INTER-NOISE 2007
28-31 AUGUST 2007
ISTANBUL, TURKEY

Noise annoyance around an international airport planned to be extended

Dirk Schreckenberg[a] and Markus Meis[b]
[a] ZEUS GmbH
Centre for Applied Psychology, Environmental and Social Research
Sennbrink 46, D-58093 Hagen
[b] Hoerzentrum Oldenburg GmbH
Marie-Curie-Str. 2, D-26129 Oldenburg
GERMANY

ABSTRACT

A large field study with 2312 residents from 66 areas around Frankfurt Airport was performed in 2005 in order to investigate the effects of aircraft noise on annoyance and health-related quality of life. The survey was carried out in a period between the announcement and the planned implementation of an airport extension (construction of a new runway). The results show among others a shift in noise annoyance in comparison to dose-response curves generated from meta-analyses including older studies. In addition to noise exposure non-acoustical factors like attitudes towards the noise source, expectations concerning future residential situation after airport extension and (dis-)trust in authorities had a substantial influence on noise annoyance.

1 INTRODUCTION

Aircraft noise is well known as an environmental stressor leading to disturbances of communication, concentration, recreation and sleep among residents living around an airport. However, noise reactions like annoyance or disturbances as well as self-reported health effects are only partly explained by the noise exposure itself. It is clear from numerous studies that non-acoustical factors affect noise reactions, too [1][2][3].

Several studies report evidence of an overreaction in noise annoyance when the noise environment changes (see [4][5][6] for an overview). Attitudes towards the source, authorities, and expectations regarding future residential situation after the change of noise exposure seem to play a significant role for the change in noise reactions even before the change occurs [7][8][9][10].

According to Guski [11] who distinguishes between social and personal co-determinants of noise annoyance the attitudes and expectations belong to the category of social co-determinants. Whereas personal factors like noise sensitivity and coping capacity are linked to the person and quite stable over time, social factors are linked to the situation and shared between individuals, [11] p. 47. Thus, social co-determinants of noise annoyance could be used by noise management authorities to reduce annoyance, in particular in situations where changes in operations of the source lead to changes in noise exposure and residential quality of life for the residents.

[a] Email address: schreckenberg@zeusgmbh.de
[b] Email address: m.meis@hoerzentrum-oldenburg.de

The study presented in this paper aims at analysing the dose-response relationship of aircraft noise annoyance of residents around an international airport in a situation between the announcement and the planned implementation of the extension of the airport. Furthermore the effect of several personal and social non-acoustical factors on noise annoyance were analysed in order to assess the different strength of association with annoyance in the dynamic situation of the planning phase of the airport extension.

2 METHOD

A field study consisting of two parts was conducted in 66 residential areas within a radius of up to 40 km around Frankfurt International Airport [12]. The data were collected from April to December 2005. The study was carried out in a period after a mediation process concerned with the planning of the airport extension (construction of a 4^{th} runway, new terminal and A380 dockyard) had been completed (1998 – 2000). As a result of the mediation process a round table (Regional Dialogue Forum Frankfurt Airport; RDF) was established for continuing information on and discussion about the development of the airport. Members of the round table are representatives of action groups, local authorities, a trade union, churches, regional industry and aviation industry. The field study on aircraft noise effects was commissioned by RDF to get detailed background information for further discussions and recommendations.

In the first part of the study face-to-face interviews on 'long-term' noise annoyance (in the last 12 month) due to several sources, residential situation, environmental and health-related quality of life were conducted with 2312 residents (55% female; 17-93 y, mean age: 53 y). In addition to the mentioned dimensions attitudes towards the source and authorities, sensitivity to environment stressors (noise, odour) and demographic variables were ascertained. All variables included in the questionnaire are approved items taken from previous noise effect studies (e.g. [13][14][15][16]) and standardised scales (e.g. quality of life: SF-36 [17], sleep quality: Pittsburgh Sleep Quality Index (PSQI) [18][19], health complaints: 'Giessener Beschwerdebogen' [20]).

Residents were sampled by random in selected areas (stratified random sample; criteria for area selection: aircraft noise contours, wide comparability with regard to the socio-economic status and structure of building between areas exposed to different noise contours). For sampling address data were provided by local registry offices.

