How aircraft noise impact management can improve residents' quality of life – A field study

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ABSTRACT

The EU research project Aviation Noise Impact Management through Novel Approaches (ANIMA) aims to develop new methods and instruments for reducing aircraft noise impact and enhancing the quality of life (QoL) of residents near airports. The focus of the current study is to identify those aspects that improve residents' QoL, based on existing interventions implemented by airports, the aviation industry, or public authorities. Four different European Airport regions (in France, Germany, The Netherlands, and UK) were chosen to investigate the impact of different interventions, such as sound insulation schemes and a dialogue forum, on residents' QoL. Focus groups and in-depth interviews were carried out at three airport locations to get a comprehensive and thorough understanding of the specific interventions, if and how these are perceived by residents, and which aspects of these interventions have an impact on their QoL. Further, existing data from a survey conducted around Schiphol Airport was re-analysed, indicating which aspects of residents' living environment are most relevant comparing three noise contours. In this contribution, the procedure and the results of the study are described and discussed.

Keywords: ANIMA, aircraft noise, intervention, quality of life

INTRODUCTION

Aircraft noise exposure can have various negative health effects and adverse effects on people's quality of life (QoL; e.g. [1]). The experience of aircraft noise annoyance, which can be viewed as a stress response to noise, has been identified as an important factor within this pathway [2]. To address and minimize the negative effects of aircraft noise exposure, various interventions have been implemented by air traffic stakeholders. It is, however, often unclear how these interventions are perceived by residents in airport regions and if and how they

affect residents' QoL. Further, little is known about QoL in airport regions per se and which aspects are most relevant for the residents. Answering these questions and developing new tools and methods for mitigating the negative impact of aircraft noise exposure, while simultaneously enhancing residents' QoL, was one aim of the EU research project Aviation Noise Impact Management through Novel Approaches (ANIMA).

A vast amount of literature exists with respect to different approaches to define QoL and its components (e.g. [3]). Based on a literature review done within ANIMA [4], the EUROSTAT [5] framework was adopted for this research including nine QoL dimensions: health, economic and physical safety, natural and living environment, productive or main activity, education, material living conditions, leisure and social interactions, governance and basic rights, and overall life satisfaction.

To assess QoL in airport regions and examine the impact of different interventions on residents' QoL as well as identifying which aspects of an intervention play a role, four European airport regions and different interventions were selected: Schiphol Airport (Mikroklimaat Leimuiden), Frankfurt Airport (consultation procedure), Marseille Airport (sound insulation), Heathrow Airport (sound insulation). All these interventions are included in the scope of ICAO's Balanced Approach [6]. This approach consists of four pillars: reduction of noise at its source, land use planning and management, operational procedures and operational restrictions. Communication and engagement, such as a consultation procedure, are thought to be relevant throughout all these four pillars. Initially, it was planned to conduct quantitative surveys at each location allowing for a comparison not only between different interventions and their impact on QoL, but also for a comparison between different countries. Due to the COVID-19 pandemic, the initially planned study design had to be adjusted.

The current paper focusses on the qualitative study that was conducted around Frankfurt Airport and on the re-analysis of existing quantitative data collected around Schiphol Airport, for which the ANIMA team received permission to use. A detailed description of the work that has been done, as well as the results, can be found in [7]. First, the methodology and results of the qualitative in-depth telephone interviews will be described shortly. Afterwards, the methodology and results from the survey conducted in the Schiphol airport region will be discussed.

IN-DEPTH INTERVIEWS AROUND FRANKFURT AIRPORT

Since 2008, there has been the *Forum Flughafen und Region* (FFR, forum airport and region) at Frankfurt Airport which seeks to encourage an open dialogue between Frankfurt Airport and the communities of the Rhine-Main-region. In 2018, the FFR presented an active noise abatement program (*Aktiver Schallschutz*) including a proposal for a flight path change of the route *AMTIX kurz*. The proposal was to shift *AMTIX kurz* to the North thereby avoiding densely populated areas. This shift would decrease aircraft noise exposure for some areas but would lead to an exposure increase for other communities. As part of the decision-making process with respect to this change, a consultation procedure was conducted from May to December 2018 engaging affected local communities. The idea was to engage local representatives and residents and give them the opportunity to voice their opinions, share their concerns and give input with new ideas. In this way, additional alternative flight path changes were included in the procedure and discussed as well. There were four components of the consultation procedure: 1) public informative events, 2) a citizen group, 3) a group with political stakeholders, and 4) a website.

