral control group), while an unfair procedure led to an increase in the average annoyance response. In these experiments the manipulations of fair and unfair conditions were straightforward such that there could be no doubt what constitutes fair/unfair. For example, in the unfair experiment subjects were given the opportunity to express their preference with respect to the particular sound to which they would be exposed, but this preference was explicitly ignored. In many situations, however, multiple definitions of fairness may coexist and contradict each other. A particular outcome or

process may thus be identified as fair according to one definition, but as unfair according to another. The debate of concentrating versus distributing air traffic is a case in point. While concentrating air traffic above sparsely populated areas is fair from a collective point of view (i.e. minimizing the aggregated health impacts of noise exposure), it may be regarded as unfair from a local/individual point of view. From an individual point of view equal distribution of air traffic (regardless of the total number of affected people) would be fair. Other (intermediate or orthogonal) definitions of fairness may also exist. For policy it would be relevant to explore these definitions and the ways in which they manifest themselves in practice. An interesting question in this respect is also how, under the influence of varying social conditions and/or relationships, certain definitions may become more or less relevant.

With respect to chapter 9 an interesting direction would be to investigate the influence of the degree of polarization in a debate on the ways subjects interpret (scientific) knowledge within a controlled experimental environment. In this respect, Hayes and Turgeon (2010) have shown that when people have to choose between two presidential candidates who are strongly (ideologically) distinctive they will engage less in active information processing compared to when the candidates have more similar positions. As a follow-up, it would be an interesting question whether polarization also leads to biased information processing and, if so, how messages could be framed to counter such tendencies. These are important questions if social policy is to benefit from social science.

Finally, an interesting research direction is to model changes over time within the conceptualized discursive model of aircraft noise (Figure 7). Using panel data it can be assessed whether qualitative changes occur in the frames towards aircraft noise and/or whether transitions occur in frame membership over time allowing the researcher to assess the amount of 'traffic' between the varying frames. In addition, these transitions can in turn be predicted by structural covariates or traced back (nonstatistically) to discrete events in the period between the two measurements.[43] In effect, a more profound understanding would arise as to how (social) events and arguments condition frames and/or how these can explain movements between frames over time. A latent class transition model would provide the means to study these effects over time (see Figure 9) (Collins and Lanza, 2009).

[43] For example, a crucial policy decision, an aircraft crash or the opening of a new runway.

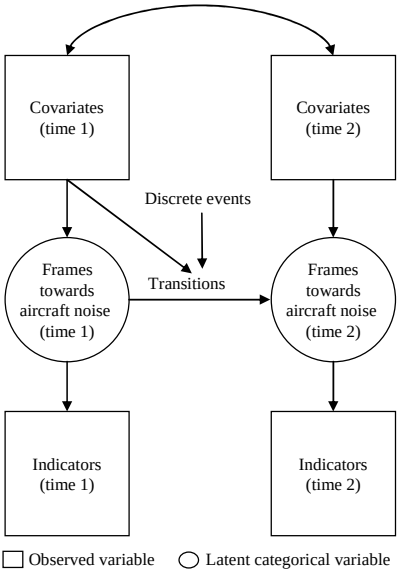

Figure 9. A latent class transition model

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11. Policy Recommendation

Aircraft noise policy in the Netherlands has a clear acoustic orientation. Over the past decades numerous policy proposals have been written that aimed to accomplish a 'paradigm shift' towards an alternative orientation, one that is informed by the social-psychological nature of annoyance. Pieter Jan Stallen, a professor in community annoyance, put much effort in developing and communicating these proposals to the actual policy field (see e.g. Stallen et al., 2004; Stallen and Van Gunsteren, 2002; Stallen and Smit, 1999). In this thesis special attention has been paid to his proposal for a *regional transaction model* (see Chapter 9).

The ideas and concepts put forward in these proposals have been brought under the attention of policy actors. However, their resonance seems to have been limited; the ideas and concepts have not been institutionalized in specific policies. The study among policy actors (Chapter 9) confirms that the ideas have been assimilated by policy actors but that no true accommodation has taken place. Due to the existing polarization policy actors use insights in 'non-acoustic factors' instrumentally to strengthen their (opposite) perspectives. Ironically, while appreciation of the social-psychological nature of annoyance could decrease polarization and frustration (and annoyance), transferring knowledge about non-acoustic factors to the policy field actually reinforces the existing controversy.

While actors will always, to some extent, evaluate new knowledge from their own (perceived) interests, it is likely that in the face of controversy actors will be more strongly led by instrumental interpretations. Assuming that this will be difficult to change, the focus should instead be on the researcher and the (framing of) the message he tries to bring across. This message should be such that both sides stand to gain from it, or, at least, be (initially) indifferent towards it. With respect to the message of 'non-acoustic factors' the instrumental interpretation mostly favoured the economic coalition ('actual noise levels around Schiphol are relatively low, thus people's response is irrational') and undermined the environmental argument. So how can Stallen's message be 'reframed' such that both coalitions stand to gain from it, while still being responsive to the social-psychological nature of noise annoyance?

Most of Stallen's recommendations are targeted at individual preferences and responsibilities which aim at enhancing individual/local control. Since acoustic policies focus on collective

control, these proposals fill an important void in policy. The proposal for a regional transaction model is a concrete example of how individual/local control can be enhanced. Several other examples are also brought forward by Stallen and Smit (1999) such as an individually-tailored noise insulation program (for the wider region around Schiphol) or a house moving scheme. These measures increase individual control over the exposure and accommodate specific individual preferences. The very awareness of an entitlement to these measures could already lower the annoyance felt by residents (Stallen and Van Gunsteren, 2002).[44]

By focusing on individual control these measures address an important gap in policy. However, in line with policy's definition of annoyance as an acoustic problem, the feeling of control derives from the way the central government handles the noise problem. Control, as understood by residents who are affected by aircraft noise, is not so much a matter of personal resources to cope with noise or regional involvement in (noise) policy, but a national matter. In this respect, the latent class analysis (Chapter 6) has shown that majority of people believe that the central government has failed to control aircraft noise (see also Box 1).

Policy measures to enhance individual control will never be effective in the context of ineffective collective control. As the analysis among policy actors illustrates (Chapter 9) such measures may even work contra-productive since they would easily be interpreted as attempts to divert attention from what people believe really matters (namely collective control). This is also acknowledged by Stallen and Smit (1999), who mention that measures in the 'non-acoustic' sphere are doomed to fail if the issue of collective control is not appropriately addressed first.

Stallen and Smit propose to enhance collective control by (partly) relegating the responsibility of policy enforcement to the proposed regional institution. Given that the negative consequences of aircraft noise are felt in the region, trust in collective control would be strengthened if regional actors would have a role in enforcing the collective noise limits.

It can be argued, however, that similar to the central government, regional actors have a double interest with regard to Schiphol. Faced with the trade-off between 'economy' and 'environment' it is likely that they too will favour the economy. In the end, given the dominance of the economic argument, the economy-environment frame will always work to support continued growth, both at the national and the local level.

From this perspective it can be argued that actors on the environmental side indeed stand little to gain from Stallen's policy proposals. The economy-environment frame will likely persist and serve to protect the status quo. From the environmental perspective, 'transactions', in this context, will be viewed as figurative left-overs from the dinner table. To break through the economy-environment frame it is necessary that an alternative dimension is introduced, one that is orthogonal to the economy-environment one.

[44] In this respect, Stallen and Smit also argue that policy could appeal to individual responsibilities by obliging municipalities or real estate agents to properly inform residents moving into the affected area. Such a measure would emphasize the voluntary nature of being exposed to aircraft noise for newcomers.

Box 1. Why is aircraft noise experienced as being 'out of control'

It can be argued that the national government has been most effective in bringing aircraft noise 'under control'. Growth and noise reduction have been going hand in hand since 1990 (see Figure 1). Even though a large part of these reductions did not directly come about due to the Dutch government's efforts, it is nevertheless hard to imagine that aircraft noise is experienced as being 'out of control'. Yet, the latent class analysis showed that a considerable portion of the affected population living near Schiphol experiences aircraft noise as such. Why is this the case?