In the second part of the field study (August – November 2005) a subsample of 200 persons assessed every hour from 7am to 11pm the more 'short-term' annoyance (in the last hour) due to aircraft noise, location, activity and window position on four consecutive days (2 weekdays, weekend) by means of a handheld computer (experience sampling study). In addition, the participants of this study part filled in subsidiary questionnaires every morning and evening, answering items on sleep and course of daily events.

For each address individual aircraft noise levels were calculated on the base of flight movements of the 6 busiest months of the year 2005 according to the German regulation for aircraft noise calculation ('AzB'). In addition, noise parameters for participants of the second study were calculated on the base of the flyovers per hour on the specific days under study.

Analyses and results presented in this paper refer to the first study part, the interview study with 2312 residents.

3 RESULTS

3.1 Dose-response relationship between aircraft noise exposure and annoyance

As Table 1 indicates judgements on aircraft noise annoyance assessed with the verbal 5-point and the numerical 11-point scale according to the recommendations of the International Commission on Biological Effects of Noise (ICBEN; [21]) are associated with aircraft noise exposure. The equivalent noise levels shows the strongest correlation with annoyance followed by mean maximum noise levels and parameters of the number of events above a defined threshold.

Table 1: Correlation between noise annoyance due to aircraft noise and parameters of aircraft noise exposure
n = number; r = correlation coefficient; p = p-value

Parameters of aircraft noise exposure			Aircraft noise annoyance (ICBEN 5point)	Aircraft noise annoyance (ICBEN 11point)
	equivalent noise level			
L_{den} 7h-19h-23h	Day-evening-night level	r	.433	.426
	day: 7am-7pm; evening 7pm-	p	.000	.000
	11pm; night: 11pm-7am	n	2308	2272
L_{tan} 6h-18h-22h	Day-evening-night level	r	.428	.418
	day: 6am-6pm; evening 6pm-	p	.000	.000
	10pm; night: 10pm-6am	n	2308	2272
L_{dn}	Day-night level	r	.418	.411
		p	.000	.000
		n	2308	2272
	maximum noise level			
$L_{max55, 24h}$	Mean maximum noise level	r	.392	.360
	above 55 dB(A) in 24h	p	.000	.000
		n	2308	2272
$L_{max70, 24h}$	Mean maximum noise level	r	.338	.292
	above 70 dB(A) in 24h	p	.000	.000
		n	2308	2272
	number of events above threshold			
$NAT_{55, 24h}$	Number above threshold	r	.332	.343
	55 dB(A) in 24h	p	.000	.000
		n	2308	2272
$NAT_{70, 24h}$	Number above threshold	r	.335	.335
	70 dB(A) in 24h	p	.000	.000
		n	2308	2272

Figure 1 shows the percentage of highly annoyed (left) and annoyed (right) persons due to aircraft noise by noise level expressed in L_{den}. %HA is defined as the percentage of persons responding an annoyance score above a cut-off of 72% of the annoyance scale. For this the annoyance judgements assessed with the ICBEN 5-point and 11-point annoyance scale were transferred to a scale from 0 – 100 points [22].

