Attitudes towards authorities and aircraft noise annoyance: Sensitivity analyses on the relationship between non-acoustical factors and annoyance

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ABSTRACT

Numerous studies have shown correlations between non-acoustical factors and noise annoyance. Particularly, source- and authority-related attitudes have been identified as important modifiers of annoyance. Some authors have discussed non-acoustical factors not just in terms of confounding variables need for adjustment in exposure-response models but as variables that might help to relief residents from adverse noise effects. In order to clarify the potential of non-acoustical factors to reduce annoyance sensitivity analyses of attitudinal and annoyance data from the NORAH study were carried out. Considerable differences in exposure-response curves for aircraft noise annoyance were found depending on 'trust in authorities', ‘perceived procedural fairness’ and 'expectations regarding the air traffic's impacts'. Taken the example of 'trust in authorities', different hypothesised causal directions between annoyance and attitudes ('trust in authorities' contributes to the prediction of annoyance and vice versa) were analysed using longitudinal data of the NORAH study. The relationship between trust and annoyance seems to be reciprocal with changing strength of one of the two causal directions depending on whether there is a change in noise exposure (e.g. airport expansion) or not.

INTRODUCTION

As aircraft technology developed and became more sophisticated, sound levels produced by airplanes could be considerably decreased. Nevertheless, the number of people annoyed by aircraft noise remained steady or even increased and it became clear that acoustical factors alone cannot explain noise annoyance. Indeed, early research found an association between noise annoyance and non-acoustical factors [e.g. 1].

Stallen [2] argues that non-acoustical factors such as perceived control are not only confounding variables in need of adjustment, but rather important aspects to consider and to include in annoyance reduction interventions. In Stallen's stress-related annoyance model, trust in authorities is seen as one aspect of perceived control.

Various research strengthens the model's assumptions and stresses the importance of enhancing perceived control via targeting attitudes such as 'trust in authorities' in interventions as a mean to reduce noise annoyance [3 - 5]. Results from the NORAH study support the causal direction between attitudes and noise annoyance. Sensitivity analyses of attitudinal and annoyance data revealed that 'trust in authorities', 'perceived procedural fairness' and 'expectations regarding the air traffic's impacts' significantly affect noise annoyance at a later time.

There is, however, also evidence indicating that the causal relationship between attitudes and noise annoyance may be reversed [6]. In a longitudinal study at Amsterdam Schiphol Airport [6] found that changes in attitudes ('concern about the negative health effects of noise' and in 'belief that noise can be prevented') measured at time 2 could be explained by aircraft noise annoyance measured at time 1.

Hence, the causal link between noise annoyance and attitudes is still unclear. Therefore, using the longitudinal data from the NORAH study, the aim of the current study is to explore the causal direction of noise annoyance and 'trust in authorities' as an indicator of people's attitudes towards authorities.

METHODS

Study design and sampling

Within NORAH WP1 a panel study at Frankfurt Airport before and after the opening of the new runway Northwest and the implementation of a night-flight ban from 11pm to 5 am (both in October 2011) has been conducted. Three main measurements were carried out: The first measurement in 2011 before the runway opening and repeated measurements in the first (2012) and the second year (2013) after the opening of the new runway and the implementation of the night-flight ban.

The study area around Frankfurt Airport was curtailed by the "envelope" of the 40 dB contours of the continuous aircraft sound levels for daytime ($L_{p\text{Aeq},06\text{-}22h}$) and night-time ($L_{p\text{Aeq},22\text{-}06h}$). Within this area adult residents were randomly sampled from population registries in 2011 with (1) aircraft sound levels (2.5 dB classes of the maximum of $L_{p\text{Aeq},06\text{-}22h}$ and $L_{p\text{Aeq},22\text{-}06h}$ calculated for 2007) and (2) the change in aircraft sound exposure, i.e. the difference between address-related estimated $L_{p\text{Aeq},24hrs}$ as predicted for 2020 and $L_{p\text{Aeq},24hrs}$ of 2007, categorized in three groups (increase in $L_{p\text{Aeq},24hrs}$ > 2 dB, decrease in $L_{p\text{Aeq},24hrs}$ > 2 dB, change within the range of ± 2 dB) as strata. Telephone numbers available from telephone registration were assigned to the sampled residents to enable telephone interviews as the main mode of survey. The continuous sound levels used for stratum and to define the perimeter of the study region were calculated for the residential address of each participant and refer to the air traffic of the six busiest months of the year 2007. Similarly, the sound levels predicted for 2020 refer to the six busiest months in 2020. See the acoustic report of the NORAH study [7] for more information about the address-related estimation of aircraft sound levels.

Procedure

Panel participants were sampled in the spring of 2011. All sampled residents received a cover letter to inform about the study and invite to participate in telephone interviews or optional online surveys with the same questionnaire. The first measurement was done from summer to autumn of 2011 and finished before the opening of the runway Northwest on 21 October 2011.

Repeated measurements were carried out in summer/autumn of 2012 and again in 2013. The sampling and data management was supervised and certified by the responsible agency for data protection.