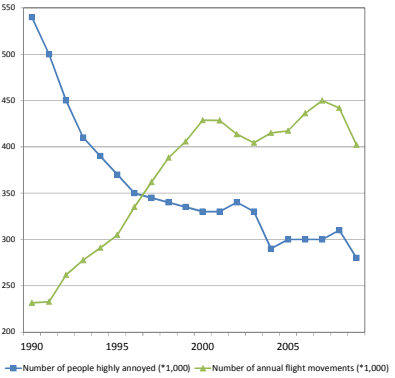

Figure 1. Estimated number of highly annoyed people based on exposure-response curve for Schiphol and annual number of flight movements at Schiphol between 1990 and 2009

A straightforward explanation is that the noise norms have been exceeded numerous times (see also Huys, 2011). Both the Dutch Cabinet and parliament tolerated these transgressions, reasoning that better and more transparent system needed to be designed. The history of tolerance is a likely cause for the feeling that noise is out of control. But why, if noise exposure patterns around Schiphol have generally shrunk, did these transgressions occur in the first place?

The transgressions can be attributed to the rigidity of the system to control noise. The fundamental criterion of the noise regulations is that no more than 10,000 residences are allowed to fall within the 35 KU contour.[45] While the choice could have been made to simply enforce this norm, a spatial contour was fixed to delineate the area where the aviation industry was allowed to expose residents to more than 35 KU. Since aircraft noise was traditionally treated as a planning problem, a spatial contour was viewed as the most logical means to control aircraft noise (Bröer, 2006). The aviation sector, however, developed differently than the projected contour. This meant that at some points along the contour the limits were reached, while at other points there was still excess 'noise capacity'. In the end, violations occurred not because the underlying criterion of 'maximally 10,000 residences within the 35 KU contour' was reached, but because the system was too rigid.

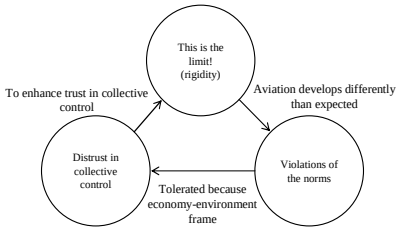

Figure 2. Self-enforcing loop

[45] Based on research of Kosten and Bitter it was estimated that at this level approximately 25% of the population was seriously disturbed by aircraft noise (Kosten, 1967).

The rigidity of the system to control noise proved to be self-enforcing. As soon as limits were reached and, as a result, the growth ambition endangered, transgressions would be tolerated. As a result, regional and environmental actors became distrustful towards the central government and the aviation industry. To enhance trust the central government, in turn, responded by drawing a (firmer) limit once more (be it in a slightly differ form) and emphasizing the rigidity of the new limit. Given that the no real changes were made the limits continued to be transgressed. A self-reinforcing process is the result (see Figure 2).
Currently, the idea is discussed to let go of the noise contour as well as the underlying criterion of 'maximally 10,000 residences within the 35 KU contour'. This flexibility has come at the price of a new norm, namely a maximum on the number of annual flight movements (510,000) (Rijksoverheid, 2009).[46] As before, however, there are no legal guarantees that when this limit is reached, further growth will be made impossible.

The legal protection provided by the noise policy is a potential candidate.[47] The main principle of the constitutional state is that the power of the government is constrained by law. It can be argued that this principle is violated when transgressions of the noise limits are tolerated. In the end, the government does not feel compelled to abide to the laws it has issued, neither can it (within the present legal framework) be forced to abide to them in court (Spaendonck, 2006; Ten Heuvelhof and Stoute, 2000).

This possibility would exist if Schiphol (as any other company) would fall under the environmental law (Wet milieubeheer). There are no substantial legal barriers to apply this law to Schiphol (Spaendonck, 2006; Ten Heuvelhof and Stoute, 2000). This change could lead to either of the following outcomes. The first is that (similar to the present situation) stringent norms are formulated, which will (unlike the present situation) effectively constrain further growth. The other is that lenient norms are formulated, which do not constrain growth in the middle to long-term future. In both cases, the false assumption that a win-win solution is possible (in the long term) will necessarily have to be dropped. And in both cases residents can be certain that the formulated norms will actually be enforced.

Since legal protection represents a core value in our society it cannot be 'traded-off' against economic values in such a way as economic values can presently be exchanged against environmental ones. Additionally, given its independence to the economy-environment dimension, we can expect that actors on either side of the debate (economy or environment) will support a policy change that strengthens the legal protection of citizens. Improving the legal protection of citizens will enhance the perception of collective control, which, we argued, is required to successfully implement measures that address individual and local needs. This policy recommendation is therefore responsive to the social-psychological nature of noise annoyance.

While providing legal protection will likely positively affect the perception of control there is a political barrier. It is probable that within a model where the enforcement of norms is actually guaranteed by the legal system, political parties will accept neither stringent nor lenient noise norms. None of the political parties wants to constrain growth nor does any of the parties wish to be regarded as one with little concern for the environment. As a result, the process of muddling through, where rigid limits are imposed but not actually enforced is likely to continue.

[46] Note that this norm resembles the passenger norm back in 1995, which at the time, disappeared because it did not reflect noise levels in the Schiphol region.
[47] I thank Michel van Eeten for bringing this idea to my attention.

Acknowledgements

This chapter is based on a discussion with Michel van Eeten. I would like to thank Michel for his valuable ideas and contributions.

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Summary: Human Response to Aircraft Noise

Background

While air travel has become a socially accepted means of transportation, its local impacts, most notably noise, but also risk and pollution, continue to be a source of much controversy surrounding airports. Presently, three factors can be identified that enhance the urgency of aircraft noise on the political agenda. Firstly, while new aircraft technology has generally led to a decrease in noise levels near airports in the past, technological improvements are expected to be offset by the growth of aviation in the future. Globally the number of people exposed to aircraft noise levels of 55 dB(A) L_{dn} or more is expected to rise from 23.6 million currently to 30 million in 2025 (Fleming et al., 2008). Second, many airports around the world are faced by a shortage of capacity in the mid-term future (Graham and Guyer, 1999). While new infrastructure is needed to accommodate demand, such expansion efforts easily become focal points in the (noise) debate and generally enhance controversy. Finally, more studies have become available that establish relationships between (aircraft) noise exposure and certain medical outcomes, such as high blood pressure and cardiovascular disorders. While these relationships are still far from conclusive, newspaper headings that read 'Noise kills' add another sting to the noise debate. These factors further add to tensions which may already exist and turn airports into sensitive political entities.

Impacts of aircraft noise

To effectively deal with aircraft noise from a policy perspective, research has been concerned with studying the effects of noise on human well-being. In addition to the already mentioned cardiovascular consequences, studies have mostly concentrated on psychological effects, like annoyance, sleep disturbance, mental health and performance. While the attributable burden of cardiovascular disease due to community noise exposure (including aircraft noise) has been estimated at 0.1% of the total national disease burden (in the Netherlands), a burden expressed in 'severe annoyance' adjusted life-years may amount to 2% of the total disease burden (De

Hollander, 2004).[48] Subjective reaction to noise (e.g. annoyance) can therefore be regarded as an important policy indicator, even more so given that it likely plays a mediating role in the relationship between noise and the 'hard' medical outcomes like hypertension (Job, 1996). In the Netherlands approximately 12% of the population is severely annoyed by aircraft noise (Franssen et al., 2004).
However, for effective noise policy, establishing effects between noise exposure and psychological or clinical outcomes is not enough. This is because the psychological health effects of noise are also influenced by social (e.g. trust in the noise source) and personal variables (e.g. noise sensitivity). With respect to annoyance noise exposure can only explain 25-40% of the observed variance. A third of the variance has been attributed to other *non-acoustic* factors (Guski, 1999). Hence, noise policy that does not appropriately address these factors may at best be partially ineffective and at worst be counterproductive.