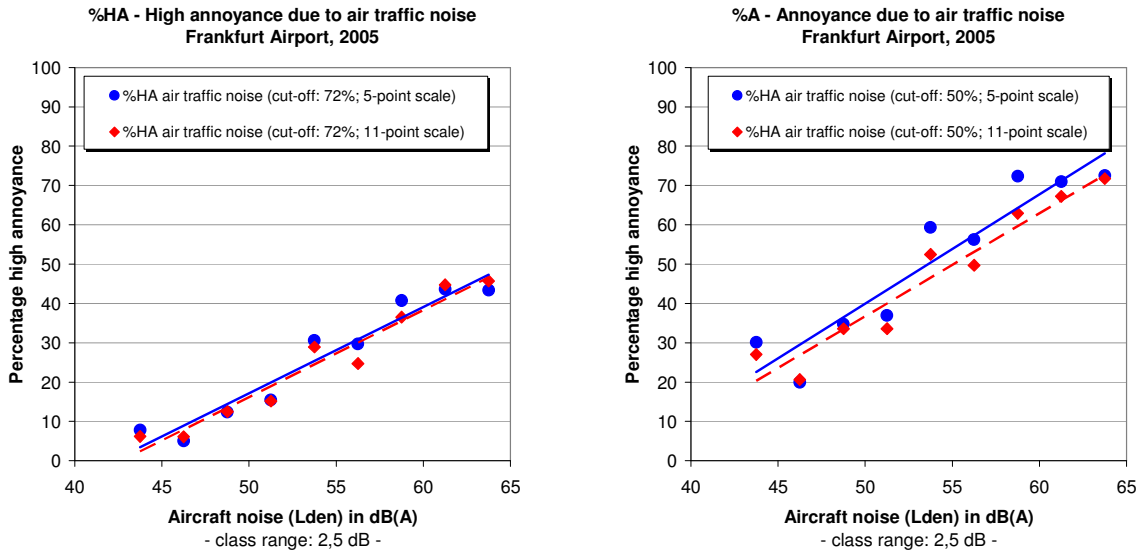

Figure 1: High annoyance (left) and annoyance (right) due to aircraft noise by L_{den} noise level.
A cut-off point of 72% of the response scale was used to define person as being highly annoyed.

As can be seen from Figure 1 already moderate noise levels lead to severe noise annoyance due to aircraft noise. For example, above L_{den} = 55 dB(A) at least 50% of the residents are annoyed, 30% highly annoyed. The dose-response curves are well above the generalised curves revealed from the meta-analysis of Miedema and Oudshoorn and published in the EU position paper on noise annoyance ([23][24]], see red curve in Figure 2). The EU-curve, however, refers to data collected from 1965 – 1992; the mean age of studies included in the generalized curve is 29 years (in 2007). Figure 2 suggests that the annoyance data of the Frankfurt Noise Annoyance Study are in line with several other recently published European studies, in particular with data from Schiphol Airport, Amsterdam.

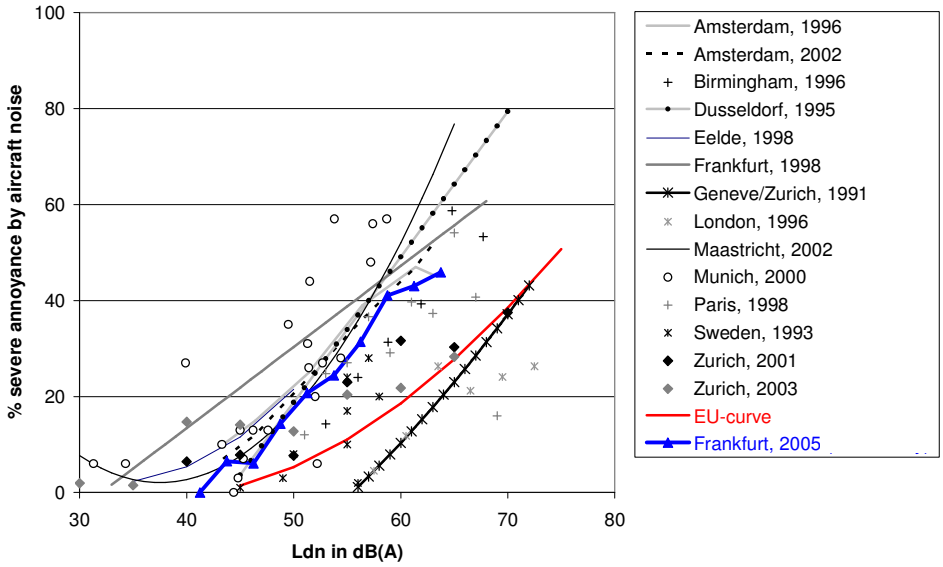

Figure 2: Dose-response data for severe aircraft noise annoyance from several surveys using a cut-off point of 70 – 75% of response scale for definition of high annoyance (HA)

Source: van Kempen, und van Kamp (2005, p. 25, Fig 3b, [25]) – modified and supplemented; EU-curve: generalised dose-response curve for aircraft noise annoyance ([23] [24]). Source of the data of Zurich 2001/2003: Brink et al. (2005, [26]). Blue line and dots: data of the Frankfurt Noise Annoyance Study presented in this paper. References of all the other studies: see [25].