Noise exposure

The exposure to sound levels for each participant's residential address (continuous and mean maximum sound levels of aircraft, railway and road traffic) was calculated for a 12 months period from October to September for each survey wave for daytime, evening and night-time and for 24 hours. For the assessment of aircraft sound levels the German calculation method AzB 2008 was used. The average sound levels of railway and road traffic were determined based on the methods for calculation used for EU noise mapping [7]. For the analyses in this study the $L_{pAeq,24hrs}$ as indicator of aircraft sound exposure was used. In addition, in some of the analyses the source-specific $L_{pAeq,24hrs}$ or road traffic and railway sound, respectively, were used for model adjustment.

Questionnaire

In all three survey waves 2011, 2012, and 2013 the questionnaire includes the assessment of disturbances and annoyance to aircraft noise and other transportation noise (railway, road traffic), mental and physical quality of life, potential co-determinants of annoyance and HQoL as well as the potential co-determinants noise sensitivity and attitudes. The attitudes include judgments of attributes of the noise source (aircraft), 'trust in authorities', perceived procedural fairness and expectations with regard to the impact of air traffic on the regional development and the residential life, participation in programs of sound insulation and compensation and satisfaction with sound insulation at home. Furthermore, the questionnaire contains questions concerning residential conditions (e.g. window type and position) and demographics. In the analyses described in this contribution the following main variables were assessed:

- *Aircraft noise annoyance* is assessed with the ICBEN 5-point scale according to the ICBEN recommendation [8]. Respondents reporting to be 'very' (4) or 'extremely' (5) annoyed were categorised as being 'highly annoyed' (HA).
- *'Trust in authorities'*: As indicator of attitudes towards the aviation community and authorities residents' belief about authorities' effort for reducing the aircraft noise annoyance in communities around the airport was measured using a 5-point scale (endeavours (1) not at all – (5) very). The authorities judged in this way were the aircraft manufactures, airlines, the airport operator (Fraport AG), the regional aircraft noise commission, German Air Traffic Control, municipalities, the regional dialogue forum 'Forum Airport & Region', the Federal State Government of Hesse, the aircraft noise commissioner, and the Federal Aviation Office. According to analysis of reliability and confirmative factor analysis (CFA) the authorities' endeavour to reduce aircraft noise annoyance was judged rather homogenous, which would allow for a summarised score of 'trust in authorities'. Responses to the items concerning the regional aircraft noise commission, German Air Traffic Control, the regional dialogue forum 'Forum Airport & Region', the aircraft noise commissioner, and the Federal Aviation Office were excluded from the scoring because of missings in responses ≥ 10%. For the other items a mean score of 'trust in authorities' was calculated (Cronbach's alpha: α_{2011} = .81, α_{2012} = .83, α_{2013} = .84).
- *'Perceived procedural fairness'*: The perceived fairness of the decision process regarding the air traffic operations and noise management at Frankfurt Airport was assessed only in the first survey wave (2011) with items developed by [9] and adopted to the situation at Frankfurt Airport in agreement with the author of the original items. A

summarised mean score of 'perceived procedural fairness' was calculated from responses on a 5-point scale (agree (1) not – (5) very) to the following four items (Cronbach α = .67): (1) I think that aircraft noise is distributed fairly amongst all residents; (2) When decisions concerning aircraft noise are being made, I have opportunities to express my views to the relevant people; (3) I have the chance to appeal decisions that I consider to be wrong; (4) Decisions concerning aircraft noise are explained and justified to me in detail.

- The variable *'Positive expectations concerning the impact of air traffic on the regional development and the residential life*' is assessed by a mean score of the following items on a 5-point scale (agree (1) not – (5) very): (1) The airport improves the regional development; (2) The air traffic leads to fall in value of residence and properties; (3) The air traffic brings new jobs to the region; (4) The air traffic spoils residents' outdoor stay in the garden, on the terrace or on the balcony.

Statistical analysis

Descriptive analysis of the data includes the calculation of frequency, means, standard deviations, and correlations. For different response categories of 'trust in authorities' and expectations concerning the air traffic assessed in the second survey wave 2012 and for response categories of perceived fairness as measured in 2011 exposure-response relationships for the percentage of people highly annoyed by aircraft noise (%HA) were estimated for the last year of measurement in 2013. The %HA-curves were estimated by means of multiple logistic regressions based on the Generalized Linear Model (GzLM) with $L_{p\text{Aeq, 24hrs}}$ as the acoustical parameter of aircraft noise exposure. The models were adjusted for noise sensitivity (single item assessed on a 5-point scale), age, gender, migration background, socio-economic status, mode of survey (phone vs. online), and $L_{p\text{Aeq, 24hrs}}$ for road traffic and railway sound exposure.

For 'trust in authorities' the causal direction of the relationship with aircraft noise annoyance was analysed by means of structural equation modelling (SEM) [10] with AMOS V.24. To allow for analysis and interpretation of results of SEM with non-normal data the asymptotically distribution-free estimation (ADF) was used for all SEM.