The results of the consultation procedure were considered in the decision-making process regarding a potential flight path change. This consultation procedure was evaluated within

ANIMA by means of qualitative in-depth telephone interviews in March and April 2020. The aim was to gain a better understanding of QoL aspects that are relevant for people living near Frankfurt Airport, to shed light on residents' perception of the consultation procedure and identify a potential influence of the intervention on residents' QoL.

Method

To assess people's perceptions on the consultation procedure and its impact on QoL, two different samples were considered: 1) former participants of the citizen group and 2) regular residents. Former participants were recruited with the help of the Gemeinnütziges Umwelthaus GmbH, who contacted these former participants asking for their willingness to participate in the current study.

The other sample was recruited from the general population. To consider the diverse impact of the flight path change to different communities, three areas were selected of which all were involved in the consultation procedure:

- Weiterstadt-Gräfenhausen (overall no significant change in noise exposure, but impact differs between districts),
- Erzhausen (increase in aircraft noise exposure), and
- Darmstadt-Arheilgen (reduction of aircraft noise exposure).

The recruitment was done via phone. The interviews were audio recorded with the permission of the participants and transcribed [8]. The data was analysed according to [9]. The questionnaire included three main topics: 1) quality of life and living environment, 2) airport and the consultation procedure, and 3) the consultation procedure and QoL.

Results and Discussion

In total, 27 people participated in the interviews. Two participants had previously been engaged in the citizen group; both lived in Darmstadt-Arheilgen. Table 1 gives a short overview of the sample descriptions for the groups.

Table 1: Sample description

		Darmstadt-Arheilgen	**Citizen group**	**Erzhausen**	**Weiterstadt-Gräfenhausen**	**Total**
N		9	2	7	9	27
Sex	Female	7	1	0	4	12
	male	2	1	7	5	15
Age	(*M*, *SD*)	57 (14.3)	54 (18)	72 (7.2)	68 (8.8)	64 (13.4)
	Min	28	36	58	55	28
	Max	76	72	78	81	81

When asked about their understanding of QoL and which aspects they perceive to be relevant for their QoL, participants mentioned aspects such as family, health, and their social and living environment. Nature as well as social and financial security also play a role for participants' QoL. Most participants stated that their living environment is central for their QoL with factors like neighbours, the local infrastructure and noise having an impact on their QoL.

With respect to the intervention, 24 participants knew that the consultation procedure had taken place. The aim of the intervention was perceived by most participants to be reducing aircraft noise exposure for high exposed areas by changing the flight path accordingly. Six participants living in Erzhausen and Weiterstadt-Gräfenhausen, specifically stated that the intervention aimed at enabling the construction of residential areas in Darmstadt-Arheilgen, which is currently restricted.

Participants criticised various aspects of the procedure. Approximately one-third of participants did not perceive the consultation as being open-ended. According to them, the decision in favour of a flight path change had already been made. Some had the impression of it being a token event. Other negative aspects mentioned were a lack of honesty and transparency. Interestingly, two thirds of the sample had not participated in the consultation procedure. Nevertheless, the overall participation possibilities within the consultation were viewed as positive. Both participants from the citizen group criticized the lack of information about the citizen group to the public, as they perceived the citizen group was oftentimes misrepresented in the media. Further, inviting residents, who are familiar with the topic, to participate in such a group instead of selecting a random sample was viewed as beneficial. Overall, the general concept of a consultation procedure was regarded as positive and participants would recommend and welcome the implementation of such a procedure at other locations as well. With respect to the specific consultation procedure conducted in the Frankfurt Airport region, the opinions about its usefulness were quite mixed.

Linking QoL and the consultation procedure, participants did not perceive the procedure itself as having an influence on their QoL, only the flight path change and the corresponding change in aircraft noise exposure would impact their QoL.