3.2 Impact of non-acoustical factors on aircraft noise annoyance

Most of the socio-demographic variables investigated were found to be not or marginally related to annoyance due to aircraft noise. A weak non-linear relation was found between age and aircraft noise annoyance in the sense that residents between 40 – 60 y were more annoyed than younger and older residents. Although statistical significant (ANOVA: $F_{[2,2281]} = 13{,}261$, $p < .001$) the effect size is rather small ($\eta_p^2 = 0{,}012$). Education, profession and household income was summarised to an index representing the socio-economic status ('Scheuch-Winkler Index', [27]). This index was associated with aircraft noise annoyance, indicating that interviewees with higher socio-economic status tended to be more annoyed by aircraft noise than interviewees with lower socio-economic status (ANOVA: $F_{[2,2138]} = 7{,}768$, $p < .001$). Again, the effect size is rather small ($\eta_p^2 = 0{,}007$). Somewhat higher but still weak effect on aircraft noise annoyance was found for the variable 'house ownership' (homeowner/tenant; $\eta_p^2 = 0{,}025$; $F_{[1,2138]} = 53{,}734$, $p < .001$). That is, house owners reported somewhat higher aircraft noise annoyance than tenants.

Besides further reactions on aircraft noise like disturbances of activities, coping with noise in the noise situation and long-term activities against noise, which are not considered in this paper, several non-acoustical factors known to co-determine or to moderate variations in noise annoyance were assessed in the questionnaires. A factor analysis (principle components analysis with varimax rotation) was done in order to achieve less intercorrelated factors and therewith a decrease of the problem of multicollinearity in further regression analyses. The factor analysis revealed 6 factors explaining 67% of variance (see Table 2).

Table 2: Resulting factors of a factor analysis (principle component analysis with varimax rotation) of non-acoustic variables, potentially associated with noise annoyance

Factor	Description
Fears / negative attitudes towards air traffic	Fears of airplane crash, aircraft-related nuisance (other than noise), distrust in authorities, negative expectations concerning residential situation after airport extension
Sensitivity to environmental stressors	Noise sensitivity, odour sensitivity
Self-reported diseases (health complaints)	Complaints about exhaustion, stomachache, rheumatic pain, cardiac pain, morbidity, sleep quality (PSQI)
Residential satisfaction	Satisfaction with dwelling, residential area, infrastructure
Positive attitudes towards regional development	Positive expectations concerning regional development after airport extension: improvement of services at the airport, tourism industry and quality of life
Quality of life	Vitality (SF-36), mental health (SF-36), life satisfaction

To quantify the association between these 6 factors, noise level and aircraft noise annoyance multiple regression analysis was done with annoyance assessed on the 5-point scale as the criterion. Results are shown in Table 3.

Table 3: Results of multiple regression analysis with aircraft noise annoyance (assessed on ICBEN 5-point scale) as the criterion and noise level and several non-acoustical factors as predictors

Parameters	B	SE	Beta	T	p
Intercept	3,09	0,02		159,06	0,000
Fears / negative attitudes air traffic	0,64	0,02	0,49	30,86	0,000
Sensitivity to environmental stressors	0,43	0,02	0,33	21,60	0,000
Noise level (L_{den}) (averaged over 6 month)	0,37	0,02	0,28	17,43	0,000
Self-reported diseases (health complaints)	0,22	0,02	0,16	11,07	0,000
Residential satisfaction	-0,21	0,02	-0,16	-10,01	0,000
House ownership	0,10	0,02	0,08	4,63	0,000
Socio-economic status	0,10	0,02	0,07	4,56	0,000
Positive attitudes towards reg. development	0,04	0,02	0,03	2,02	0,043
Quality of life	0,00	0,02	0,00	0,10	0,920

$R^2 = .59$

Table 3 shows that regression coefficients for (negative) attitudes towards the source and persons/institutions seen as responsible for the noise exposure as well as sensitivity to environmental stressors (noise, odour) are higher than for noise level. Other non-acoustical factors like health complaints (the more complaints, the more annoyed), residential satisfaction (the less satisfied, the more annoyed), house ownership (owner more annoyed than tenants) and socio-economic status (the higher the status, the more annoyed) contribute to the prediction of noise annoyance. Positive attitudes towards the regional development after airport extension and quality of life fail as significant predictors of noise annoyance on the 1%-level of significance, although the positive attitudes contribute marginal and in tendency ($p < .05$) to the prediction of noise annoyance.