Longitudinal data of the NORAH panel study were used in the SEM to address the issue of temporal order of annoyance and trust in authorities as either dependent or independent variables. The logic for SEM with longitudinal data in research on noise annoyance is, for example, described in [6] (see also [11] for similar analyses with regard to the relationship between aircraft noise annoyance and mental health). That is, the direct and indirect effects of aircraft sound exposure and 'trust in authorities' as measured in one survey wave (t1) on aircraft noise annoyance measured in the following survey wave (t2) was tested whilst controlling for the impact of the previous value of annoyance (measured at t1). The same was done for the estimation of the effect of aircraft noise annoyance measured at t1 on 'trust in authorities' measured at t2. In addition, as aircraft sound exposure changed after the first measurement in 2011 due to the opening of runway Northwest and the implementation of the night-flight ban, a variable of change in exposure was included in the model. For this, the standardised residuum of the regression of the aircraft sound exposure ($L_{p\text{Aeq,24hrs}}$) calculated for t2 on the $L_{p\text{Aeq,24hrs}}$ calculated for t1 was estimated and used as an 'exposure change variable' in the SEM. The advantage of the residuum is that it expresses the residual change in exposure which cannot be explained by the aircraft sound level at t1. An integrated model formed by two sub-models for the two outcomes (i) aircraft noise annoyance explained by aircraft sound exposure and 'trust in authorities' and (ii) 'trust in authorities' explained by aircraft sound exposure and aircraft noise annoyance was calculated (Figure 1). The integrated model was calculated for three combinations of two measurement years defined as t1 and t2 (Model A, B, and C; Table 1).

Table 1: Overview of times (years) of measurements t1 and t2 in the SEMs of longitudinal NORAH data

Model (SEM)	Measurement t1	Measurement t2
A	2011	2012
B	2011	2013
C	2012	2013

Models A and B include changes in aircraft sound exposure due to the airport expansion between t1 and t2. The times of measurement t1 and t2 in model C both refer to the period after the opening of the runway and the implementation of the night-flight ban and include minor changes in exposure, if at all. In addition to the SEM, the statistically significance of mediation effects of annoyance and 'trust in authorities', respectively, was tested using the OLS regression approach by [12]. All modelling included bootstrapping [13] with 5000 'bootstrap'-samples in order to assess the robustness of the models.

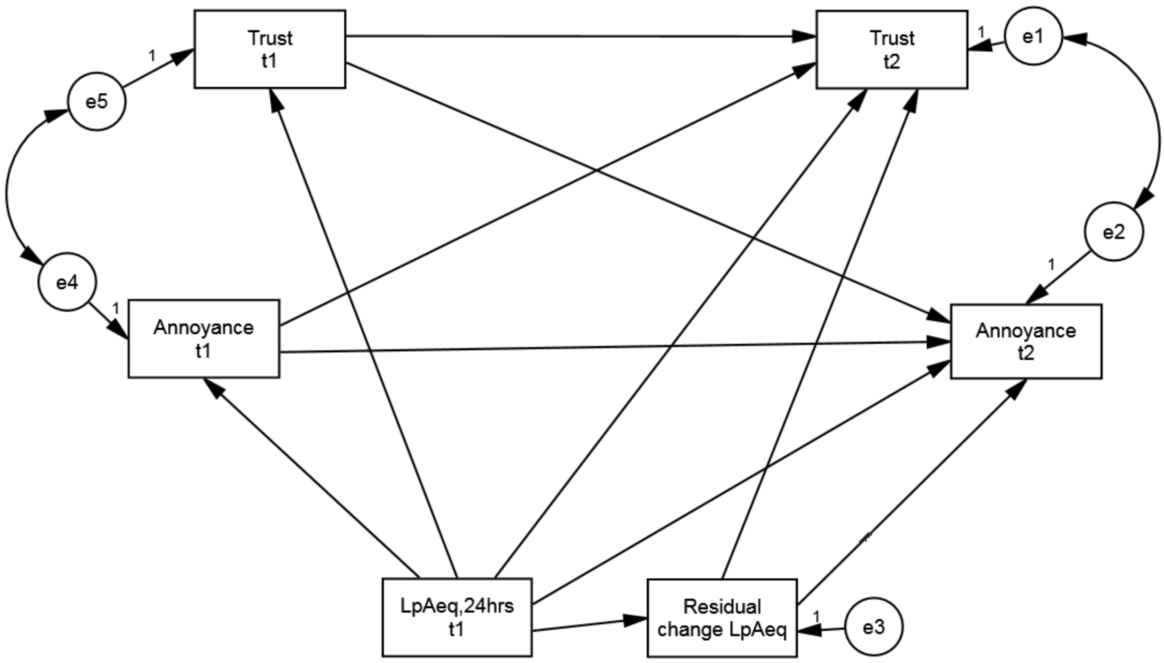

Figure 1: Specification of the structural equation models (SEM) for the relationship between 'trust in authorities' and aircraft noise annoyance

RESULTS

Descriptive statistics

In the NORAH panel study 9244 residents were interviewed in the first wave before the opening of the runway Northwest (2011). 4867 of them took part in the second measurement after the opening of the new runway and the implementation of the night-flight ban (2012), and 3508 respondents took part in the third measurement in 2013.

