PROCEEDINGS of the
23rd International Congress on Acoustics

9 to 13 September 2019 in Aachen, Germany

Assessment of the impact of changes in noise exposure at an expanding airport by means of the multiple item aircraft noise annoyance scale (MIAS)

Dirk SCHRECKENBERG[1]; Rainer GUSKI[2]; Julia HAUBRICH[1]; Jan SPILSKI[3]

[1] ZEUS GmbH, Germany

[2] Ruhr University Bochum, Germany

[3] Technical University Kaiserslautern, Germany

ABSTRACT

The Multiple Item Noise Annoyance Scale (MIAS) measures noise annoyance as a multidimensional concept including (1) the experience of an often repeated noise-related disturbance and the behavioural response to it, (2) an emotional/attitudinal response to the sound and its disturbing impact, (3) the perception of control of the noise situation. MIAS consists of seven items including the 5-point ICBEN noise annoyance scale and the sub-dimensions 'noise disturbances' and 'lack of coping capacity', each consisting of three items. Its psychometric properties are investigated for aircraft, road, and railway noise annoyance. In this study, we analyse changes in values of the sub-dimensions of MIAS for aircraft noise annoyance before and after the opening of a new runway and the implementation of a night curfew in communities around Frankfurt Airport. Previous studies have shown evidence of a shift in exposure-response relationships for annoyance in situations of changes in noise exposure (change effect). With the assessment of MIAS and its components, it can be identified whether the change effect is more pronounced in the 'disturbance' component of annoyance or in the lack of capacity to cope with the (new) noise situation. This improves the understanding of annoyance in situations of changes in noise exposure.

Keywords: Aircraft noise annoyance, change effect, MIAS, ICBEN, NORAH

1. INTRODUCTION

Noise annoyance is a complex psychological response to noise. According to Guski and colleagues (1) noise annoyance comprises three elements: (i) the experience of an often repeated noise-related disturbance and the behavioural response to it, (ii) an emotional/attitudinal response to the sound and its disturbing impact, (iii) the perception of control of the noise situation. The Multiple Item Noise Annoyance Scale (MIAS) developed originally for the measurement of aircraft noise annoyance (2) aims at measuring the components of noise annoyance as defined by (1). MIAS consists of seven items including the 5-point ICBEN noise annoyance scale (3) and the sub-dimensions (factors) 'noise disturbances' (F1) and 'lack of coping capacity' (F2), each consisting of three items. Its psychometric properties are investigated for aircraft, road, and railway noise annoyance (2). MIAS was found to be a reliable, valid theory-driven measure to assess annoyance due to transportation noise.

In this contribution, it is investigated to what extent the detailed assessment of aircraft noise annoyance with MIAS is able to improve the understanding of changes in noise annoyance before and after an airport expansion. This is analysed with longitudinal survey data of the German NORAH study (Noise-related annoyance, cognition, and health) before (in 2011) and after (in 2012) the opening of the 4th new runway at Frankfurt Airport and implementation of a night flight curfew which both took place in October 2011 (4). These interventions together with further operational noise abatement measures and a sound insulation program have led and still lead to both increase and reductions in aircraft noise exposure in different communities around the airport. This, probably, leaves the development of the individual aircraft noise exposure situation unclear (unpredictable) to individual residents.

1 schreckenberg@zeusgmbh.de; haubrich@zeusgmbh.de
2 rainer.guski@rub.de
3 jan.spilski@sowi.uni-kl.de

Previous studies have shown evidence of a shift in exposure-response relationships for annoyance in situations of changes in noise exposure (5–7), the so-called 'change effect' or excess in response. There is no evidence of a full adaptation to the new situation months or years followed by a change in noise exposure. Brown and van Kamp (6) discuss different explanations for the change effect. According to them, no accepted and evidence-based view on a single mechanism for the explanation of the change effect could be identified. Some explanations could be rejected due to insufficient evidence. The remaining plausible explanations fall into three categories: (1) changes in factors modifying the exposure-response relationship in the context of noise exposure changes, (2) methodological artefact of a different criterion for the use of the annoyance response scale in steady-state versus changing exposure situations and/or at different levels of noise exposure, and (3) retention of coping strategies after a change in exposure.