Due to the small number of participants and the qualitative nature, these findings can only give a first impression of residents' perception of the consultation procedure and its impact on their QoL. As people might not be consciously aware of any potential direct or indirect effect of the consultation procedure on their QoL, further research is needed on this topic to enable the development of firmer conclusions.

SURVEY IN SCHIPHOL AIRPORT REGION

Existing quantitative data from a survey conducted around Schiphol Airport was used to assess one dimension of residents' QoL, i.e. natural and living environment. This survey was commissioned by the Community Council Schiphol and conducted by Team Vier from November 2018 until October 2019. The ANIMA team received permission to use the data for further analysis. The survey covered topics such as residential satisfaction, aircraft noise annoyance and asked about residents' concerns regarding different topics such as pollution and noise annoyance. The questionnaire and descriptive results are online available in Dutch language (http://www.belevingsthermometer.nl/#/).

Method

To examine a potential impact of aircraft noise exposure, three study areas within different noise contours were selected:

1. Inner area (58dB L_{den}),
2. Outer area (48dB – 57dB L_{den}),
3. Area outside noise contour (< 48dB L_{den}).

A disproportionate stratified sample was used to account for the relatively low number of inhabitants in the high exposure area (58 dB L_{den}) compared to the other two areas. The company Team Vier conducted approx. 100 phone interviews each month within the duration of the study. The sample consisted of 1,216 participants (<18 years of age). The response rate was approx. 14%.

The following variables were assessed: age, sex, duration of residence (years: 0-5, 5-10, 10-20, 20-30, >30), residential satisfaction (5-pt scale: 1 = *very satisfied* to 5 = *very unsatisfied*), sleep disturbance and noise annoyance caused by different noise sources (11-pt scale: 0 = *not at all* to 10 = *extremely*; ISO norm ISO/TS 15666), comparison between previous and current experience of aircraft noise annoyance (3-pt scale: 1 = *increased*, 2 = *stayed the same*, and 3 = *decreased*), expectations regarding future aircraft noise annoyance (3-pt scale: 1 = *have increased*, 2 = *have remained the same*, 3 = *have decreased*), how often aircraft noise disturbances occurred in the past month (4-pt scale: 1 = *often* to 4 = *seldom or never*), and worries concerning various topics (3-pt scale: 1 = *a lot of worries* to 3 = *no worries*).

Further, participants were asked whether there were specific days or a time of a day when they experience the most annoyance due to aircraft noise. If participants mentioned specific days or times of a day, three follow-up questions were presented asking about this in more detail (n=749).

Descriptives (means, standard deviations) and correlations were calculated for all variables (only the most relevant variables are depicted in this paper). To examine which variables have an impact on residents' natural and living environment (here: residential satisfaction), a regression analysis was performed. An ANOVA was conducted assessing whether there are significant differences in the responses between the three groups. A Tukey post-hoc analysis was run identifying which groups significantly differ from each other. The data were analysed using SPSS 27 and RStudio for graphics.

Results

In total, responses from 1,212 participants (55% female) were included in the analyses. Participants' age ranged from 18 to 87 (*M*=58.2, *SD*=13.6). Residential satisfaction was on average quite high with 1.85 (*SD*=.87). Approx. 13% stated that they were not satisfied with their residential area. Participants experienced the highest annoyance due to aircraft noise compared to other noise sources, although, the degree of annoyance was relatively low with a mean of 4.52 (*SD*=3.35). Looking at the follow-up questions assessing certain days and times of a day, it seems that participants experience aircraft noise annoyance especially on the weekend (18.6%) compared to weekdays (13.4%; 100% equals the subsample of n=749). For 19.5%, aircraft noise annoyance occurs especially around noon. Table 2 depicts the descriptives of noise annoyance and sleep disturbances due to different sources and worries regarding different topics comparing the three groups.

Table 2: Descriptives (mean, standard deviations) of variables and results of ANOVA analysis comparing the three group.