The following analyses were done with data of the respondents that took part in all measurements and responded to all items analysed in this contribution. Cases with non-response in items included in the analyses of this contribution were excluded. That is, the analyses based on a net sample of 3426 respondents (53.1% female, age range in 2011: 18 to 96 yrs., *M* = 53 yrs., *SD* = 14.5 yrs.). In 2011, 88.9% of them (2012: 88.8%, 2013: 88.7%) were interviewed by phone, 11.1% (2012: 11.2%, 2013: 11.3%) responded to the same questions using the online mode. In 2011, the average aircraft sound levels for 24 hours $L_{pAeq,\,24hrs}$ ranged from 36 to 61 dB (*M* = 48.3, *SD* = 6.2). The range of $L_{pAeq,\,24hrs}$ was from 35 to 71 dB (*M* = 48.0, *SD* = 6.4 dB) in 2012 and from less than 35 dB to 70 dB (*M* = 47.3, *SD* = 6.3) in 2013. After the opening of the new runway, 508 persons (14.8% of the net sample) experienced a decrease in aircraft sound exposure of more than 2 dB $L_{pAeq,\,24hrs}$ in 2012 compared to 2011, 393 respondents (11.5%) experienced an increase of more than 2 dB and for 2525 participants (73.7%) there was no change in $L_{pAeq,\,24hrs}$ above 2dB.

Table 2 presents the descriptive statistics for aircraft noise annoyance and 'trust in authorities' by aircraft sound exposure (2.5 dB-classes of $L_{pAeq,\,24hrs}$). Means of aircraft noise annoyance increase with increasing aircraft sound levels in all years of measurements. In all sound classes, the annoyance is higher in 2012 than in 2011 and 2013. The correlations are quite similar in all years of measurement ($.47 \le r \le .48$, $p < .001$). Mean values of 'trust in authorities' are higher in lower than in higher sound level classes. The correlations with aircraft sound levels ($L_{pAeq,\,24hrs}$) in 2011, 2012, and 2013 are, although statistically significant, much weaker ($-.15 \le r \le -.13$, $p < .001$) compared to the correlations between annoyance and sound level. The correlations between 'trust in authorities' and annoyance are in the range of $-.39 \le r \le -.32$ ($p < .001$) in 2011 before the opening of the new runway and in the range of $-.44 \le r \le -.40$ ($p < .001$) after the runway opening in 2012 and 2013.

Table 2: Aircraft noise annoyance and 'trust in authorities' by aircraft sound exposure ($L_{pAeq,\,24hrs}$ – classes)

$L_{pAeq,24hrs}$ in dB	Aircraft noise annoyance (ICBEN 5-pt scale)									Trust in authorities (mean score)								
	2011 (t1)			2012 (t2)			2013 (t3)			2011 (t1)			2012 (t2)			2013 (t3)		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD
≤ 37.5	53	1,9	1,0	175	2,3	1,1	235	2,2	1,0	53	3,0	0,9	175	2,7	0,9	235	2,7	0,8
37.6 - 40.0	272	2,3	1,2	328	2,4	1,2	317	2,4	1,2	272	2,7	0,8	328	2,5	0,9	317	2,7	0,9
40.1 - 42.5	474	2,6	1,2	362	2,8	1,2	434	2,6	1,1	474	2,5	0,9	362	2,5	0,9	434	2,6	0,9
42.6 - 45.0	431	2,9	1,2	368	3,0	1,2	322	3,0	1,2	431	2,4	0,9	368	2,5	0,9	322	2,4	0,9
45.1 - 47.5	381	3,1	1,2	329	3,3	1,2	382	3,3	1,2	381	2,4	0,9	329	2,3	0,8	382	2,4	0,8
47.6 - 50.0	385	3,3	1,2	391	3,7	1,2	450	3,5	1,2	385	2,5	0,9	391	2,4	0,9	450	2,4	0,8
50.1 - 52.5	439	3,7	1,1	378	3,8	1,2	456	3,8	1,1	439	2,4	0,9	378	2,2	0,8	456	2,2	0,8
52.6 - 55.0	409	3,9	1,1	546	3,9	1,1	411	3,9	1,2	409	2,3	0,8	546	2,2	0,8	411	2,3	0,8
55.1 - 57.5	335	4,2	1,0	406	4,1	1,0	256	4,0	1,0	335	2,2	0,8	406	2,3	0,9	256	2,3	0,9
> 57.5	247	4,2	1,0	143	4,3	0,9	163	4,1	1,0	247	2,4	0,8	143	2,3	0,8	163	2,4	0,8
Total	3426	3,3	1,3	3426	3,4	1,3	3426	3,3	1,3	3426	2,4	0,9	3426	2,4	0,9	3426	2,4	0,9

Similarly (not tabled here), perceived procedural fairness with regard to decisions on air traffic and aircraft noise management as measured in 2011 correlates with aircraft sound exposure ($L_{pAeq,24hrs}$) $r = -.11$ ($p < .001$) and with aircraft noise annoyance (2011) $r = -.34$. Furthermore, the expectations concerning the air traffic in the region around Frankfurt Airport correlate in the survey waves 2011, 2012, and 2013 in the range of $-.65 \le r \le -.53$ ($p < .001$) with aircraft noise annoyance and in the range of $-,33 \le r \le -.29$ ($p < .001$) with aircraft sound exposure.