Scope of the study

The present thesis investigates the relationships between noise exposure, non-acoustic factors and annoyance. Previous research in this area is characterized by an important limitation; quantitative models which attempt to explain subjective noise reaction lack a 'sound' theoretical basis. Typically, using conventional regression techniques the effects of a relatively common set of non-acoustic factors (i.e. attitudes towards the source, fear and sensitivity) on annoyance is estimated while controlling for noise exposure. Such an approach takes an ineffective middle ground between a deductive approach, in which the definitions of concepts and the specified relationships are informed by theoretical considerations, and an inductive approach, in which subjects' categories and relationships are central.

Importance of theory

The lack of theory in explanatory models of noise reaction has five consequences. In the first place, causal claims stand on weak grounds. The description of the underlying theoretical mechanism is usually regarded as a criterion for establishing a causal effect. Second, without theory we can never really understand noise annoyance. What is actually expressed by a person who indicates that he/she is highly annoyed? Third, without theory non-acoustic factors and aircraft noise annoyance cannot be integrated within in an encompassing conceptual model. In effect, the underlying (causal) structure of aircraft noise annoyance will remain obscured. Fourthly, without theory progress in empirical research related to non-acoustic factors will be slow. Without reflection on the question why certain non-acoustic factors influence annoyance response, it will likely reveal the significance of a similar set of factors over and over again. Finally, if annoyance is not properly understood, neither can it be properly dealt with. Theory is therefore also important from a practical and policy-related perspective.

Aim of the thesis

While explanatory models of noise reaction generally lack a theoretical basis, two theories of (aircraft) noise annoyance have been previously developed. The main aim of the present thesis is to operationalize and test these theories *quantitatively*. The first is the psychological stress theory, which has been translated to the concept of annoyance by Stallen (1999). This theory will be tested following the conventional hypothetico-deductive approach. In contrast

[48] Note, however, that this figure depends strongly on the attached severity weight.

to previous models of noise reaction, model specification will be informed by theoretical considerations. The second theory is the discourse resonance theory, which has been developed and qualitatively verified by Bröer (2006). In contrast to the psychological stress theory, which aims to provide an universal explanation for aircraft noise, the discourse resonance theory is contextual; it is responsive to the meanings which people in their everyday lives attribute to aircraft noise. Unlike previous explorative models, the discourse resonance theory can therefore be characterized as truly inductive.

Outline of the thesis

The overall outline of the thesis is as follows. After the psychological stress theory is tested in the first study two explorative studies follow. These explorative studies attempt to address a short-coming of the model in the first study. The (surprising) findings of these explorative studies can be accounted for by the discourse resonance theory. This theory is quantitatively tested in study four and five. The sixth study tests several additional hypotheses that follow from the discourse resonance theory. The seventh study is again explorative in nature and indirectly tests an idea derived from the discourse resonance theory. The eighth study focuses on policy actors' response to present insights in non-acoustic factors. Below the results of the individual studies are summarized.

Results

Study 1: Testing a theory of aircraft noise annoyance

In line with Stallen (1999), the first study conceptualizes aircraft noise annoyance as a form of psychological stress. Noise annoyance, according to this model, arises when a stressor (like aircraft noise) is perceived as such and when the abilities to cope are perceived to be insufficient. Non-acoustic factors such as the noise management by the source (e.g. the airport operator) or beliefs about the social and economic impacts of aviation, affect annoyance indirectly by increasing or decreasing coping potential. As such, the model provided the theoretical mechanisms which supported the relationships between non-acoustic factors and noise reaction. Data gathered from a survey among residents living near Schiphol fitted the structure of the theoretical model. Hence, the psychological stress theory could account for the empirical relationships between acoustic factors, non-acoustic factors and aircraft noise annoyance.

Study 2: Determining the direction of causality

Since the first study was based on cross-sectional data (i.e. measurements at one point in time) the criterion of time-precedence could not be empirically investigated. The second study attempted to address this shortcoming via the use of panel data (i.e. data containing measures of the same variables from the same respondents observed repeatedly through time). These data could be used to estimate a model that could predict changes in the main dependent variable, aircraft noise annoyance. The results showed that, even though changes in the model variables (i.e. aircraft noise annoyance and non-acoustic factors) were correlated, changes in aircraft noise annoyance could not be predicted by the included non-acoustics factors measured at an earlier point in time. The stability of the model variables as well as the strong associations between aircraft noise annoyance and the non-acoustic factors acted as (statistical) suppressors. The correlated changes, however, indicated that if someone became less or more annoyed in the period between the measurements, his position on a range of non-acoustic factors would change in congruent directions. This led to the idea that aircraft noise

annoyance and several non-acoustic factors reflected an underlying general attitude towards aircraft noise. This idea was tested in the third study.

Study 3: Annoyance as a reflection of a general attitude

Previous research has shown that people use many different words to describe their responses to aircraft noise other than the concept of annoyance (e.g. disturbance, fear, anxiety). While annoyance is the dominate indicator of noise reaction in research, it likely does not capture the full breadth of human negative emotional reaction to noise. From a societal point of view this is problematic since reaction measures such as annoyance are the basis of regulation in many countries where noise exposure limits have been based on dose-response relationships. Moreover, if annoyance reflects dimension specific variance which does not relate to causes (e.g. noise exposure) or consequences of noise reaction (e.g. general health), the relationships between these factors will be structurally underestimated. In the third study, noise annoyance is conceptualized as a reflection of a general attitude towards aircraft noise along with two previously identified determinants of annoyance, namely activity disturbance and feelings of fear and anxiety. The model structure is verified with data gathered from a survey near Frankfurt airport. The results indicate that in the explanation of two criterion variables, physical and mental health, the concept of annoyance indeed performs worse that the assumed general attitude. Based on these results it is concluded that general measures of noise reaction (e.g. dissatisfaction with noise) are more valid indicators of negative reaction to (aircraft) noise than specific dimensions such as annoyance or disturbance.

Study 4: Policy, frames and annoyance

The second study showed that changes in aircraft noise annoyance and non-acoustic factors were correlated. The third study showed that the pattern of associations between noise annoyance and several non-acoustic factors could be explained by a common underlying factor. However, neither study elaborated on the theory that could explain these patterns. This void was filled by the discourse resonance theory (Bröer, 2006). The main tenet of this theory is that policy arguments resonate among the public and thereby shape people's evaluative *frames of aircraft noise*.[49] The meanings subjects attribute to aircraft noise lie at the core of this theory. Based on the theory it was expected that the scope of these meanings would be discursively constrained by the macro policy frame of aircraft noise. In other words, policy arguments set (social) limits on what can and cannot be said and felt with respect to aircraft noise. Since the concept of a frame could explain why substantively independent arguments, beliefs and feelings are empirically interrelated, the discourse resonance theory could account for the common factor structure suggested by the second study and tested in the third. Using qualitative research methods Bröer (2006) empirically verified the discourse resonance theory. The objective of the fourth study was to quantitatively objectify the theory. Consistent with previous findings of Bröer (2006), a small and strategically-selected sample revealed three policy-related frames of aircraft noise. Depending on its stance towards noise policy each frame was associated with a fitting level of annoyance response. The specific frames will be described below in the summary of study 5.

Study 5: Policy, structural variables and annoyance

Due to the small and strategically-selected sample the results of fourth study could not be generalized to the population of residents living within the Schiphol region, nor could the influence of structural variables related to the individual (e.g. aircraft noise exposure or

[49] A frame is defined as a coherent set of beliefs, attitudes and feelings, like aircraft noise annoyance.

personal dispositions) be assessed. The fifth study addressed these remaining questions. The analysis was based on the same dataset as the second study. Again, the results were consistent with findings of Bröer (2006) and the fourth study. The study revealed three policy-related frames of aircraft noise, which, using Bröer's labels, were identified as: 'don't complain', 'mainport[50] and environment' and 'free state Schiphol'. The majority of the sample was assigned to one of these three frames; only a small portion was assigned to an autonomous position.