Variables		**Inner area**	**Outer area**	**Outside noise contour**	**Total**
N		251	722	239	1212
Age		58.7 (13.2)	58.5 (13.9)	56.7 (13.2)	58.2 (13.6)
Sex	Female	140	393	131	664

	male	111	329	108	548
Residential satisfaction		2.05 (1.02)	1.83 (.85)	1.73 (.75)	1.85 (.86)
Noise annoyance	Road traffic	2.93 (2.83)	2.51 (2.72)	2.64 (2.95)	2.63 (2.79)
	Neighbours	1.71 (2.48)	1.97 (2.57)	1.90 (2.50)	1.90 (2.54)
	Railway	.17 (.86)	.50 (1.44)	.71 (1.76)	.47 (1.42)
	Aircraft	6.61 (3.11)	4.30 (3.20)	2.97 (2.99)	4.52 (3.35)
	Industry	.88 (1.82)	.67 (1.74)	.76 (1.98)	.73 (1.81)
	Construction and demolition	1.46 (2.46)	1.74 (2.46)	2.01 (2.78)	1.73 (2.53)
	Loitering teenagers	1.15 (2.17)	1.28 (2.27)	1.29 (2.42)	1.25 (2.28)
Sleep disturbance	Road traffic	1.18 (2.10)	1.04 (2.08)	1.06 (1.93)	1.08 (2.05)
	Neighbours	.55 (1.56)	1.02 (2.08)	1.09 (2.00)	.94 (1.97)
	Railway	.05 (.37)	.23 (1.04)	.26 (1.12)	.20 (.96)
	Aircraft	4.35 (3.64)	2.28 (3.07)	1.26 (2.42)	2.51 (3.25)
	Industry	.35 (1.23)	.29 (1.19)	.32 (1.22)	.31 (1.21)
	Construction and demolition	.51 (1.64)	.61 (1.56)	.59 (1.56)	.58 (1.58)
	Loitering teenagers	.66 (1.74)	.76 (1.82)	.80 (2.01)	.75 (1.85)
Worries	Safety	2.39 (.73)	2.35 (.71)	2.41 (.70)	2.37 (.71)
	Climate Change	1.97 (.77)	1.94 (.76)	1.90 (.78)	1.94 (.77)
	CO2-emission	1.96 (.81)	2.02 (.78)	2.08 (.76)	2.02 (.78)
	Particulate matter, incl. ultra-fine dust	1.81 (.81)	2.01 (.80)	2.03 (.81)	1.98 (.81)
	Air pollution	1.70 (.77)	1.91 (.77)	1.97 (.75)	1.88 (.77)
	Noise annoyance	1.89 (.82)	2.32 (.74)	2.47 (.66)	2.26 (.77)
	Crowded supply routes	2.29 (.76)	2.24 (.79)	2.28 (.77)	2.26 (.78)
	Parking facilities	2.58 (.71)	2.40 (.79)	2.37 (.77)	2.43 (.77)
	Public transport connections	2.54 (.72)	2.52 (.74)	2.60 (.65)	2.54 (.72)

Correlation calculations reveal that residential satisfaction is significantly positively associated with noise annoyance and sleep disturbance from all 7 different sources. The highest correlations were found for annoyance due to loitering teenagers (r=.28, p < .01) and sleep disturbances due to road traffic noise (r=.27, p < .01). Residential satisfaction is negatively correlated with the frequency of disturbances due to aircraft noise during the past month (r=-.20, p < .01), the comparison between past and current aircraft noise annoyance (r=-.08, p < .05), as well with future expectations concerning aircraft noise annoyance (r=-.10, p < .01). A graphic depiction of the strength of the correlations can be found in Figure 1. A blue square indicates a positive relationship between the variables and a red square describes a negative relationship. The darker colours show a high correlation between the variables.