To get a deeper inside in which extend the different parts of positive and negative attitudes concerning aircraft in general and, in particular, the airport extension are associated with aircraft noise annoyance, a second multiple regression with noise annoyance as criterion and the different aspects of aircraft/airport-related attitudes as predictors was done. A preceeding factor analysis revealed five factors of attitudes explaining 62% of variance. The factors are

1. 'fears/aircraft-related nuisance';
2. 'negative expectation regarding residential situation after airport extension';
3. 'positive expectation regarding future regional situation after airport extension';
4. 'trust in aviation industry' (airport, airlines, aircraft manufacturer);
5. 'trust in administration, regional/local authorities' (municipality, government of the state Hesse, commissioner for aircraft noise protection, RDF).

Table 4: Results of multiple regression analysis with aircraft noise annoyance (assessed on ICBEN 5-point scale) as the criterion and noise level and aspects of aircraft/airport-related attitudes as predictors

Parameters	B	SE	Beta	T	p
Intercept	2,98	0,03		95,31	0,00
Fears / aircraft-related nuisance	0,77	0,03	0,61	23,40	0,00
Negative expectation regarding future after airport extension	0,42	0,03	0,34	13,36	0,00
Trust in aviation industry	-0,31	0,03	-0,25	-9,87	0,00
Positive expectation regarding future after airport extension	-0,20	0,03	-0,16	-6,42	0,00
Noise level (L_{den})	0,18	0,03	0,15	5,45	0,00
Trust in administration, local/regional authorities	0,05	0,03	0,04	1,43	0,15

$R^2 = .65$

The results of the second multiple regression (Table 4) show that actual perceived and anticipated future aircraft-related nuisance are associated with actual noise annoyance ('actual' in the sense of 'before airport extension'). Furthermore the factors 'trust in aviation industry' and 'positive expectation regarding the future in regional development after airport extension' are associated with noise annoyance, i.e. the less a person trust in the aviation industry and expects a positive development due to airport extension, the more she/he is annoyed by aircraft noise. In sum these aspects contribute more to the prediction of noise annoyance than the noise level. Only 'trust in administration, local/regional authorities' fails to contribute significantly to the prediction of annoyance.

Correlation analyses between noise level and the attitudes show that noise level (L_{den}) is correlated with fears/aircraft-related nuisance (r = .29) and less strong with trust in authorities (r = -.19).

4 CONCLUSION

It was shown that already moderate aircraft noise levels lead to severe annoyance due to aircraft noise. The mean difference between the percentage of high annoyance revealed in the presented Frankfurt Noise Annoyance Study and the dose-response-curve published in the EU position paper [23] is according to visual inspection of the curves equivalent to a difference of about 10 dB. A main argument for this difference is that the generalised EU-curve include old study data (mean age of study data in 2007: 29 years) and that an increase in annoyance due to aircraft noise over time could be observed [25][28]. Therefore, an update of the generalised curve is recommended.

Van Kempen and van Kamp [25] discuss several factors affecting differences in dose-response relationships like study location, willingness to participate in surveys, change in aircraft noise in the last decades (decrease in maximum noise level, increase in number of events) and non-stable situation around the airport investigated because of (planned) changes in noise situation ('overreaction').

As the Frankfurt Noise Annoyance Study was carried out in a situation before implementation of the planned airport extension, the discourse on this issue in the region around the airport may have an influence on the actual noise annoyance. This assumption is supported by the findings of the presented study on the strong impact of not only aircraft-related attitudes in general but also the expections regarding future situation on actual aircraft noise annoyance before change of noise exposure. This is in line with similar results on aircraft noise effects (e.g. Sidney Airport [7][8]) but also with findings regarding other noise

sources (e.g. for residents living at planned (new) and extended railway lines before these lines were built and extended, [9][10]).

According to Guski [11] (social) attitudes towards the source, trust in source authorities and expectations of residents can be defined as social co-determinants of annoyance. The results of our study suggest that among the non-acoustical co-determinants the social factors play a major role for predicting noise annoyance at least in situations between announcement and implementation of changes in noise exposure due to an airport extension.

The findings provide evidence that an enrichment of noise management with procedures considering the social issues as proposed by Maris et al. [29][30] and Stallen [31] may be able to decrease noise annoyance. This seems to be particularly important in the dynamic long-term planning procedure as it is the case for the planning of an airport extension.