In the largest frame ('don't complain') residents are cheerful towards aviation. They strongly emphasize the economic argument ('Schiphol is an engine of the economy') and downplay the environmental one ('aviation is a threat to the environment'). According to this frame people who complain about noise do not see the bigger picture. This frame goes together with an average low annoyance response. The second frame ('mainport and environment') is slightly more critical. This frame also strongly supports the economic argument, but also emphasizes the environmental one. People do not readily trust the government to uphold the noise norms and feel rather powerless in relation to the situation. This frame goes together with an average moderate annoyance response. The third frame ('free state Schiphol') is most critical towards aviation. This frame favours the environmental argument over the economic one. Yet, it does not actually deny the mainport argument, contrary to the 'don't complain'-frame which does deny the environmental argument. In line with policy, the status of the mainport argument is less disputed than the environmental argument. Similar to the second frame people believe the government is responsible for the fact that aircraft noise is out of control. Schiphol acts as a free state, unbound by national regulations. On average, people in this frame feel more annoyed by aircraft noise than in the second frame, but are, in the end, not extremely annoyed. This can be explained by the fact that people still acknowledge the economic benefits of aviation.

Study 6: The effects of survey context

The analysis showed that arguments and feelings are integrated in coherent perspectives towards aircraft noise. Policy arguments should therefore not be regarded as determinants of annoyance within a traditional cause-and-effect perspective, but as 'shapers' of the discursive space surrounding the issue of aircraft noise. They constrain what can be legitimately said and felt about aircraft noise. Other ways of thinking or feeling are therefore excluded. For example, in the evaluation of aircraft noise around Schiphol, the dominance of the economic argument prevents the development of a frame in which extreme annoyance is (socially) accepted.

In the sixth study, a theorized consequence of the discourse resonance theory was tested. If the idea holds that policy arguments discursively constrain human subjectivity with regard to aircraft noise, it can be assumed that the evaluation of aircraft noise will be different if it is placed in a context other than its 'natural' (policy-related) context. An often-used context in surveys about aircraft noise is the one of multiple noise sources. In this context aircraft noise annoyance is measured alongside other noise sources such as road traffic, railway traffic and neighbours. Confronted with noise sources of which several are hardly audible in the residential environment, it was expected that aircraft noise (as the dominant noise source)

[50] The term mainport was introduced in the Dutch political field in the 1980's and was initially applied to the seaport of Rotterdam and later also to airport of Amsterdam (Schiphol). The mainport concept combines the identification of several external forces (internationalization, liberalization and the development of hub-and-spoke networks) with the necessity of a strong national strategy (concentration and large infrastructure development) in order to bring about national economic prosperity (to create so-called 'engines of the economy') (Bröer, 2006).

would, in contrast, be judged more annoying than when measured in isolation. In other words, given the context of these other noise sources, people would feel legitimized to express a more extreme annoyance response, something which, due to the dominance of the economic argument, is not accepted in people's ordinary frames of reference. Data to test this hypothesis were gathered using a survey among citizens living in the neighbourhood of Amsterdam Buitenveldert.

In line with the formulated hypotheses it was shown that varying contexts influenced the response distribution of aircraft noise annoyance and the meanings subjects attached to the concept of aircraft noise annoyance. When aircraft noise annoyance was measured in relation to other noise sources the percentage of 'high annoyed' people[51] was more than twice as high as when measured in isolation; 43% and 17% in the experimental and control condition respectively. In addition, when aircraft noise annoyance was measured in the context of multiple noise sources it was more strongly related to noise sensitivity than when measured in isolation. However, other hypotheses related to the correlational patterns between aircraft noise annoyance and the included scales could not be confirmed.

Study 7: Aircraft noise and residential satisfaction

If aircraft noise annoyance (partly) represents a political attitude (in line with the discourse resonance theory), it should be regarded less as a negative evaluation of the residential environment and therefore be less strongly related to residential satisfaction than annoyance by other noise sources (e.g. like road traffic or neighbour noise). This idea was tested in the seventh study, which aimed to assess the relative strength of the relationships between aircraft noise exposure, aircraft noise annoyance and residential satisfaction. A model was estimated which included both objective background variables and subjective evaluations of other noise sources. Data from a survey conducted by TNO and RIVM in 1996/7 were used to estimate the model (TNO and RIVM, 1998). The relatively weak relationship between aircraft noise annoyance and residential satisfaction indeed suggested that aircraft noise annoyance represents a political statement/frustration rather than a negative aspect of one's living conditions. However, the study also showed that a strong direct remained between aircraft noise exposure and residential satisfaction, suggesting the presence of other mediating variables.

Study 8: Policy actors' response to 'non-acoustic factors'

The final study revealed policy actors' perspectives on future (noise) policy including their stance towards non-acoustic factors and Stallen's proposal of a regional transaction model.[52] The findings showed that the two largest perspectives express opposite views; the first advocating continued growth of aviation and the second stringent norms to control aircraft noise. Within these perspectives knowledge about the social-psychology of annoyance is used instrumentally and interpreted such that it strengthens the original arguments. According to the growth-perspective 'non-acoustic factors' confirm that Dutch people, compared to other Europeans, are somehow more (politically) sensitive to noise. Even though the Dutch aviation industry performs relatively well in terms of actual noise exposure levels residents' response

[51] Defined here as a person scoring 8 or higher on a scale from 0 (not annoyed at all) to 10 (extremely annoyed).

[52] According to Stallen et al. (2004) there should be room for local actors to formulate their interests in multiform ways instead of the two opposing collective claims of growth and noise. When interests are formulated locally, binding transactions can be established between the specific desires of the aviation industry and those of local communities. To facilitate these transactions Stallen et al. (2004) advocate the creation of regional institution with an administrative mandate. The authors use the term *regional transaction model* to define this new governance model.

is viewed as irrational. For actors in the noise-control-perspective, it proves that the government and the aviation industry are trying to find ways to relief themselves from efforts to reduce actual noise levels. They advocate control over aircraft noise and not the clever management of people's perceptions. It can be concluded that while Stallen's emphasis on non-acoustic factors and his proposal for a regional transaction model where meant to relief the unproductive tension between the collective claims of growth and collective limits, the insights in non-acoustic factors became part of and strengthened the controversy. Led by instrumental interpretations policy actors did not interpret the insights on their own merits. The centralistic orientation of Schiphol noise-policy therefore proved to be self-enforcing.

Contributions of the thesis

To conclude two theoretical, two methodological and two practical (policy-related) contributions of the thesis can be identified.

Theoretical

The first theoretical contribution is that the present thesis has provided quantitative tests of two theories of aircraft noise annoyance. Formalising these theories in models of noise reaction has led to a better understanding of aircraft noise annoyance and its underlying structure. In line with the discourse resonance theory this structure is informed by the way policy makers conceptualise the noise problem. Policy arguments shape human subjectivity with regard to aircraft noise. Within the resulting discursive space three frames towards Schiphol policy are socially viable. The majority of the residents living near Schiphol use one of these frames to give meaning to aircraft noise.

The second substantive contribution is that the research has shown how personal characteristics, like noise sensitivity, influence annoyance indirectly via frame membership. In comparison to previous explanatory models this conceptualization provides a more insightful perspective on how social and personal factors actually influence subjective reaction to noise. Social factors (attitudes/arguments) do not 'cause' noise annoyance but operate discursively; they set limits on what can arguably be said and felt in a particular situation, resulting in a limited number of internally consistent and socially viable positions. Personal factors, i.e. a person's personality, can be said to operate within a traditional cause-and-effect model. They (at least partly) determine in which of the existing socially viable perspectives a person ends up.