The third category of explanations for the change effect goes back to Raw and Griffiths (8), who studied the impact of changes in road traffic noise on noise responses. Although they found a significant change effect (excess) also on interferences, this effect was less evident than for the judgments of annoyance or dissatisfaction. In their model Raw and Griffiths postulate that, when the noise exposure changes, the coping behaviour partly retains and does not fully change to those appropriate for the new exposure situation. They explain the absence of adaptation in annoyance with a rapid process of (de-)sensitization to the (less) aversive component of the sound after the change in exposure. Raw and Griffiths argue that both, the judgment of the interfering effects of noise and of the aversive components of the sound are included in the annoyance ratings. That is, any change in coping behaviour would "chronically lag behind sensitization" ((8), p. 52) which hampers the adaptation of annoyance judgments to the new exposure situation.

Whether a sensitization to the sound itself or the perception of loss of control or capacity to cope with the noise is responsible for the partial retention of coping behaviour or both, is unclear. At least, perceived control (or coping capacity) is an important contributor (9) to or, following (1), even an element of noise annoyance. In particular, in a situation of increasing or unclear development of noise exposure, it is likely that the perception of (loss of) control makes it difficult or even impossible ('learned helplessness') (10) to change the coping behaviour appropriate to the new exposure situation. Therefore, it can be hypothesized that in a region around an expanding airport with several activities and dynamics leading to increases or decreases in aircraft noise exposure for residents of the airport region (a) a change effect in aircraft noise annoyance occurs, i.e. an excess response following the direction of the change in exposure, (b) which, according to (8), is less strong for the disturbance component of annoyance as assessed with MIAS and (c) stronger for the MIAS factor of (lack of) coping capacity.

2. PROCEDURE, METHODS

2.1 Study design, sampling

For the analysis, longitudinal data of the NORAH study was used. The survey was conducted in 2011 prior to the opening of the 4th new runway at Frankfurt Airport and implementation of a night flight curfew in October 2011. One follow-up was carried out the year after, in 2012. A third survey wave (not analysed further here) was conducted in 2013. Residents living in residential areas within the "envelope" of the 40 dB contours of the continuous aircraft sound levels for daytime ($L_{\mathrm{Aeq,06\text{-}22h}}$) and night-time ($L_{\mathrm{Aeq,22\text{-}06h}}$) were included in the study. A random stratified sample was drawn from the regional population registries in 2011, stratified by continuous aircraft sound level classes (2.5 dB classes of the maximum of $L_{\mathrm{Aeq,06\text{-}22h}}$ and $L_{\mathrm{Aeq,22\text{-}06h}}$) and by predicted change in aircraft noise exposure for 2020 in relation to the aircraft noise exposure in 2007 (increase in $L_{\mathrm{Aeq,24h}} > 2$ dB, decrease in $L_{\mathrm{Aeq,24h}} > 2$ dB, change within the range of $\pm$ 2 dB). The survey was carried out as telephone interviews and optionally as an online survey with the same questionnaire. For this, the sample data was linked to contact information (phone numbers, email addresses) from telephone databases.

2.2 Assessment of aircraft noise exposure

The aircraft noise exposure was modelled for 12 months from October 2010 to September 2011 for the first survey wave and from October 2011 to September 2012 for the survey wave in 2012 according to the German calculation model AzB 2008 (11). Radar track information of flight movements in these periods was used as input data for the modelling. Details of the acoustic modelling of the aircraft noise exposure for all parts of the NORAH study are described in (12).

2.3 Assessment of MIAS and its elements

With the Multiple Item Annoyance Scale (MIAS) noise annoyance (here: aircraft noise annoyance) is assessed as a hierarchical higher order score including the factors F1 'Disturbances due to aircraft noise', F2 'Lack of coping capacity' and a direct, self-reported annoyance judgment. MIAS is developed ex-post based on the NORAH survey data collected in 2013 (2).