Some limitations of the results have to be considered. Note, that the definition of predictors as done in the regression analyses described above cannot be interpreted in the sense of causality and the direction of the found associations with noise annoyance. For example, as the factor 'fears/negative attitudes' as well as residential satisfaction are (in contrast to the other predictors of the first regression analysis) correlated with noise level L_{den} ($r = .30$ and $r = -.26$, respectively) this may indicate that the attitudes and residential satisfaction partly mediates noise exposure–annoyance relation, that noise annoyance mediates the relation between noise exposure and fear/negative attitudes towards air traffic and residential satisfaction, respectively, or that annoyance and attitudes/residential satisfaction are reciprocal related. Therefore, the multiple regression analysis is as a method to analyse the relation between environmental conditions (noise exposure), intervening variables and reactions on the environment (noise reaction) not sufficient. Further analysis methods such as the structural equitation model will be applicated to the data of the Frankfurt Noise Annoyance Study.

Nevertheless, the results of the regression analysis presented in this paper indicate that among the non-acoustical factors aircraft-related attitudes are stronger associated with noise annoyance than personal factors concerning the vulnerability of individuals (sensitivity, self-reported diseases) demographic aspects and that in sum the non-acoustical factors contribute more to the prediction of noise annoyance than the noise exposure.

5 ACKNOWLEDGEMENT

The Frankfurt Noise Annoyance Study was carried out on behalf of IFOK GmbH, Bensheim, Germany, in the framework of the Regional Dialogue Forum Frankfurt Airport. The authors like to thank Kurt Mueller for noise calculations, Frank Faulbaum and Lars Ninke and their team for the management of the interview work, Ute Felscher-Suhr, Cara Kahl, Christine Peschel and Henk Vos as well as Fraport AG and the municipalities around Frankfurt Airport for assistance and Martin van den Berg, Monika Bullinger, Barbara Griefahn, Rainer Guski, Henk M.E. Miedema, Alexander Samel, August Schick, Rudolf Schuemer, H.-Erich Wichmann for valuable scientific advice and quality assurance.

6 REFERENCES

[1] J. M. Fields, "Effect of personal and situational variables on noise annoyance in residential areas." Journal of the Acoustical Society of America, 93(5), 2753-2763 (1993).

[2] R. F. S. Job, R."Community response to noise: A review of factors influeincing the relationship between noise exposure and reaction", of the Acoustical Society of America, 83(3) 991-1001 (1988).

[3] H. M. E. Miedema, H. Vos, Demographic and attitudinal factors that modify annoyance from transportation noise. Journal of the Acoustical Society of America 105(6), 3336-3344 (1999).

[4] J. M. Fields, G. E. Ehrlich, P. Zador, *Theory and design tools for studies of reactions to abrupt changes in noise exposure* (NASA / CR-2000-210280, Hampton, VA, 2000).

[5] R. D. Horonjeff, W. E. Robert, *Attitudinal responses to changes in noise exposure in residential communities* (NASA CR-97-205813, Hampton, VA, 1997).

[6] R. Schuemer, D. Schreckenberg. "Änderung der Lärmbelästigung bei Maßnahme bedingter, stufenweise veränderter Geräuschbelastung," Zeitschrift für Lärmbekämpfung, **47**, 134-143.

[7] R. F. S. Job, A. Topple, N. L. Carter, P. Peploe, R. Taylor, S. Morell, "Public reactions to changes in noise levels around Sydney Airport", *Proceedings of INTER-NOISE 96,* Liverpool*,* UK, 30 July–2 August 1996 Vol. 5, pp. 2419-2424, 1996.

[8] J. Hatfield, , R. F. S. Job, N. L. Carter, P. Peploe, R. Taylor, S. Morell, "Attitude-mediated reaction to noise influences physiological responses: evidence supporting causality," *Proceedings of INTER-NOISE 98,* Christchurch, New Zealand, 16-18 November 1998.

[9] U. Moehler, R. Schuemer, (Eds), *Veränderung in der Lärmwirkung an Neu- und Ausbaustrecken der Eisenbahn*, (SGS, München, 1999).