Methodological

The first methodological contribution is that the research illustrated that advanced statistical techniques can be applied to operationalize the post-positivistic tradition in a quantitative way, something which is a commonplace in the relatively closed scientific community around Q-methodology, but not widely acknowledged within the social sciences. Hence, whereas previous comparisons of positivistic and post-positivistic traditions generally lead to contrasting quantitative and qualitative methods, both traditions can actually be given shape within a quantitative framework.

The second methodological contribution the thesis made is by illustrating how, with the use of latent class analysis, the results of a Q-study can be generalized towards a population of people. In effect, knowledge can be obtained about the distribution of frame membership and how structural variables influence this distribution. A latent class analysis can therefore support both types of generalization, i.e. towards the population of perspectives and the

population of people. As such, it may serve the purpose of supporting the shift towards the increased use of post-positivistic quantitative techniques within the social sciences.

Practical

The first practical contribution of the thesis relates to the measurement of annoyance in surveys. The present thesis has shown that the survey context can strongly influence the response distribution of aircraft noise annoyance. In effect, aggregate estimates of the numbers of 'highly annoyed' people in the population may vary greatly depending on the specific context used to measure noise reaction. The selection of a particular method to measure human reaction to noise can therefore lead to drastically different policy implications. From this perspective it seems unwise to use a single exposure-response model as the basis for noise policy.

The second practical contribution relates to the finding that citizens living near Schiphol relate noise annoyance to (failing) collective control. Therefore, to reduce noise annoyance trust in collective control should be restored. This can be achieved by revising the legal basis of Schiphol-noise policy. The fact that previous transgressions of the noise limits are discussed in the parliament and not in court reflects the deficient legal protection of citizens in the case of Schiphol. Improving the legal protection of citizens will likely also improve the (perception of) collective control and thereby lower the (aggregate) annoyance response.

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Samenvatting: menselijke reactie op vliegtuiggeluid

Achtergrond

Hoewel vliegen is verworden tot een maatschappelijk aanvaarde vervoerswijze blijven de lokale effecten van de luchtvaart, in het bijzonder geluid, maar ook risico's en verontreiniging, een bron van veel maatschappelijke controverse rond luchthavens. Momenteel kunnen er drie factoren geïdentificeerd worden die de urgentie van vliegtuiggeluid op de politieke agenda vergroten. In de eerste plaats is de verwachting dat toekomstige technologische verbeteringen, die in het verleden voor sterke geluidsreducties rond luchthavens hebben gezorgd, in de toekomst niet meer zullen opwegen tegen de groei van de luchtvaart. Vandaag de dag zijn 23,6 miljoen mensen wereldwijd blootgesteld aan geluidsniveaus van 55 dB(A) of meer, maar dit aantal zal naar verwachting stijgen tot 30 miljoen in 2030 (Fleming et al., 2008). Ten tweede kampen veel luchthavens wereldwijd met capaciteitstekorten op de middellange termijn (Graham and Guyer, 1999). Er is nieuwe infrastructuur nodig om aan de stijgende vraag te voldoen, maar dergelijke uitbreidingen vergroten doorgaans de (vaak al bestaande) discussie. Als laatst komen er meer en meer studies beschikbaar die een relatie vinden tussen geluid en medische effecten, zoals hoge bloeddruk en hart- en vaataandoeningen. Al zijn deze relaties nog niet overtuigend vastgesteld, voegen krantenkoppen als 'geluid is dodelijk' een extra scherpe dimensie toe aan het geluidsdebat.

De effecten van vliegtuiggeluid

Om vanuit een beleidsperspectief effectief met vliegtuiggeluid om te kunnen gaan heeft onderzoek zich voornamelijk gericht op de effecten van geluidsblootstelling op het welzijn van de mens. Naast de al genoemde cardiovasculaire gevolgen, hebben de meeste studies zich daarbij geconcentreerd op de psychologische effecten, zoals geluidhinder, slaapverstoring, de mentale gezondheid en prestatie. Het gezondheidsverlies dat kan worden toegeschreven aan hart- en vaataandoeningen als gevolg van de blootstelling aan omgevingsgeluid (waaronder

vliegtuiggeluid) wordt geschat op 0,1% van de totale nationale ziektelast, een ziektelast uitgedrukt in het aantal 'ernstig gehinderde' verminderde gewogen gezondheidsjaren kan echter oplopen tot maar liefst 2%[53] van de totale nationale ziektelast (De Hollander, 2004). De subjectieve reactie op geluid (e.g. hinder) kan daarom worden gezien als belangrijke beleidsindicator, te meer omdat deze waarschijnlijk een mediërende rol speelt in de relatie tussen geluidbelasting en de 'harde' medische uitkomsten zoals hoge bloeddruk (Job, 1996). In Nederland voelt ongeveer 12% van de bevolking zich ernstig gehinderd door vliegtuiggeluid (Franssen et al., 2004).

Voor effectief geluidsbeleid is het vaststellen van de relaties tussen geluidbelasting en psychologische en klinische uitkomsten echter onvoldoende. Dit komt omdat de psychologische gezondheidseffecten ook beïnvloedt worden door sociale (e.g. het vertrouwen in de geluidsbronautoriteiten) en persoonlijke factoren (e.g. de mate van geluidgevoeligheid). Met betrekking tot geluidhinder kan de geluidsbelasting slechts 25-40% van de geobserveerde variantie verklaren. Een derde van de variantie kan worden toegeschreven aan andere niet-akoestische factoren (Guski, 1999). Geluidsbeleid dat geen rekening houdt met deze factoren is dus in het beste geval gedeeltelijk ineffectief en in het ergste geval contraproductief.

Afbakening

In deze dissertatie worden de relaties onderzocht tussen akoestische factoren, niet-akoestische factoren en geluidhinder als gevolg van vliegtuiggeluid. Onderzoek in dit veld wordt gekenmerkt door een belangrijke beperking; kwantitatieve modellen die beogen geluidhinder te verklaren zijn niet verankerd in theorie. Doorgaans worden via conventionele regressietechnieken de effecten van een relatief vaststaande set van niet-akoestische factoren (i.e. de houding ten opzichte van de bron, angstgevoelens en geluidgevoeligheid) op geluidhinder geschat, waarbij wordt gecontroleerd voor de mate van geluidsbelasting. Een dergelijk aanpak neemt een ineffectieve middenpositie in tussen een deductieve aanpak, waarbij de concepten en relaties worden gedefinieerd op basis van theoretische overwegingen, en een inductieve aanpak, waarbij de categorieën en relaties door subjecten worden gedefinieerd.

Het belang van theorie

Het gebrek aan theorie in verklarende modellen voor geluidhinder heeft vijf negatieve gevolgen. In de eerste plaats is er zonder theorie geen grond voor causale claims. Een beschrijving van het theoretisch mechanisme wordt doorgaans beschouwd als één van de voorwaarden om een causale relatie vast te stellen. Ten tweede kunnen we zonder theorie geluidhinder nooit goed begrijpen. Wat bedoelt iemand nu precies als hij/zij aangeeft zich ernstig gehinderd te voelen door geluid? Ten derde is theorie noodzakelijk om niet-akoestische factoren en geluidhinder te kunnen integreren in een omvattend conceptueel model. Zonder theorie kan de onderliggende causale structuur van geluidhinder niet in kaart gebracht worden. Ten vierde kan er gesteld worden dat zonder theorie de vooruitgang in empirisch onderzoek naar geluidhinder langzaam zal zijn. Zonder reflectie op de vraag waarom bepaalde niet-akoestische factoren een rol spelen in de hinderbeleving, zal onderzoek zich waarschijnlijk herhalen in het aantonen van het belang van een beperkte set van niet-akoestische factoren. Tenslotte zal er, zolang geluidhinder niet goed begrepen is, ook niet goed mee omgegaan kunnen worden. Theorie is daarom ook van belang vanuit een praktisch beleidsperspectief.