In the longitudinal survey, aircraft noise annoyance referring to the period of the past 12 months prior to the interview was assessed by means of the standardized 5-point verbal annoyance scale from 1 (not at all) to 5 (extremely annoyed or disturbed) as recommended by the International Commission on the Biological Effects of Noise (3), the ICBEN annoyance scale. Furthermore, disturbances of activities concerning among others communication (talk or phone call, listening to radio or watching TV) and recovery, concentration were assessed with a 5-point rating scale similar to the ICBEN scale (not at all [1] to extremely [5] disturbed). These disturbance ratings form the MIAS factor F1 'Disturbances'. The factor F2 'Lack of coping capacity' consists of three items asking the respondents to judge statements referring to the perceived ability to protect themselves against noise, to close the windows when it is too loud or to feel at the mercy of the noise. The statements were rated by means of a 5-point scale from 1 (agree not) to 5 (agree strongly). The components of MIAS F1, F2, and the ICBEN annoyance item were summarized to the MIAS score using weights for the contributing items as identified in a confirmatory factor analysis of the 2013 data (see Figure 1).

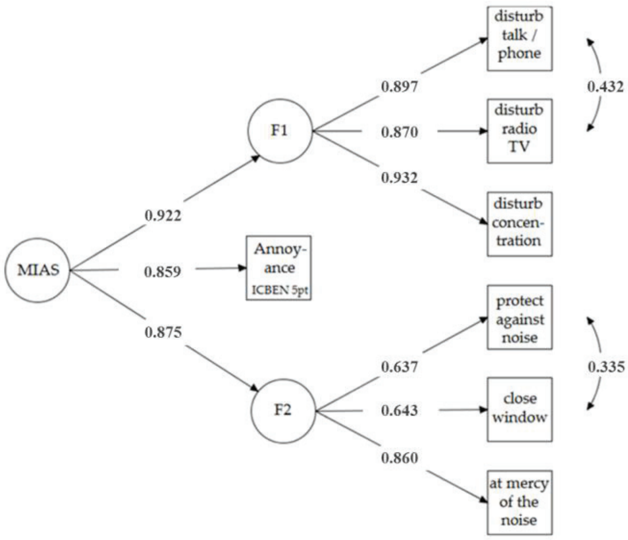


Figure 1: Confirmatory factor analysis of the MIAS score for aircraft noise annoyance as measured in the NORAH panel sample at Frankfurt Airport in 2013 (n = 3508). The numbers between MIAS, the factors F1, F2 and the items are factor loadings. Source: (2).

3. RESULTS

3.1 Descriptive statistics

A total of 3508 subjects participated in all waves of the longitudinal survey from 2011 to 2013. For this study, after deleting cases with missing items the sample size is n = 3459 (53.6 % female; 46.4 % male). In the first measurement (2011), age ranged from 18 to 96 years (M = 52.5, SD = 14.5). Aircraft noise exposure in terms of the day-evening-night level L_{den} was for all but one between 39.2 and 65.2 dB in 2011 and between 37.9 and 63.6 dB in 2012. In one further case, the aircraft noise exposure increased from L_{den} = 61.4 dB in 2011 to L_{den} = 74.8 dB in 2012. Descriptive statistics for MIAS and its sub-dimensions in the total sample are depicted in Table 1.

Table 2 shows the mean L_{den} for aircraft sound in area groups of change in L_{den} after the opening of the new runway (2012) versus before (2011). On average, L_{den} decreased about 3 dB (2 to 7 dB; SD = 0.8) in the 'decrease > 2dB' group and increased about 3 dB (2 to 13 dB; SD = 1.3) in the 'increase > 2 dB' group. The changes in L_{den} varied (as defined) between -2 to +2 dB (M = -0.4; SD = 1.0) in the group 'no change ± 2 dB'.

Table 1 – Descriptive statistics for MIAS and its sub-dimensions assessed before (2011) and after (2012) the 4th runway opening at Frankfurt Airport

Variables	*N*	*M*		*SD*		*Min*		*Max*	
Year		2011	2012	2011	2012	2011	2012	2011	2012
MIAS	3459	12.23	12.32	5.02	5.18	4.44	4.44	22.18	22.18
Annoyance (ICBEN)	3459	3.31	3.41	1.32	1.29	1.00	1.00	5.00	5.00
F1 Disturbances	3459	6.55	6.58	3.47	3.54	2.74	2.74	13.71	13.71
F2 Lack of coping capacity	3459	6.48	6.46	2.48	2.58	2.00	2.00	9.99	9.99
L_{den}	3459	51.89	51.30	6.20	6.43	39.20	37.90	65.20	74.80