Exposure response models for %HA due to aircraft noise

Figure 2 depicts %HA-curves against the $L_{pAeq,\,24hrs}$ for the third measurement in 2013 for different discrete values of 'trust in authorities', expectations concerning the impact of air traffic on regional development and residential quality of life (both variables assessed in 2012), and perceived procedural fairness of decisions related to air traffic and noise management as measured in 2011. Considerable differences in %HA depending on discrete values of the attitudes could be observed in particular in a range of $L_{pAeq,\,24hrs}$ between 45 to 55 dB. For example, at a level of $L_{pAeq,\,24hrs}$ = 45 dB an increase from value 1 to value 2 in 'trust in authorities' is associated with a %HA decrease of -24%, the same increase in perceived fairness corresponds with %HA decrease of -16% and when the (positive) expectations change from value 1 to 2 at a level of $L_{pAeq,\,24hrs}$ = 45 dB this is associated with a %HA decrease of -24%. At a level of $L_{pAeq,24hrs}$ = 55 dB a change in attitude levels from 3 to 4 corresponds with a %HA decrease of -23% for trust in authority, -15% for perceived fairness and -31% for positive expectations regarding the impact of air traffic. For $L_{pAeq,\,24hrs}$ levels above 60 dB changes in annoyance are less associated with changes in attitudes.

However, these %HA-curves suggest that the causal paths of the association between aircraft noise annoyance and the attitudes follow from attitudes to annoyance. This assumption was tested exemplarily for 'trust in authorities' by means of the SEMs A to C.

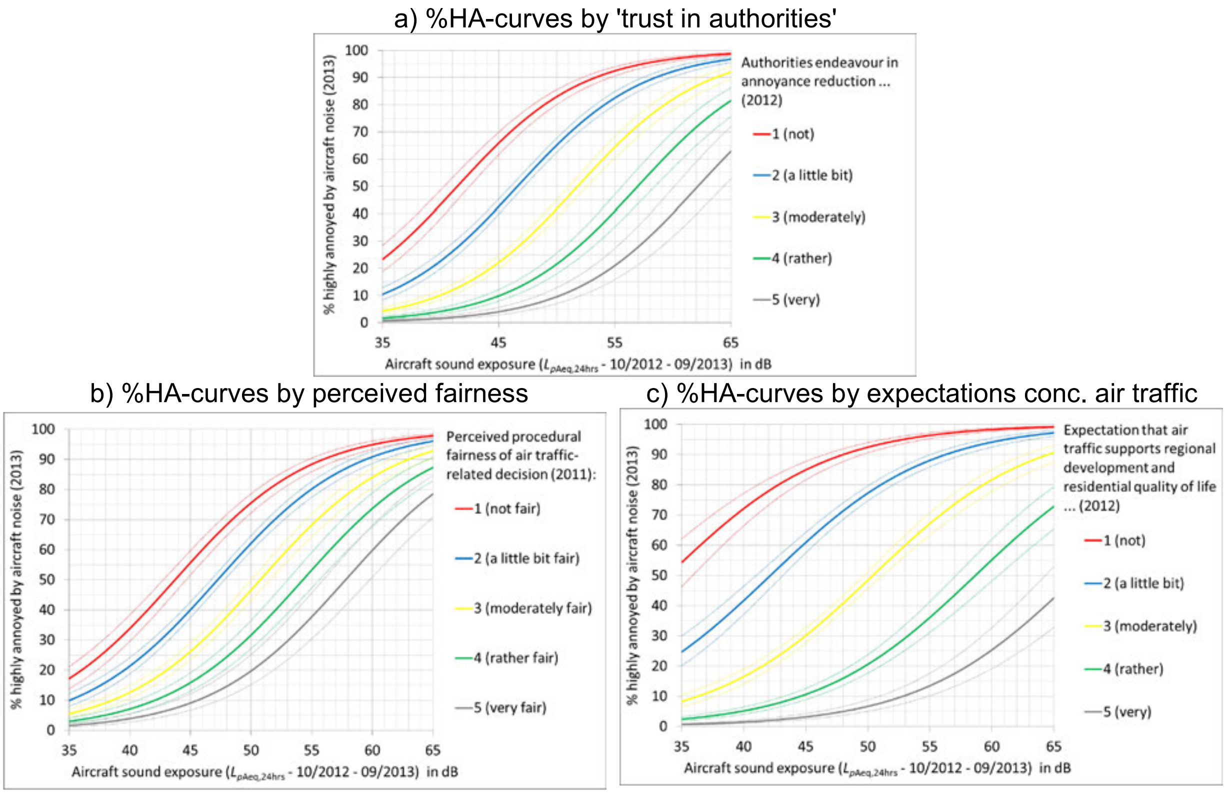

Figure 2: Percentage of people highly annoyed by aircraft noise (%HA) in 2013 by $L_{pAeq,24hrs}$ (12 months continuous sound level of 10/2012 – 09/2013), and by discrete values of attitudes assessed previously in 2012 (a, c), and 2011 (b): (a) 'trust in authorities' (2012), (b) perceived procedural fairness of decisions related to air traffic and noise management (2011), and (c) positive expectations concerning the impact of air traffic on regional development and residential quality of life (2012)

Structural equation model for aircraft noise annoyance and 'trust in authorities'

Table 3 shows values of modal fit for the models A, B and C. The test statistics show that the covariance matrix of each model differs in a statistically significant manner from the sample covariance matrix. However, the values of the descriptive approximate fit indices shown in Table 3 indicate a sufficient fit for the models A, B, and C as, except for the ratio χ^2/df, the index values are inside the range of conventionally defined cut-off values for a good model fit (cut-off values: χ^2/df ratio < 2, CFI ≥ 0.95, RMSEA ≤ 0.05 together with p_{close} > 0.50, SRMR ≤ 0.08 10).