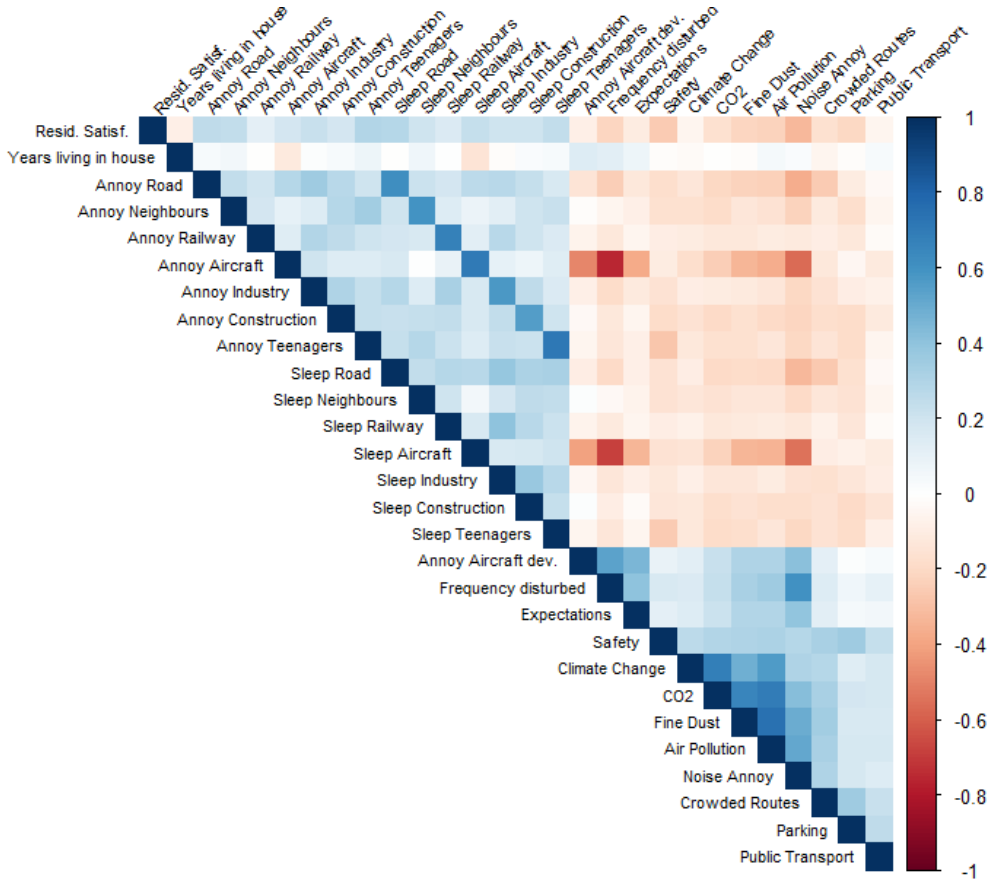

Figure 1: Correlation plot displaying the relationship between the different variables, N=1212

Regression analyses were conducted to assess a potential influence of annoyance and sleep disturbances due to different noise sources as well as worries concerning different topics on residential satisfaction. Sex and age were included as well. When adding aircraft noise annoyance and sleep disturbances due to aircraft noise, the variance in residential satisfaction explained by the model improves from 14.5% to 19% (adjusted R^2=.181; $F(13,1190)=21.425$, $p < 0.01$), showing a moderate goodness-of-fit [Cohen, 1988]. Worries regarding noise annoyance had the largest effect on residential satisfaction, followed by worries concerning safety (Table 3). Noise annoyance due to loitering teenagers and sleep disturbance related to road noise also reach significance. Aircraft noise annoyance does not have a significant effect on residential satisfaction. Age reaches significance at a .05 level.

Table 3: Results of the regression analysis

Predictor	**B**	**SE**	**p**	**95% CI**	
				Lower	**Upper**
Intercept	2.137**	.189	.000	1.767	2.508
Sex	-.003	.046	.955	-.093	.088
Age	.003*	.002	.043	.000	.007
Road traffic noise annoyance	-.005	.011	.674	-.026	.017

Neighbour noise annoyance	.036**	.010	.000	.016	.055
Aircraft noise annoyance	-.016	.010	.116	-.036	.004
Industry noise annoyance	.048**	.014	.000	.021	.075
Construction and demolition	.003	.010	.728	-.016	.023
Loitering teenagers	.052**	.015	.000	.023	.081
Sleep disturbance road	.048**	.015	.001	.019	.077
Sleep disturbance aircraft noise	.020*	.011	.053	.000	.041
Sleep disturbance teenagers	.000	.018	.985	-.035	.036
Worry safety	-.131**	.035	.000	-.199	-.064
Worry noise annoyance	-.162**	.040	.000	-.240	-.084

Results from an ANOVA and a Tukey post hoc analysis show significant differences between the groups for some variables (Table 4 for ANOVA). All aircraft-related variables are more negatively pronounced in the high exposure group. For example, participants in the high exposure group were more frequently bothered by aircraft noise in the past month and more often expected their aircraft noise annoyance to increase in the future.