Note. *N* = number; *Min* = minimum; *Max* = maximum; *M* = arithmetic mean; *SD* = standard deviation

Table 2 – Change in L_{den} (aircraft) in dB at Frankfurt Airport after the opening of the new runway (2012) vs. before (2011) in area groups of change (decrease, no change, increase in Lden > 2 dB)

Groups of change in L_{den} 2012 versus 2011		L_{den} (2011)		L_{den} (2012)		Change in L_{den} (dB) 2012 vs. 2011			
		M	*SD*	*M*	*SD*	*M*	*SD*	*Min*	*Max*
Decrease > 2 dB	*n* = 630	53.0	7.6	49.8	7.7	-3.2	0.8	-7.3	-2.1
No change ± 2 dB	*n* = 2518	51.6	6.0	51.1	6.0	-0.4	1.0	-2.0	+2.0
Increase > 2 dB	*n* = 311	52.3	3.8	55.7	4.5	3.4	1.3	+2.1	+13.4
Total	*N* = 3459	51.9	6.2	51.3	6.4	-0.6	1.9	-7.3	+13.4

Note. *N*, *n* = number; *M* = arithmetic mean; *SD* = standard deviation; *Min* = minimum; *Max* = maximum

3.2 Correlations between MIAS, its sub-dimensions and the L_{den}

Table 3 presents the correlations between MIAS and its sub-dimensions as well as the correlations of these response variables with L_{den}. The correlations were calculated separately for the assessments in 2011, before the opening of the new runway at Frankfurt Airport and in the year 2012, after the opening of the runway. It turns out that the relationships are quite stable over time. In both years, MIAS correlates strongest with the disturbance factor F1 ($r \geq 0.92$) and somewhat lower in a similar range with the single ICBEN annoyance item and with the factor of lack of coping capacity F2 ($r \geq 0.82$). With $r \geq 0.50$, F1 shows the highest correlation coefficients with aircraft noise exposure (L_{den}) among the aircraft noise response variables. With correlations coefficients of $0.46 > r > 0.48$, MIAS and the ICBEN annoyance item correlate with L_{den} in a similar range.

Table 3 – Correlation *r* between aircraft noise responses MIAS and its sub-dimensions and L_{den} – before (2011) and after (2012) opening of the 4th runway at Frankfurt Airport

MIAS dimensions	Annoyance (ICBEN)		F1		F2		L_{den}	
	before	after	before	after	before	after	before	after
MIAS	0.823	0.845	0.924	0.930	0.838	0.864	0.464	0.483
Annoyance (ICBEN)			0.719	0.747	0.587	0.650	0.476	0.465
F1 Disturbances					0.594	0.641	0.502	0.512
F2 Lack of coping capacity							0.243	0.306

Note. *N* = 3459; *p* < .001 for all correlation coefficients

3.3 Exposure-response relationship for aircraft noise annoyance (MIAS) and its components) before and after changes in aircraft noise exposure at Frankfurt Airport