[53] Dit percentage is echter sterk afhankelijk van het gewicht dat men aan hinder toekent.

De onderzoeksdoelstelling

Hoewel verklarende modellen voor geluidhinder over het algemeen een theoretische basis missen, zijn er in eerder onderzoek twee theorieën aangaande geluidhinder opgesteld. Het doel van deze dissertatie is om deze theorieën kwantitatief te operationaliseren en te testen. De eerste is de psychologische stress theorie, een theorie die eerder door Stallen (1999) op het concept van geluidhinder is toegepast. Deze theorie is getest volgens het conventionele hypothetische-deductieve model. In tegenstelling tot eerdere verklarende modellen geschiedt de modelspecificatie op basis van theoretische inzichten. De tweede theorie is de discours resonantie theorie die ontwikkeld en kwalitatief getest is door Bröer (2006). In tegenstelling tot de psychologische stress theorie, welke een universele verklaring voor hinder zoekt, is de discours resonantie theorie contextueel van aard. Dit betekent dat deze theorie de betekenissen die mensen zelf in de alledaagse praktijk aan vliegtuiggeluid verlenen centraal stelt. In tegenstelling tot eerdere exploratieve modellen kan de discours resonantie theorie daarom worden gekenmerkt als waarachtig inductief.

Structuur

De opbouw van de dissertatie is als volgt. De psychologische stress theorie wordt getest in de eerste studie. Daarna volgen twee exploratieve studies die een tekortkoming van het model in de eerste studie adresseren. De (verassende) bevindingen van de exploratieve studies kunnen aan de hand van de discours resonantie theorie verklaard worden. Deze theorie wordt kwantitatief getest in de vierde en vijfde studie. In de zesde studie worden een aantal additionele hypothesen getest die afgeleid zijn van de discours resonantie theorie. De zevende studie is wederom exploratief van aard en test een indirect idee afgeleid van de discours resonantie theorie. De achtste studie richt zich op de reactie van beleidsmakers op de inzichten in de niet-akoestische determinanten van geluidhinder.

Resultaten

Studie 1: het testen van een theoretisch gefundeerd model van geluidhinder

In lijn met Stallen (1999) is geluidhinder van vliegtuigen in deze studie geconceptualiseerd als een vorm van psychologische stress. Geluidhinder ontstaat volgens dit model als een bepaalde *stressor* (zoals vliegtuiggeluid) geïdentificeerd is als zodanig en wanneer de capaciteiten om deze stressor het hoofd te bieden als ontoereikend worden geschat. Binnen dit model beïnvloeden niet-akoestische factoren, zoals het geluidsmanagement van de bron (i.e. de luchthaven) of overtuigingen met betrekking tot de sociale of economische effecten van de luchtvaart, geluidhinder indirect, doordat ze bijdragen aan of juist een afbreuk doen op het coping potentieel. Op deze wijze voorziet de theorie in de werkzame mechanismen die de relaties tussen niet-akoestische factoren en geluidhinder ondersteunen. Data voor het model was verzameld onder omwonenden rond Schiphol. De resultaten lieten zien dat deze goed pasten bij de structuur van het theoretische model. Kortom, de psychologische stress theorie bleek een goede beschrijving van de empirische relaties tussen akoestische factoren, niet-akoestische factoren en geluidhinder.

Studie 2: het vaststellen van de richting van de causale verbanden

Omdat de eerste studie was gebaseerd op cross-sectionele data (i.e. gemeten op één moment in de tijd) kon het criterium van causale volgorde (X gaat vooraf aan Y) niet empirisch worden vastgesteld. In de tweede studie is getracht deze beperking te adresseren door het gebruik van panel data (i.e. data van herhaalde metingen van dezelfde variabelen bij dezelfde

personen). Deze data konden gebruikt worden om veranderingen in de afhankelijke variabele, geluidhinder van vliegtuigen, te voorspellen. De resultaten lieten zien dat, hoewel veranderingen in de modelvariabelen (i.e. geluidhinder van vliegtuigen en de niet-akoestische factoren) gecorreleerd waren, de veranderingen in geluidhinder van vliegtuigen niet verklaard konden worden door de niet-akoestische factoren gemeten op een eerder tijdstip. De gecorreleerde veranderingen toonden echter dat als iemand zich meer of minder gehinderd was gaan voelen in de periode tussen de twee metingen, dit gepaard ging met veranderingen in verwachtte richtingen op een range van niet-akoestische factoren. Dit leidde tot het idee dat geluidhinder van vliegtuigen en enkele niet-akoestische factoren reflecties vormden van een onderliggende generieke houding ten aanzien van vliegtuiggeluid. Dit idee gaf aanleiding voor de derde studie.

Studie 3: geluidhinder als een reflectie van een generieke houding

Eerder onderzoek heeft aangetoond dat mensen verschillende woorden gebruiken om hun reacties op vliegtuiggeluid te beschrijven (e.g. gerelateerd aan storingen, angst of bezorgdheid). Ondanks dat hinder de dominante indicator is om subjectieve reactie te meten, is het waarschijnlijk dat deze indicator niet de volledige reikwijdte van de emotionele reacties als gevolg van blootstelling aan geluid beslaat. Dit is vanuit een maatschappelijk oogpunt problematisch omdat maatstaven voor subjectieve reactie zoals geluidhinder (in de vorm van dosis-effect relaties) vaak aan de basis van geluidsbeleid liggen. Daar komt bij dat als geluidhinder dimensiespecifieke variantie bevat die niet gerelateerd als aan de oorzaken (i.e. geluidbelasting) of de gevolgen van geluidhinder (e.g. de algemene gezondheid), de relaties tussen deze factoren structureel onderschat zullen worden. In de derde studie wordt geluidhinder samen met twee eerder geïdentificeerde oorzaken van hinder, namelijk activiteitstoringen en gevoelens van angst/bezorgdheid, geconceptualiseerd als reflectie van een generieke attitude ten aanzien van vliegtuiggeluid. De modelstructuur is geverifieerd met data die verzameld is middels een survey onder omwonenden van de luchthaven Frankfurt. De resultaten laten zien dat in de verklaring van twee criteria, fysieke en mentale gezondheid, geluidhinder als concept slechter presteert dan de veronderstelde generieke attitude. Op basis van dit resultaat wordt de conclusie getrokken dat generieke reactiematen (e.g. ontevredenheid met geluid) meer valide indicatoren zijn dan specifieke dimensies als geluidhinder of verstoringen.

Studie 4: beleid, denkkaders en geluidhinder

De tweede studie liet zien dat veranderingen in geluidhinder en de niet-akoestische factoren gecorreleerd waren. De derde studie bevestigde dat het patroon van associaties tussen geluidhinder en enkele niet-akoestische factoren verklaard kon worden door een gedeelde onderliggende factor. In geen van beide studies was echter expliciet ingegaan op de theorie die dit patroon zou kunnen verklaren. Deze leemte kon gevuld worden met de discours resonantie theorie van Bröer (2006). Deze theorie postuleert dat beleidsargumenten resoneren onder burgers en zodoende de denkkaders[54] vormen die mensen gebruiken om vliegtuiggeluid te waarderen. De betekenissen die mensen verlenen aan vliegtuiggeluid staan centraal binnen deze theorie. Specifiek werd er verwacht dat deze betekenissen op discursieve wijze gelimiteerd worden door het nationale beleidskader. Anders gesteld, beleidsargumenten leggen sociale beperkingen op aan wat er wel en niet gezegd en gevoeld kan worden met betrekking tot vliegtuiggeluid. Omdat het concept van een denkkader kon verklaren waarom inhoudelijk ongerelateerde argumenten, overtuigingen en gevoelens empirisch gerelateerd

[54] Een denkkader is gedefinieerd als een coherent patroon van overtuigingen, houdingen en gevoelens, zoals geluidhinder.

zouden zijn, kon de discours resonantie theorie een verklaring geven voor de gedeelde factor structuur die gesuggereerd was door de tweede studie en getest in de derde. Bröer had zijn theorie met kwalitatieve onderzoeksmethoden geverifieerd. Het doel van de vierde studie was om de theorie kwantitatief te objectiveren. Met een kleine en strategisch geselecteerde steekproef werden in overeenstemming met de resultaten van Bröer drie denkkaders ten aanzien van vliegtuiggeluid gevonden die het beleidsdiscours hadden verinnerlijkt. Zoals verwacht bleek de hinderrespons binnen elk denkkader afhankelijk van de positie van ieder kader ten opzichte van het beleidsdiscours. De specifieke denkkaders die gevonden waren worden hieronder beschreven in de samenvatting van de vijfde studie.