[10] D. Schreckenberg, Dirk R. Schuemer, U. Moehler, Railway-noise annoyance and 'misfeasance' under conditions of change. *Proceedings of INTER-NOISE 01,* The Hague, 27-30 August, 2001**.**

[11] R. Guski, "Personal and social variables as co-determinants of noise annoyance," Noise & Health, **3**, 45-56 (1999).

[12] Schreckenberg D & Meis M (2006). *Effects of Aircraft Noise on Noise Annoyance and Quality of Life around Frankfurt Airport*. Final abbridged report. ZEUS GmbH, Bochum . Retrieved May 20th 2007, http://www.verkehrslaermwirkung.de.

[13] Deutsche Forschungsgemeinschaft (DFG), Fluglärmwirkungen – eine interdisziplinäre Untersuchung über die Auswirkung des Fluglärms auf den Menschen (Boldt, Bonn, 1974).

[14] H.-O. Finke, R. Guski, B. Rohrmann, *Betroffenheit einer Stadt durch Lärm,* Bericht über eine interdisziplinäre Untersuchung, Projekt BSL, Band 1: Gesamtkonzept und Hauptuntersuchung, Umweltbundesamt, Forschungsbericht 80-10501301, (Physikalisch-Technische Bundesanstalt, Braunschweig, 1980).

[15] B. Griefahn, U. Möhler, R. Schuemer (Eds.), *Vergleichende Untersuchung über die Lärmwirkung bei Straßen- und Schienenverkehr,* (SGS, München, 1999).

[16] D. Schreckenberg, R. Guski, *Lärmbelästigung durch Straßen- und Schienenverkehr in Abhängigkeit von der Tageszeit*, Schlussbericht zur Einzelaufgabe 2131 im BMBF-Forschungsnetzwerkes „Leiser Verkehr", ZEUS GmbH, Bochum (2004).

[17] M. Bullinger, I. Kirchberger, SF-36 Fragebogen zum Gesundheitszustand – Manual (Hogrefe, Göttingen, 1998).

[18] D. J. Buysse, C. F. Reynolds, T. H. Monk, S. R. Berman, D. J. Kupfer, "The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research," Psychiatry Research, 28, 193-213 (1989).
[19] J. Backhaus, T. Niemann, F. Hohagen, D. Riemann, K. Junghanns, "Test-retest reliablity of the Pittsburgh Sleep Quality Index (= PSQI) in patients with primary insomnia," World J Biol Psychiatry 2, 374 (2001).
[20] E. Brähler, J. Schumacher, J. W. Scheer, Der Gießener Beschwerdebogen (GBB-24) (Hogrefe, Göttingen, 2004).
[21] J. M. Fields, R. G. DeJong, T. Gjestland, I. H. Flindell, R. F. S. Job, S. Kurra, P. Lercher, M. Vallet, R. Guski, U. Felscher-Suhr, R. Schuemer, "Standardized general-purpose noise reaction questions for community noise surveys: Research and a recommendation," Journal of Sound and Vibration, **242**(4), 641-679 (2001).
[22] H. M. E. Miedema, H. Vos, "Exposure-response relationships for transportation noise," Journal of the Acoustical Society of America, 104, 6, 3432-3445 (1998).
[23] EC/WG2 – Dose/Effect, *Position paper on dose response relationships between transportation noise and annoyance*. (2002). Retrieved May 20th 2007, http://ec.europa.eu/environment/noise/ pdf/noise_expert_network.pdf.
[24] H. M. E. Miedema, C. G. M. Oudshoorn, "Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals," Environmental Health Perspectives, **109**, 409-416 (2001).
[25] E. E. M. M van Kempen, I. van Kamp, *Annoyance from air traffic noise. Possible trends in exposure-response relationships*, Report Nr. 01/2005 MGO Evk, (RIVM, Builthoven, 2005).
[26] M. Brink, K. Wirth, Ch. Schierz, *Lärmstudie 2000: Dosiswirkungskurven zur Belästigung durch Fluglärm im Umfeld des Flughafens Zürich (elektronische Daten),* ETH Zürich, Zentrum für Organisations- und Arbeitswissenschaften, (2007). Retrieved May 20th 2007, http://www.laerm2000.ethz.ch/files/LS2000_DW-Kurven.zip.
[27] J. Winkler, "Die Messung des sozialen Status mit Hilfe eines Index in den Gesundheitssurveys der DHP," in *RKI-Schriften, Messung soziodemographischer Merkmale in der Epidemiologie, 1/1998,* (MMV Medizin Verlag, München, 1998).
[28] R. Guski, "How to forecast community annoyance in planning noisy facilities," Noise and Health, **6**(22), 59-64. (2004).
[29] E. Maris, P. J. M. Stallen, H. Steensma, R. Vermunt (2006). "(Un-)Sound management. Three laboratory experiments on the effect of social nonacoustical determinants of noise annoyance," *Proceedings of INTER-NOISE 06*, Honolulu, USA, 3-6 December, 2006.
[30] E. Maris, P. J. M. Stallen, R. Vermunt, H. Steensma, Noise within the social context: Annoyance reduction through fair procedures, Journal of the Acoustical Society of America, **121**(4), 2000-2010 (2006).
[31] P. J. M. Stallen, "A theoretical framework for environmental noise annoyance", Noise & Health, **3**(2), 69-79 (1999).