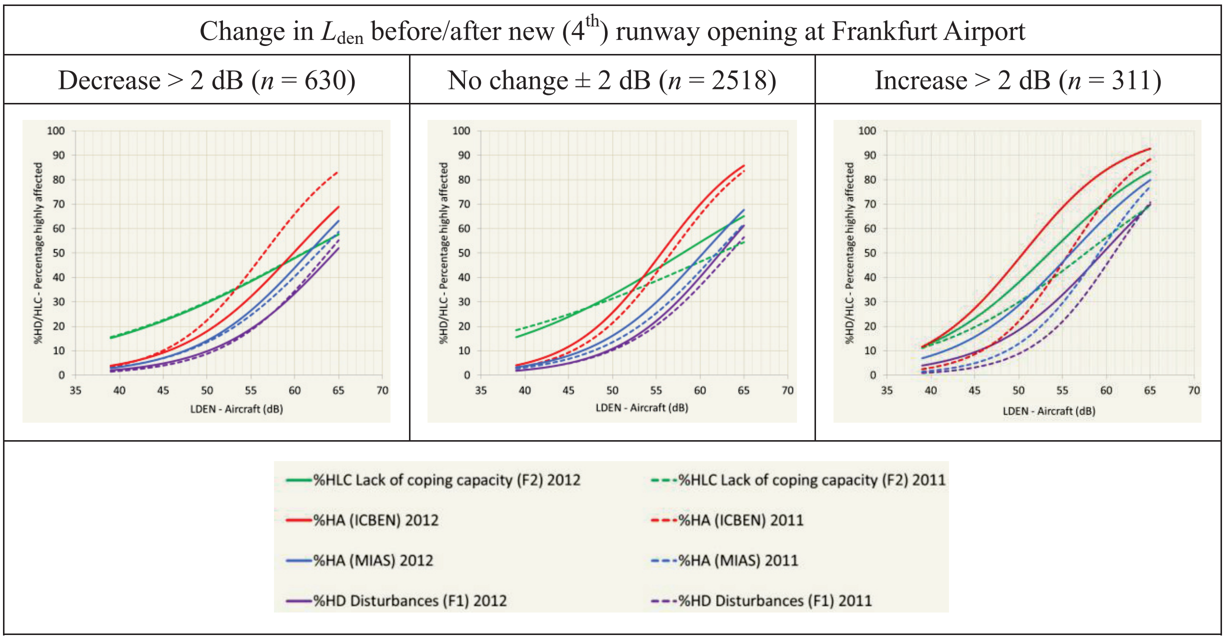
For MIAS and its components, Figures 2 and 3 show the results of the exposure-response analyses before and after changes in aircraft noise exposure at Frankfurt Airport. The results refer to the percentage of persons highly annoyed (%HA), highly disturbed (%HD), and perceiving high lack of coping capacity (%HLC). Response scores above a cut-off of 72% of the response scale indicate HA, HD, and HLC, respectively (13). The results can be summarized as follows:

%HA due to aircraft noise is lower when assessed with MIAS than with the single 5-point ICBEN item. This is because the percentage of persons reporting high responses to the MIAS factors F2 'Lack of coping capacity and, in particular, F1 'Disturbances' are lower than the percentage of those self-assessing their aircraft noise annoyance with the ICBEN annoyance item.

Differences between the curves of responses in 2012 compared to the respective ones from 2011 indicate change effects. Change effects are less pronounced in the 'no change' group (i.e., in areas with changes in $L_{\text{den}} \leq 2$ dB) and strongest in the condition of changes of $L_{\text{den}} > 2$ dB. Change effects in %HA differ dependent on the annoyance assessment: For aircraft noise annoyance self-assessed with the ICBEN annoyance item a change effect occurs in all areas and in both directions. That is, in the condition of a decrease in L_{den} after the opening of the new runway the %HA curve based on the assessments with the ICBEN item in 2012 is lower to the curve of the 2011 assessments, in the condition of no change above 2 dB L_{den} the %HA curve is marginal and in the condition of an increase above 2 dB strongly shifted up compared to the respective 2011 curve. When %HA is based on the MIAS assessment, no significant change effect can be found in areas with a decrease in L_{den}, but still a marginal effect in 'no change' areas and a stronger effect in areas with an increase in L_{den} above 2 dB.