Studie 5: beleid, structurele variabelen en geluidhinder

Door het gebruik van een strategisch geselecteerde steekproef konden de resultaten van de vierde studie niet gegeneraliseerd worden naar de populatie van omwonenden rond Schiphol. Ook kon de invloed van structurele individuele variabelen (e.g. de mate van blootstelling aan vliegtuiggeluid of de mate van geluidgevoeligheid) hierdoor niet worden onderzocht. In de vijfde studie is getracht deze resterende vragen te beantwoorden. De analyse (een latente klasse analyse) was gebaseerd op dezelfde data als de tweede studie. De resultaten waren wederom consistent met het werk van Bröer (2006) en met de vierde studie. De studie bracht drie beleidsgerichte perspectieven aan het licht die, met gebruik van de aanduidingen van Bröer, geïdentificeerd konden worden als: 'niet klagen', 'mainport en milieu' en 'Vrijstaat Schiphol'. De meerderheid van de steekproef kon geschaard worden onder één van deze drie kaders; slechts een klein deel hield er een autonoom perspectief op na.
In het meest voorkomende denkkader ('niet klagen') juichen mensen de luchtvaart toe. Omwonenden in dit perspectief benadrukken het economische belang van de luchthaven ('Schiphol is een motor van de economie') en bagatelliseren het milieuargument ('luchtvaart is een bedreiging voor het milieu'). Volgens dit perspectief zien mensen die klagen over geluid het grotere geheel niet. Dit kader gaat gepaard met een lage gemiddelde hinderrespons. Het tweede perspectief ('mainport en milieu') is kritischer dan het eerste. Dit perspectief benadrukt weliswaar ook het economische belang, maar ondersteunt tegelijkertijd het milieubelang. Mensen in dit perspectief vertrouwen er in mindere mate op dat de overheid de gestelde geluidsnormen zal handhaven en ze voelen zich in enige mate machteloos in relatie tot de gegeven situatie. Dit perspectief gaat gepaard met een gematigde gemiddelde hinderrespons. Het derde perspectief ('Vrijstaat Schiphol') is het meest kritisch over de luchtvaart. Dit kader plaatst het milieubelang boven het economische belang, maar in tegenstelling tot het 'niet klagen'-perspectief ontkent het niet expliciet het economische belang van de luchtvaart (zoals dit perspectief andersom wel het milieuargument ontkent). Consistent met het beleid is de status van het mainportargument dus minder betwist dan het milieuargument. Op eenzelfde manier als in het tweede perspectief geloven mensen in het derde perspectief dat de overheid verantwoordelijk is voor het feit dat geluid onbeheersbaar is. Schiphol gedraagt zich als vrijstaat, ongebonden door nationale regelgeving. Gemiddeld voelen mensen zich in dit perspectief meer gehinderd dan in de eerste tweede kaders, maar de gemiddelde hinderrespons is niet te duiden als extreem. Een verklaring hiervoor is dat mensen nog steeds het economische belang van de luchthaven erkennen.

Studie 6: het effect van surveycontext

De vijfde studie toonde dat argumenten en gevoelens geïntegreerd waren in coherente perspectieven ten aanzien van vliegtuiggeluid. Beleidsargumenten moeten daarom niet gezien worden als determinanten van geluidhinder binnen een oorzaak-gevolg model, maar als vormgevers van de discursieve ruimte rond het onderwerp vliegtuiggeluid. Ze beperken wat wel en wat niet gezegd kan worden met betrekking tot dit onderwerp. Andere manieren van

denken zijn daardoor uitgesloten. Zo bestaat er door de dominantie van het economische argument niet een perspectief waarin extreme hinder sociaal gerechtvaardigd wordt.
In de zesde studie wordt een veronderstelde consequentie van de discours resonantie theorie getest. Als het inderdaad zo is dat beleidsargumenten op discursieve wijze subjectiviteit vormgeven, dan kan verwacht worden dat de waardering van vliegtuiggeluid verandert als deze wordt geëvalueerd in een andere context dan de 'natuurlijke' (beleid gerelateerde) context. Zo is een veel gebruikte context in surveys over vliegtuiggeluid één waarbij geluidhinder van vliegtuigen wordt gemeten naast andere bronnen van geluid, zoals autoverkeer en buren. De verwachting was dat als mensen geconfronteerd zouden worden met geluidsbronnen waarvan een aantal (nagenoeg) niet hoorbaar zouden zijn, het vliegtuiggeluid (als dominante geluidsbron) als hinderlijker zou worden gewaardeerd dan wanneer geluidhinder van vliegtuigen zonder context wordt gemeten. Met andere woorden, gegeven de context van de andere geluidsbronnen, was de verwachting dat mensen zich gelegitimeerd zouden voelen om een meer extreme hinderscore te rapporteren dan in de natuurlijke context, waarin de dominantie van het economische argument voor een meer gematigde hinderrespons zorgt. Data om deze verwachting te toetsen was verzameld in een survey onder burgers die woonachtig zijn in Amsterdam Buitenveldert.
In lijn met de verwachting lieten de resultaten zien dat de hinderreactie inderdaad afhankelijk is van de context waarin de hindervraag wordt gesteld. Ook de betekenis die mensen aan het concept geluidhinder van vliegtuigen verleenden varieerde met de context. Wanneer geluidhinder van vliegtuigen in relatie tot andere geluidbronnen werd gemeten was het percentage ernstig gehinderden[55] meer dan twee keer zo hoog als wanneer geluidhinder op zichzelf was gemeten; het percentage lag op 43% in de experimentele conditie en op 17% in de controle conditie. Daarnaast bleek dat geluidhinder van vliegtuigen in de context van meerdere geluidsbronnen sterker gerelateerd was aan de geluidgevoeligheid van mensen dan wanneer geluidhinder in isolatie was gemeten. Andere hypothesen met betrekking tot de correlaties tussen geluidhinder van vliegtuigen en de gemeten schalen konden echter niet bevestigd worden.

Studie 7: vliegtuiggeluid en woontevredenheid

Als geluidhinder van vliegtuigen (gedeeltelijk) een politieke houding vertegenwoordigt (zoals verondersteld door de discours resonantie theorie), zou verwacht kunnen worden dat het minder sterk wordt gezien als een negatief aspect van de woonomgeving, en daarom minder sterk gerelateerd is aan woontevredenheid dan hinder van andere bronnen (zoals wegverkeer of de buren). Dit idee was getest in de zevende studie, die tot doel had om de relatieve sterktes van de relaties tussen geluidbelasting van vliegtuigen, geluidhinder van vliegtuigen en woontevredenheid te toetsen. Een model dat zowel objectieve achtergrondvariabelen en subjectieve evaluaties van andere geluidsbronnen bevatte was geschat aan de hand van data die in 1996/7 was verzameld door TNO en het RIVM onder omwonenden van Schiphol (TNO en RIVM, 1998). De relatief zwakke relatie tussen geluidhinder van vliegtuigen en woontevredenheid suggereerde inderdaad dat geluidhinder van vliegtuigen meer als politieke houding/frustratie werd gezien dan als negatief aspect van de woonomgeving. De studie liet echter zien dat een sterk direct effect tussen geluidbelasting van vliegtuigen en woontevredenheid bleef bestaan na controle voor de geluidhinder van vliegtuigen, hetgeen suggereert dat er andere mediërende variabelen aanwezig zijn.