Table 4: Results of the ANOVA analysis

Variables		**Inner area**	**Outer area**	**Outside noise contour**	**F(2,1207)**	**p**
Residential satisfaction		2.05 (1.02)	1.83 (.85)	1.73 (.75)	8.62	.000
Noise annoyance	Road traffic	2.93 (2.83)	2.51 (2.72)	2.64 (2.95)	2.06	.128
	Neighbours	1.71 (2.48)	1.97 (2.57)	1.90 (2.50)	.92	.399
	Railway	.17 (.86)	.50 (1.44)	.71 (1.76)	9.28	.000
	Aircraft	6.61 (3.11)	4.30 (3.20)	2.97 (2.99)	86.61	.000
	Industry	.88 (1.82)	.67 (1.74)	.76 (1.98)	1.32	.268
	Construction and demolition	1.46 (2.46)	1.74 (2.46)	2.01 (2.78)	2.95	.053
	Loitering teenagers	1.15 (2.17)	1.28 (2.27)	1.29 (2.42)	.35	.708
Sleep disturbance	Road traffic	1.18 (2.10)	1.04 (2.08)	1.06 (1.93)	.44	.644
	Neighbours	.55 (1.56)	1.02 (2.08)	1.09 (2.00)	6.09	.002
	Railway	.05 (.37)	.23 (1.04)	.26 (1.12)	3.80	.023
	Aircraft	4.35 (3.64)	2.28 (3.07)	1.26 (2.42)	66.75	.000
	Industry	.35 (1.23)	.29 (1.19)	.32 (1.22)	.26	.770
	Construction and demolition	.51 (1.64)	.61 (1.56)	.59 (1.56)	.38	.684
	Loitering teenagers	.66 (1.74)	.76 (1.82)	.80 (2.01)	.42	.658
Development of aircraft noise annoyance		1.32 (.52)	1.59 (.59)	1.65 (.57)	24.02	.000

Frequency bothered by aircraft noise past month	2.21 (1.12)	2.96 (1.08)	3.35 (.89)	75.81	.000
Expectations aircraft noise annoyance	1.43 (.54)	1.65 (.54)	1.67 (.50)	16.52	.000

Discussion

Looking at the results, residential satisfaction is high across all three groups, although there is a significant difference between people living in the inner area compared to both other groups. In addition, participants from the high exposure group report a higher aircraft noise annoyance, more aircraft noise-related disturbances, as well as a negative development regarding the experience of aircraft noise annoyance (i.e. a higher current noise annoyance compared to the past), and a more negative view on their future aircraft noise annoyance. Moreover, this group experience significantly less sleep disturbances from neighbourhood and railway noise and more sleep disturbances induced by aircraft noise. This could indicate that other noise sources fade into the background as aircraft noise is the most prominent source in this region.

The regression analysis reveals that, overall, participants' worries concerning general noise annoyance and safety are more relevant for residential satisfaction than aircraft noise annoyance-related variables. It is important to note that the study duration was over a year and included the winter and summer season. As noise annoyance is higher during summer than during winter as people spend more time outside [10], results are likely to differ depending on the season participants were interviewed.

Further research is still needed with respect to QoL in airport regions and specifically for assessing the impact of different noise management and mitigating interventions on residents' QoL. The qualitative part of this research implies some issues that could arise when implementing and conducting a consultation procedure. However, no firm conclusion can be drawn. The quantitative data show that residential satisfaction can differ between different aircraft noise exposure levels, but other, not specifically aircraft noise-related aspects, seem to play a more relevant role.

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