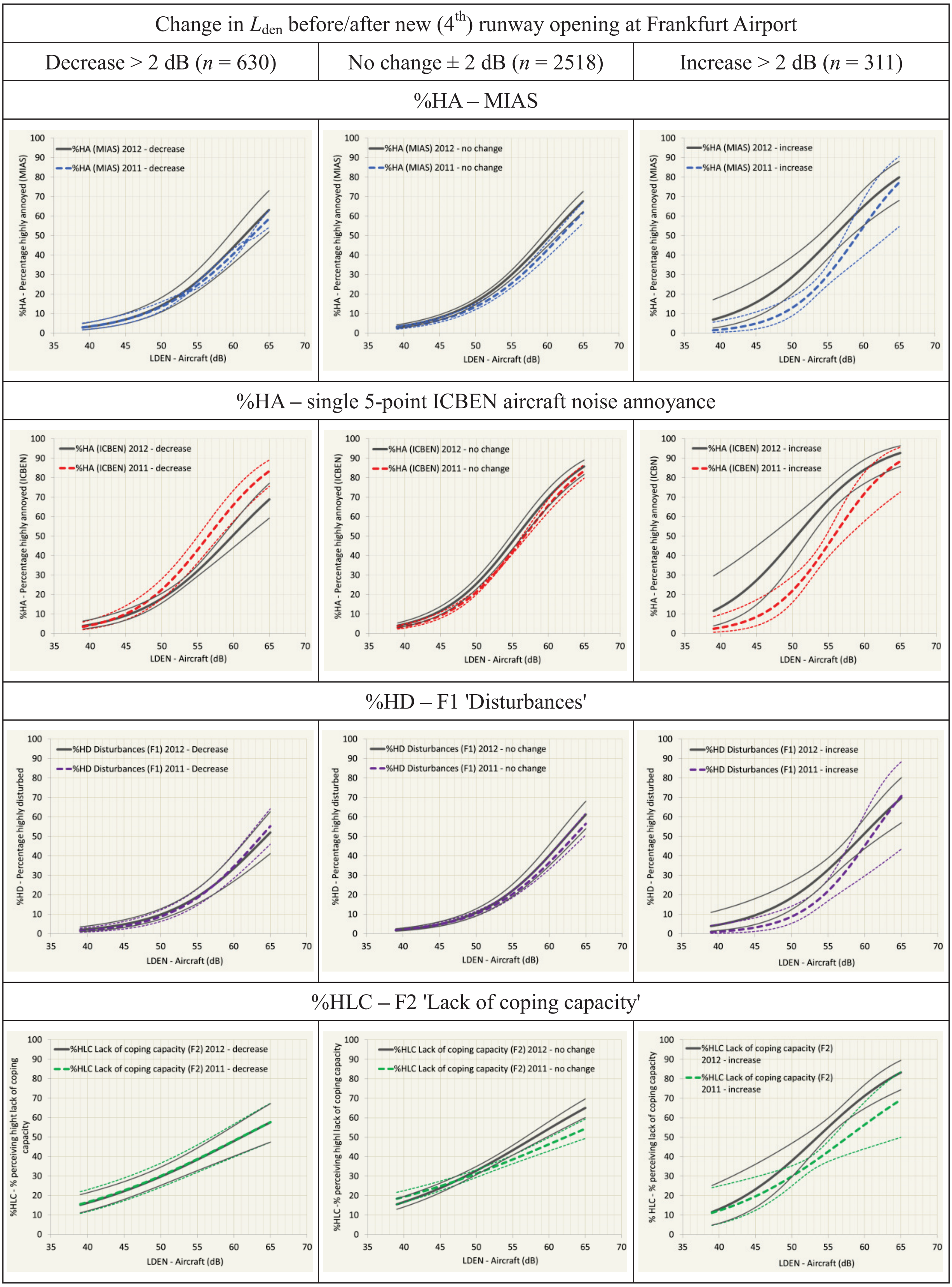
In line with this, compared to the curves of the 2011 assessments the %HD curves (factor F1) of 2012 remain stable in the 'decrease' and 'no change' areas, but is shifted up in 'increase' areas, in particular in those with aircraft sound exposure $L_{\text{den}} < 60$ dB. Similar, in 'decrease' areas the %HLC curves of 2011 and 2012 are almost the same. In 'no change' areas the %HLC curve of 2012 is marginal above the 2011 curve, particularly in areas with $L_{\text{den}} > 55$ dB, whereas in particular in 'increase' areas above 50 dB in L_{den} the 2012 curve of %HLC is shifted up compared to the 2011 curve.

In areas with an increase in aircraft sound exposure, the change effect decreases with increasing sound exposure for %HD and increases for %HLC.



Note. Blue/red curves: percentage (%) highly annoyed as assessed with MIAS (blue) and ICBEN item (red); violet: % highly disturbed; green: % perceiving high lack of control; dashed: assessments of 2011; solid: assessments of 2012. For better readability, limits of the 95% confidence intervals are not shown. All responses refer to aircraft noise.

Figure 2 – Summary of exposure response relationships for MIAS and its components against L_{den} in groups of changes in aircraft sound (L_{den}) in 2012 after the opening of the new runway.