Table 3: Model fit values of SEM A, B and C

SEM	t1	t2	Model test statistics				Fit indices				
			χ^2	df	p	χ^2/df	CFI	RMSEA	p_{CLOSE}	SRMR	AIC
A	2011	2012	11,91	2,00	0,00	5,96	1,00	0,04	0,79	0,01	49,91
B	2011	2013	9,23	2,00	0,01	4,61	1,00	0,03	0,89	0,01	47,23
C	2012	2013	10,78	2,00	0,01	5,39	1,00	0,04	0,84	0,01	48,78

χ^2 = Chi square, df = degree of freedom, CFI: comparative fit index, RMSEA: root mean square error of approximation, SRMR: standardized root mean residual, AIC = Akaike information criterion

Table 4 shows the estimated path coefficients of variables in SEM A, B and C. In all models, both the path from 'trust in authorities' to annoyance and the path from annoyance to 'trust in authorities' are statistically significant. In the models A and B (including variables of the measurement years *before and after* the opening of the new runway) the effects of annoyance t1 on 'trust in authorities' t2 and vice versa are of quite similar size. In model C, including only variables measured *after* the opening of runway Northwest the effect of annoyance t1 on 'trust in authorities' t2 is stronger (-.201) than the effect of trust t1 on annoyance t2 (-.096). The mediation effect of annoyance t1 on trust t2 is stronger in all models than vice versa indicating that the effect of trust on annoyance is more independent from aircraft sound exposure. However, the mediation effect of trust t1 on annoyance t2 is statistically significant, too. This was tested within a mediation analysis by means of OLS regressions (using the SPSS macro PROCESS [12]) with aircraft noise annoyance and trust, respectively, at t2 as dependent variable (Y_{t2}), $L_{pAeq,24hrs}$ as exposure/predictor (X_{t1}), and annoyance and trust, respectively, as mediator (M_{t1}). The OLS regression models were adjusted for previous values of Y (either annoyance t1, or trust t1) and residual change in aircraft noise exposure. The output of the PROCESS mediation analysis includes bootstrap confidence intervals for the specific mediation effect of either annoyance or 'trust in authorities' (the AMOS outputs of the SEMs A to C include bootstrap confidence intervals for the total indirect effect of sound exposure mediated by annoyance t1, trust t1, and residual change in sound exposure). Unlike signs of lower and upper limits of the 95% bootstrap interval indicate a statistically non-significant mediation effect (see Table 5).

Table 4 further shows that in all three models A, B, and C the $L_{pAeq, 24hrs}$ t1 has a strong direct effect on annoyance t1 and also an effect on annoyance t2. The effect of aircraft sound level t1 on trust t1 is statistically significant. This could not be shown for the effect of $L_{pAeq, 24hrs}$ t1 on trust t2. Instead, the $L_{pAeq, 24hrs}$ t1 affects trust t2 indirectly, mediated by annoyance t1 and trust t1. The residual change in noise exposure since 2011 (models A and B) has a statistically significant effect on both annoyance t2 and trust t2.

Table 4: Standardised estimates of structural equation models A, B and C

Y1 = Trust t2 (sub-model 1) Y2 = Annoyance t2 (sub-model 2)			**Model A**	**Model B**	**Model C**
			t1=2011 t2=2012	**t1=2011 t2=2013**	**t1=2012 t2=2013**
$L_{pAeq,24hrs}$ t1	--->	Change in $L_{pAeq,24hrs}$	-.003 [a]	-.001 [a]	.001 [a]
$L_{pAeq,24hrs}$ t1	--->	Annoyance t2	.135	.133	.118
$L_{pAeq,24hrs}$ t1	--->	Trust t2	.031 [b]	.022 [a]	.020 [a]
Change in $L_{pAeq,24hrs}$	--->	Annoyance t2	.215	.194	.065
Change in $L_{pAeq,24hrs}$	--->	Trust t2	-.109	-.075	-.010 [a]
$L_{pAeq,24hrs}$ t1	--->	Annoyance t1	.480	.480	.474
$L_{pAeq,24hrs}$ t1	--->	Trust t1	-.127	-.129	-.140
Trust t1	--->	Annoyance t2	-.153	-.156	-.096
Annoyance t1	--->	Trust t2	-.143	-.157	-.201
Trust t1	--->	Trust t2	.506	.507	.553
Annoyance t1	--->	Annoyance t2	.560	.559	.697
e4 (annoyance t1)	<-->	e5 (Trust t1)	-.375	-.376	-.420
e2 (annoyance t2)	<-->	e1 (Trust t2)	-.220	-.225	-.136
Mediation effect of M_{t1} (indirect effect of X_{t1} = $L_{pAeq,24hrs}$ t1 via M_{t1} on Y_{t2})					
M_{t1}		Y_{t2}			
Trust t1	--->	Annoyance t2	.019	.020	.013
Annoyance t1	--->	Trust t2	-.069	-.075	-.095
Trust t1	--->	Trust t2	-.064	-.065	-.077
Annoyance t1	--->	Annoyance t2	.269	.268	.330