[55] Gedefinieerd als iemand die minimaal een 8 scoort op een schaal van 0 (helemaal niet gehinderd) tot 10 (extreem gehinderd).

Studie 8: de reactie van beleidsactoren op 'niet-akoestische factoren'

De laatste studie legt bloot welke perspectieven beleidsactoren rond Schiphol hebben op de toekomst van geluidbeleid, waarbij tevens is gekeken naar hun positie ten opzichte van de huidige inzichten in niet-akoestische factoren als ook hun waardering van Stallen's voorstel voor een zogenaamd regionaal transactie model (Stallen et al., 2004). [56] De bevindingen tonen dat de twee grootste perspectieven tegenovergestelde visies hebben: de eerste pleit voor verdere groei van de luchthaven terwijl de tweede hamert op harde en handhaafbare geluidsnormen. Binnen deze perspectieven wordt het inzicht in de niet-akoestische determinanten van geluidhinder op instrumentele wijze geïnterpreteerd en gebruikt om de originele posities te versterken. Volgens het groeiperspectief bevestigen de 'niet-akoestische factoren' dat Nederlanders, in vergelijking met andere Europeanen, om de één of andere reden meer (politiek) gevoelig zijn voor geluid. Omdat de Nederlandse luchtvaartindustrie relatief goed presteert in termen van de objectieve geluidsniveaus rond Schiphol wordt de hoge hinderrespons weggeschoven als irrationeel. Voor actoren in het milieuperspectief bewijst het 'zogenaamde' inzicht in niet-akoestische factoren echter dat de overheid en de luchtvaartsector uitwegen zoeken om daadwerkelijk wat aan het geluid te doen. Zij pleiten voor harde normen om vliegtuiggeluid te beheersen en doen alles wat met niet-akoestische factoren te maken heeft af als slim perceptiemanagement. Er kan geconcludeerd worden dat hoewel Stallen's nadruk op niet-akoestische factoren en zijn voorstel voor een regionaal transactiemodel bedoeld waren om de onproductieve spanning tussen de collectieve claims van groei en geluid op te lossen, zij juist onderdeel zijn geworden van de controverse en deze hebben versterkt. Geleid door de instrumentele interpretaties konden de beleidsactoren de inzichten niet op hun eigen waarde beoordelen. De centralistische oriëntatie van het Schipholbeleid bleek daardoor zelfversterkend.

Bijdragen van deze dissertatie

Samengevat kunnen er twee theoretische, twee methodologische en twee praktische (beleidsgerelateerde) bijdragen van het proefschrift worden geïdentificeerd.

Theoretisch

De eerste theoretische bijdrage van deze dissertatie is dat twee theorieën van geluidhinder kwantitatief zijn getest. Het formaliseren van deze theorieën in modellen heeft geleid tot een beter inzicht in de aard van geluidhinder van vliegtuigen. In overeenstemming met de discours resonantie theorie wordt deze structuur beïnvloed door de wijze waarop beleidsmakers omgaan met het geluidsprobleem. Beleidsargumenten vormen de subjectiviteit ten aanzien van vliegtuiggeluid. Binnen de gecreëerde discursieve ruimte zijn er slechts drie perspectieven sociaal levensvatbaar. De meerderheid van de omwonenden rond Schiphol gebruikt één van deze perspectieven om betekenis te geven aan vliegtuiggeluid.
De tweede inhoudelijke bijdrage is dat het onderzoek heeft laten zien hoe persoonlijke kenmerken, zoals de geluidgevoeligheid, geluidhinder indirect kunnen beïnvloeden via het lidmaatschap van de denkkaders. In vergelijking tot eerdere verklaringsmodellen voor geluidhinder verschaft deze conceptualisatie meer inzicht in de wijze waarop sociale en persoonlijke factoren de subjectieve reactie op geluid daadwerkelijk beïnvloeden. Sociale

[56] Volgens Stallen et al. (2004) moet er ruimte zijn voor locale actoren om meerdere individuele belangen te formuleren in plaats van de nu tegenovergestelde collectieve belangen van groei versus minder geluid. Als belangen op lokaal niveau geformuleerd zijn kunnen deze (bindend) tegen elkaar uitgewisseld worden. Om deze transacties te ondersteunen pleiten Stallen et al. (2004) voor een regionale institutie met een administratief mandaat. Ze gebruiken de term regionaal transactie model om dit arrangement te duiden.

factoren (argumenten/houdingen) 'veroorzaken' niet direct geluidhinder, maar opereren discursief; ze bepalen de grenzen van wat wel en wat niet gedacht en gevoeld kan worden in een bepaalde situatie, hetgeen resulteert in slechts een aantal intern consistente en sociaal aanvaardbare posities. Van persoonlijke factoren, zoals de persoonlijkheid, kan wel gesteld worden dat deze opereren binnen een traditioneel oorzaak-gevolg model. Zij bepalen (gedeeltelijk) in welke van de sociaal geaccepteerde perspectieven iemand terecht komt.

Methodologisch

De eerste methodologische bijdrage is dat het onderzoek heeft geïllustreerd hoe met behulp van geavanceerde statistische technieken een post-positivistische traditie op een kwantitatieve wijze geoperationaliseerd kan worden, hetgeen een gemeenplaats is binnen het relatief gesloten netwerk rond de Q-methode, maar nog niet wijdverbreid binnen de sociale wetenschappen. Waar eerdere vergelijkingen tussen positivistische en post-positivistische tradities in het algemeen hebben geleid tot het contrasteren van kwantitatieve met kwalitatieve methoden, kunnen beide tradities dus kwantitatief worden vormgegeven.
De tweede methodologische bijdrage ligt in de toepassing van latente klasse analyse om de resultaten van een Q-studie te generaliseren naar een populatie van mensen. Hierdoor ontstaan inzichten met betrekking tot de verdeling van de perspectieven in de populatie en hoe deze verdeling afhankelijk is van structurele variabelen die gerelateerd zijn aan het individu. Een latente klasse model kan dus twee vormen van generalisatie ondersteunen: de generalisatie naar de populatie van mensen en de generalisatie naar de populatie van perspectieven. De methode kan als zodanig een bijdrage leveren aan een toename in het gebruik van post-positivistische kwantitatieve technieken binnen de sociale wetenschappen.

Praktisch

De eerste praktische bijdrage van deze dissertatie is gerelateerd aan het meten van geluidhinder in vragenlijstonderzoek. Het huidige onderzoek heeft laten zien dat de surveycontext een sterke invloed kan hebben op de geobserveerde verdeling van geluidhinder van vliegtuigen. Geaggregeerde schattingen van het aantal ernstig gehinderden kunnen daarom sterk uiteenlopen afhankelijk van de specifieke context die gebruikt is om geluidhinder te meten. Verschillende methodes leiden tot uiteenlopende beleidsimplicaties. Op basis van dit gegeven kan gesteld worden dat het onwenselijk is om de huidige dosis-respons modellen als basis te laten dienen voor het geluidsbeleid, zoals nu het geval is.
De tweede praktische bijdrage is gerelateerd aan het inzicht dat omwonenden van Schiphol geluidhinder relateren aan de falende collectieve controle op geluid. Om geluidhinder te verminderen is het noodzakelijk dat het vertrouwen in deze collectieve controle hersteld wordt. Door de wettelijke basis van het Schipholbeleid te wijzigen kan hier een bijdrage aan worden geleverd. Het feit dat eerdere overschrijdingen van de geluidsnormen in het parlement worden besproken en niet in een rechtszaal reflecteert de gebrekkige wettelijke bescherming van burgers inzake Schiphol. Het verbeteren van de rechtsbescherming zal waarschijnlijk bijdragen aan een verbeterde (perceptie van) collectieve controle en daardoor de (geaggregeerde) hinder kunnen verminderen.

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