Note. Blue/red dashed curves: % highly annoyed as assessed with MIAS (blue) and ICBEN item (red) in 2011; violet, dashed: % highly disturbed, 2011; green, dashed: % perceiving high lack of control, 2011; grey: respective assessments in 2012. Thin curves: lower/upper limits of the 95% confidence interval. All responses refer to aircraft noise.

Figure 3 – Exposure response relationships and 95% confidence intervals for MIAS and its components against L_{den} in groups of changes in aircraft sound (L_{den}) in 2012 after the opening of the new runway.

4. DISCUSSION AND CONCLUSIONS

With longitudinal data of a sample of 3459 participants of the NORAH study at Frankfurt Airport it was analysed whether the assessment of aircraft noise annoyance before (2011) and after (2012) major changes at the airport (opening of a new runway, implementation of a night flight ban) with the hierarchical higher order multiple item annoyance score (MIAS) improves the understanding of the change effect (excess response) in aircraft noise annoyance. The sum score MIAS comprises the factors F1 'Disturbances due to aircraft noise', F2 'Lack of coping capacity and the single 5-point ICBEN annoyance item. The results indicate a change effect in terms of a shift in the exposure-response curves after the change in exposure (2012) compared to the situation before (2011) in particular in areas with an increase in aircraft sound exposure of more than 2 dB in L_{den}.

This is in line with previous studies. For example, Breugelmans et al. (14) showed that after the opening of the 6th runway at Schiphol Airport a change effect in annoyance occurred in the group of residents that suffered from an increase in aircraft sound exposure (L_{den}). No change effect was observed at Schiphol Airport in groups of a decrease or no change in L_{den}.

In this study, the change effect is higher for aircraft noise annoyance as assessed with the single 5-point ICBEN item compared to the annoyance assessment by means of the MIAS score. There is low evidence of a change effect, particularly for the 'disturbance' part of MIAS, whereas, at least in areas with no change or an increase in aircraft noise exposure, a change effect is observed in the factor 'lack of coping capacity', which increases with increasing degrees of aircraft noise exposure.

A previous analysis of the NORAH panel data (4) had already shown that in the 'increase' condition the change in aircraft noise annoyance as assessed with the ICBEN item is not explained by changes in aircraft sound level after the opening of the new runway and that, instead, annoyance changes are predicted by coping capacity and attitudes and expectations regarding air traffic.

In line with this, there is evidence from the NORAH study that the trust that authorities would endeavour to minimise the aircraft noise annoyance and aircraft noise annoyance are reciprocally related to each other, but that the effect size of the path from 'trust in authority' to the annoyance judgment one year later is higher in the change period of 2011/2012 than in the steady-state period afterwards 2012/2013 (15). Furthermore, it could be shown that the aircraft noise exposure and much more the residual change in aircraft noise exposure 2012 compared to 2011 have an impact on mental health-related quality of life (HQoL) beyond noise-specific responses (16). In addition, the attitudes and mental HQoL (as assessed with the Short Form Health Survey SF-8) correlate higher with the factor F2 'Lack of coping capacity' than with F1 'Disturbances (Table 5).

Table 5 – Correlations r of MIAS and its sub-dimensions with trust in authority and mental HQoL (MCS) assessed before (2011) and after (2012) the 4th runway opening at Frankfurt Airport

	MIAS		Annoyance (ICBEN)		F1		F2	
Year	2011	2012	2011	2012	2011	2012	2011	2012
Trust in authority	-0.449	-0.464	-0.382	-0.430	-0.370	-0.382	-0.434	-0.451
MCS – mental HQoL	-0.291	-0.328	-0.180	-0.254	-0.249	-0.288	-0.300	-0.316

Note. For all correlation coefficients $p < .001$; n = 3420-3459. MCS = SF8 mental component summary.

Altogether, this indicates that, in particular when the aircraft noise exposure increased, this threatens the perceived control and the trust in others perceived as responsible for improving or at least not worsening one's own residential situation and this, again, seem to have an impact on individual's well-being in general. This might explain the change effect even when it is not or less observed in disturbances of activities due to aircraft noise.

ACKNOWLEDGEMENTS

This study is part of the conceptual and methodological work of the WPs 2 and 3 of the EU project ANIMA (Aviation Noise Impact Management through Novel Approaches). ANIMA has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 769627. For this study, data of the research project NORAH (Noise-Related Annoyance,

Cognition, and Health) was used. NORAH was commissioned by the Environment & Community Center / Forum Airport & Region, Kelsterbach, Germany.