[a] $p > 0.10$, [b] $0.05 < p < 0.10$. p for all coefficients ≤ .001 except for [a] and [b]. Paths between annoyance and 'trust in authorities' are highlighted

Table 5: Results of OLS regressions on the mediation effect of noise annoyance and 'trust in authorities' (indirect effect of aircraft sound exposure mediated by annoyance and trust, respectively)

Mediation effect of M_{t1} (indirect effect of X_{t1} = $L_{pAeq,24hrs}$ t1 via M_{t1} on Y_{t2})					
Y1 = Trust t2 (sub-model 1) Y2 = Annoyance t2 (sub-model 2)			**Model A**	**Model B**	**Model C**
			t1=2011 t2=2012	**t1=2011 t2=2013**	**t1=2012 t2=2013**
M_{t1}		Y_{t2}			
Trust t1	--->	Annoyance t2	.019 (.014; .027)	.020 (.015; .027)	.013 (.009; .019)
Annoyance t1	--->	Trust t2	-.067 (-.085; -.050)	-.075 (-.094; -.058)	-.094 (-.111; -.079)

In brackets: lower and upper limit of 95% bootstrap confidence interval (BCI; $N_{bootstrap}$ = 5000). Unlike signs of the lower and upper BCI limits indicate a statistically non-significant indirect effect of X_{t1} ($L_{pAeq,24hrs}$ t1).

Figure 3 shows the specified model A with t1 = 2011 and t2 = 2012 as an example of a model of the longitudinal association between aircraft sound exposure, aircraft noise annoyance and 'trust in authorities' in a change situation (before/after changes of noise exposure in the context of the airport extension) and model C with t1 = 2012 and t2 = 2013 representing the longitudinal association after major changes at the airport.