7 ADDITIONAL REMARKS (05. NOVEMBER 2007)

After submitting this paper for Inter-Noise additional path analyses including noise level, attitudes and noise annoyance (variables listed in Table 4) were done. The following path analysis was found to fit the data best (Figure 3), confirming the results of the second regression analysis (see Table 4). This path analysis – although not part of the original paper – was presented at the Inter-Noise conference 2007 in Istanbul.

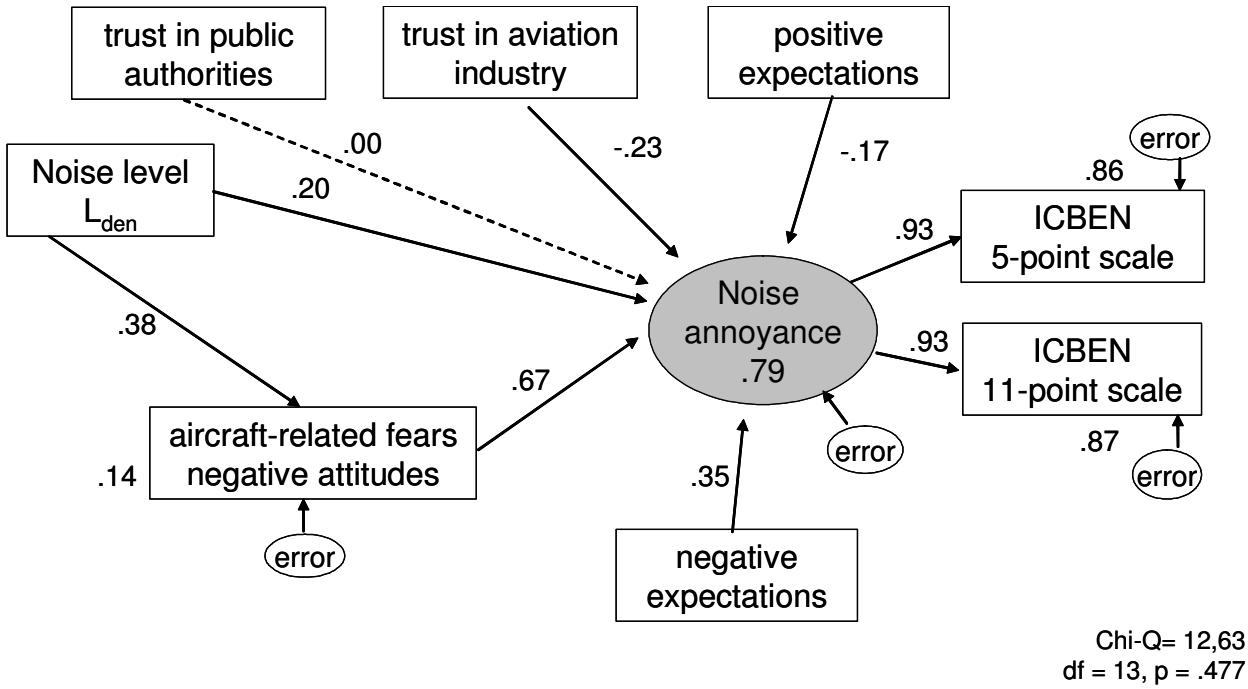

Figure 3: Results of the path analysis on noise annoyance in dependence of attitudes and noise level