REFERENCES

1. Guski R, Felscher-Suhr U, Schuemer R. The concept of noise annoyance: How international experts see it. J Sound Vibration 1999; 223(4):513–27.
2. Schreckenberg D, Belke C, Spilski J. The development of a Multiple-Item Annoyance Scale (MIAS) for transportation noise annoyance. Int J Environ Res Public Health 2018; 15(5).
3. Fields JM, Jong RG de, Gjestland T, Flindell IH, Job RFS, Kurra S et al. Standardized general-purpose noise reaction questions for community noise surveys: Research and a recommendation. J Sound Vibration 2001; 242(4):641–79.
4. Schreckenberg D, Belke C, Faulbaum F, Guski R, Möhler UM, Spilski J. Effects of aircraft noise on annoyance and sleep disturbances before and after expansion of Frankfurt Airport – results of the NORAH study WP 1 ' Annoyance and quality of life '. Proc INTER-NOISE 2016; Hamburg, Germany 2016.
5. Brown AL, van Kamp I. Response to a change in transport noise exposure: a review of evidence of a change effect. J Acoust Soc Am 2009; 125(5):3018–29.
6. Brown AL, van Kamp I. Response to a change in transport noise exposure: Competing explanations of change effects. J Acoust Soc Am 2009; 125(2):905-14.
7. Brown AL, van Kamp I. WHO Environmental Noise Guidelines for the European Region: A Systematic Review of Transport Noise Interventions and Their Impacts on Health. Int J Environ Res Public Health 2017; 14(8).
8. Raw GJ, Griffiths ID. Subjective response to changes in road traffic noise: A model. J Sound Vibration 1990; 141(1):43–54.
9. Stallen PJM. A theoretical framework for environmental noise annoyance. Noise Health 1999; 1(3):69.
10. Hatfield J, Job RS, Hede AJ, Carter NL, Peploe P, Taylor R et al. Human response to environmental noise: The role of perceived control. Int J Behav Med 2002; 9(4):341–59.
11. FlugLSV. Erste Verordnung über die Datenerfassung und das Berechnungsverfahren für die Festsetzung von Lärmschutzbereichen vom 27. Dezember 2008.: Anlage 2: Anleitung zur Berechnung von Lärmschutzbereichen (AzB). Bundesanzeiger 2008; 195a:2.
12. Möhler U, Liepert M, Mühlbacher M, Beronius A, Nunberger M, Braunstein G, Gillé M, Schaal J, Bartel R. Erfassung der Verkehrsgeräuschexposition (Estimation of transportation noise exposure). In Gemeinnützige Umwelthaus gGmbH (Hg.), NORAH (Noise related annoyance cognition and health): Verkehrslärmwirkungen im Flughafenumfeld (Impact of transportation noise in communities around an airport) (Vol. 2). Kelsterbach, Germany: Umwelthaus gGmbH; 2015. Available from https://www.norah-studie.de//en/publications.html?file=files/norah-studie.de/Downloads/NORAH_Bd2_Akustik_Endbericht.PDF.
13. Miedema HME, Vos H. Exposure-response relationships for transportation noise. J Acoust Soc Am 1998; 104: 3432-45.
14. Breugelmans O, Houthuijs D, van Kamp I, Stellato R, van Wiechen C, Doornbos G. Longitudinal effects of a sudden change in aircraft noise exposure on annoyance and sleep disturbance around Amsterdam airport. Proc ICA 2007; Istanbul, Turkey 2007.
15. Schreckenberg D, Benz S, Kuhlmann J, Conrady M, Felscher-Suhr U. Attitudes towards authorities and aircraft noise annoyance. Sensitivity analyses on the relationship between non-acoustical factors and annoyance. Proc ICBEN 2017, June 18-22, 2017: Zurich, Switzerland 2017.
16. Schreckenberg D, Benz S, Belke C, Möhler U, Guski R. The relationship between aircraft sound levels, noise annoyance and mental well-being: An analysis of moderated mediation. Proc ICBEN 2017, June 18-22, 2017: Zurich, Switzerland 2017.