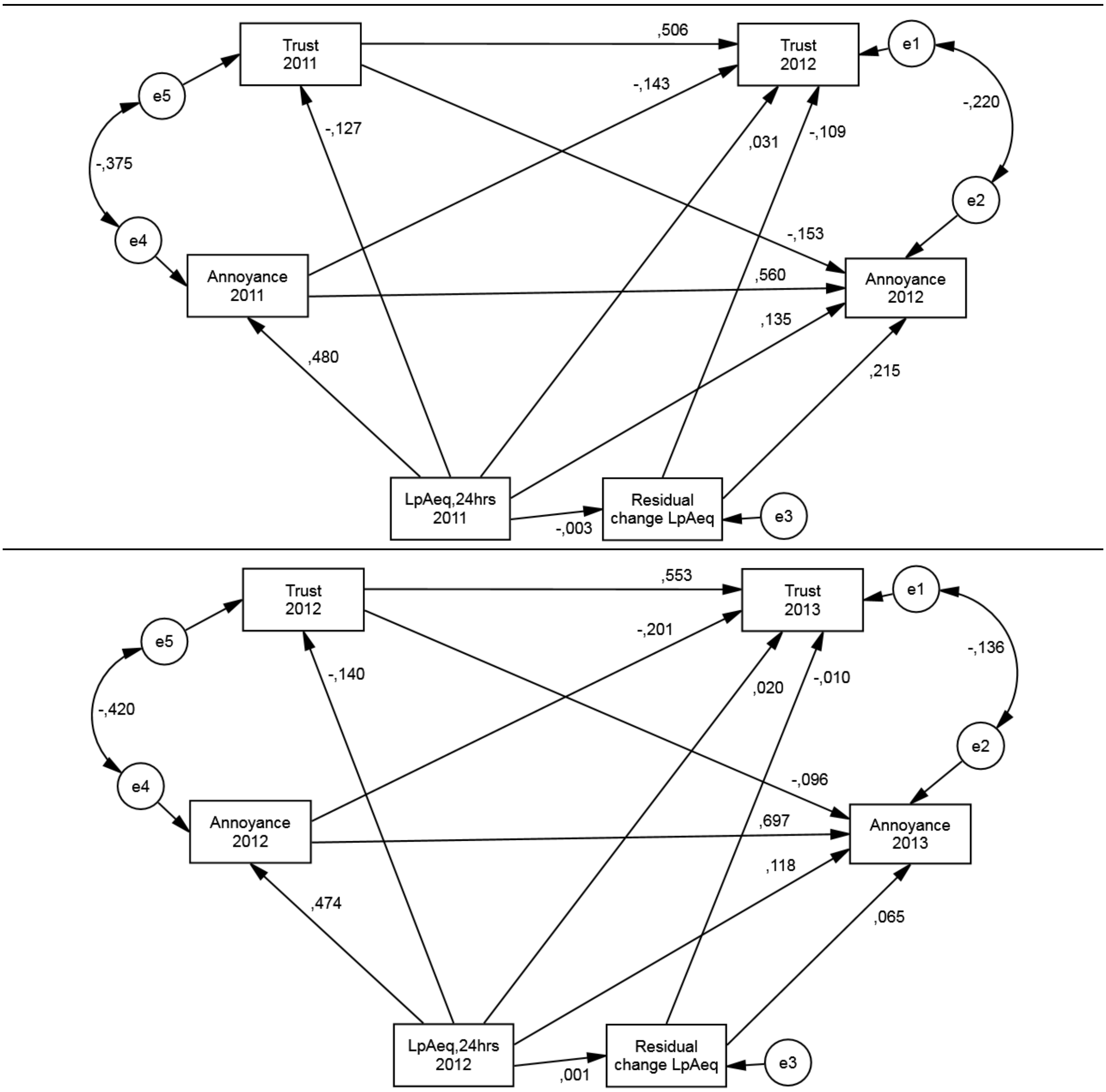

Figure 3: Structural equation models for the longitudinal relationship between aircraft sound exposure, 'trust in authorities' and aircraft noise annoyance: Upper model A for t1 = 2011 and t2 = 2012 and lower model C for t1 = 2012 and t2 = 2013

DISCUSSION & CONCLUSIONS

Within the NORAH research initiative longitudinal data on aircraft noise annoyance and associated attitudinal factors were collected at Frankfurt Airport in 2011 before the opening of the new 4^{th} runway Northwest and the implementation of a night-flight ban from 11pm to 5am (introduced in October 2011) and in repeated measurements in 2012 and 2013 after the implementation of these changes. Considerable differences in %HA against $L_{pAeq,24hrs}$ in 2013 were found depending on discrete values of 'trust in authorities', perceived fairness and expectations concerning the impact of the air traffic on the regional development and residential quality of life assessed in previous survey waves. However, these exposure-response models assume the causal direction of the relationship between attitudes and annoyance to follow (fully) from attitudes to aircraft noise annoyance.

Taken the example of 'trust in authorities', it was analysed to what extent trust assessed in a previous survey wave affects aircraft noise annoyance and vice versa. This was done by SEM models of longitudinal data of aircraft sound exposure, aircraft noise annoyance and 'trust in authorities'. Following Lazarus' transactional stress approach [14] Stallen [2] regards 'trust in authorities' as an aspect of perceived control which is conceptualised in his stress-related model on noise annoyance as part of a secondary appraisal process, i.e. the appraisal of resources to cope with noise (the environmental stressor). According to this model one would expect that 'trust in authorities' assessed in 2011 would affect aircraft noise annoyance in following measurements 2012, and 2013, respectively. The results of the longitudinal SEM estimations show that the relationship between trust and annoyance is more complex. First, the results of the SEM confirm that 'trust in authorities' as measured in previous survey waves has an effect on aircraft noise annoyance. However, the reversed causal direction is also true, i.e. the path from aircraft noise annoyance to 'trust in authorities' measured in a following survey wave is also statistically significant. This is partly in line with findings of [6], who reported that in their longitudinal study on aircraft noise effects at Amsterdam Airport Schiphol none of the paths from attitudes to aircraft noise annoyance was significant whereas the paths from aircraft noise annoyance to ‘concern about the negative health effects of noise’ and to ‘belief that noise can be prevented' were significant. In our study, the mediation effect of aircraft noise annoyance assessed at t1 on 'trust in authorities' measured at t2, i.e. the indirect effect of $L_{p\mathrm{Aeq,\ 24hrs}}$ on 'trust in authorities' mediated by annoyance, is stronger than the reversed mediation effect of 'trust in authorities' (t1) on aircraft noise annoyance (t2), but this only suggests that the effect of 'trust in authorities' on annoyance is more independent from sound exposure.

It seems that 'trust in authorities' and aircraft noise annoyance are reciprocally related to each other. However, the strength of the causal direction was found to be different depending on whether the longitudinal SEM includes variables of measurements before and after the opening of the runway (models A, B) or variables assessed after the changes at the airport only (model C). Whereas in the latter case the size of the aircraft noise annoyance measured at t1 explains more of the variance of 'trust in authorities' afterwards (at t2) than vice versa, the estimates in model A and B suggest that 'trust in authorities' gains in importance for explaining subsequent aircraft noise annoyance in a change situation (before/after a change in sound exposure). This is in line with [2] who points out that variables related to the secondary appraisal of the capacity to cope with noise (such as perceived control including among others 'trust in authorities') become particularly important when the noise exposure changes or is expected to change.

Unfortunately, the strength of the different causal directions of the association between trust in authorities (and related attitudes) and aircraft noise annoyance couldn't be observed in repeated measurements in the years before the changes at Frankfurt Airport in autumn 2011. Probably, this would have given more insight into the dynamic process of the relationship between attitudinal factors and aircraft noise annoyance before, during and after major changes in exposure. The same seems to be true for the importance of further follow-ups after the changes within the frame of the airport expansion. There are several activities of active noise control at Frankfurt Airport since the opening of the runway Northwest, some of them implemented, others planned for the near future [15]. There is some evidence that these measures of noise respite might be less effective with regard to the reduction of noise annoyance due to the lack of trust in authorities among residents [16]. Thus, it is suggested that in future noise abatement projects the aspect of attitudes related to the source or to authorities should be considered in addition to the acoustical and operational measures. The impact of such a noise management on exposed people should then be evaluated in intervention studies in order to get a better understanding of noise effects and of how to minimise aversive noise effects.

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