The perception of aircraft noise and its impact among children

Susanne Bartels[1], **Julia Quehl**[1], **& Daniel Aeschbach**[1]

[1] *German Aerospace Center (DLR), 51147 Cologne, E-Mail: susanne.bartels@dlr.de*

Introduction

Children are considered vulnerable when it comes to the effects of aircraft noise. Because they are in a sensitive phase of physical and cognitive growth and development, they are more susceptible to environmental stressors. Additionally, children have a lower ability to assess actual hazards of noise to their health and cope with them, further increasing their vulnerability. Longer sleep periods covering busy periods during the evenings and early mornings (so called shoulder hours) also contribute to the potential negative impact of aircraft noise. Furthermore, exposure to noise from an early age may increase the risk of developing cardiovascular diseases later in life [1].

Numerous studies have shown the negative psychological effects of aircraft noise on children, including impaired cognitive performance and lower quality of life [e.g., 2]. In contrast, the number of studies examining the concept of annoyance – that is assumed to be part of the causal relationship between long-term exposure to transportation noise and increased risks for mental and physical diseases [3] – is limited. Children have been found to be less annoyed by aircraft noise than adults [2]. Although the concept of annoyance and its influencing factors are assumed to be alike for children and adults, it is not yet fully understood which factors actually contribute to children's annoyance [4]. The noise impact among children is predominantly surveyed among parents, thus, children's perspective is often lacking. Moreover, surveys often refer to the aircraft noise exposure at school but not or to a lesser extent to the home environment.

The present study, thus, explored: a) how children perceive aircraft noise and its impact on themselves in their home environment, focusing on annoyance and disturbance of activities, b) potential differences between children's self-reports and parents' assessments, and c) potential factors contributing to children's overall annoyance due to aircraft noise during the past year.

Methods

Sample

We included 51 healthy children (23 female, 28 male) aged 8 to 10 years with a normal hearing ability and a minimum length of residence in the neighborhood of 12 months. Per participating child, one parent from the same household was surveyed as well (45 mothers, 6 fathers). All children lived in the vicinity of Cologne/Bonn Airport that is a German hub with a 24/7 flight operation scheme. Aircraft noise exposure ranged from 50 dB(A) $\leq L_{den} <$ 70 dB(A) to 45 dB(A) $\leq L_{night} <$ 65 dB(A) among measurement sites.

Materials

The study reported here was an explorative survey embedded in a field study across four consecutive days on the acute effects of aircraft noise on sleep and annoyance among primary school children [5]. Children and their parents were surveyed separately at the very beginning of the study to avoid any bias or sensitization due to the study protocol of the following days.

We interviewd children via a computer-assisted personal interview while parents filled in a corresponding paper-pencil version of the survey at the same time. All questions and scales of the child version were tested in a pre-test with nine children in the same age range and – if necessary – adapted according to the results of this pre-test. For instance, we slightly adjusted the original wording of the question for the assessment of annoyance during the past 12 months [6]. The word "belästigen" (German translation of "to annoy") was replaced by "ärgern" (English: "to irritate"), because in the children's view, the term "belästigen" was associated with (sexual) harassment. Moreover, we added standardized child-adequate explanations for rather abstract psychological concepts, such as the general sensitivity to noise. In the final version of the questionnaire, we used equidistant, standard verbal 5-point scales [7] to assess aircraft noise-induced annoyance during the past 12 months as well as for the majority of potential influence factors of annoyance (e.g. noise sensitivity, attitudes). In order to obtain the frequency of the disturbance of daily activities, we applied ordinal 5-point scales. All answer options were handed out in a printed version to the children for an easier visualization and representation. In case, children had difficulties to answer a question, they could use the option "do not know" to avoid a tendency to central answer options.

Aircraft noise exposure was assessed via an environmental noise map online available and provided by the Ministry for the Environment, Nature Conservation and Transport of the Federal State of North Rhine Westphalia [8]. We extracted both the L_{den} and the L_{night} in 5 dB(A)-steps for each participating household.

Statistical analyses

Paired t-tests or paired Wilcoxon signed-rank test (for ordinal data) were applied to analyze differences between children's and parents' responses. Correlations between responses were tested computing Pearson's (r) as well as Spearman's correlation coefficient (r_s, for ordinal data). Because of the small sample size and the explorative nature of the study, we considered p-values ≤ 0.1 as indicating a statistical trend.

Results

Disturbance of everyday activities

Disturbance of everyday-activities was investigated in three groups of activities, see Figure 1 (communication), Figure 2 (other daytime activities), and Figure 3 (sleep). According to the children, passive communication (watching TV or listening to the radio) was the activity most frequently disturbed (median, *Mdn* = 3, "once a month or more often disturbed"). Children tended to rate their disturbance of passive communication higher than their parents ($p = 0.10$). Active communication (personal or phone conversations) was less often disturbed in the view of the children both in terms of outdoor (*Mdn* = 2) and indoor activity (*Mdn* = 1.5). Whilst parents' assessments were not significantly different from children's responses for active communication indoors ($p = 0.782$), parents rated higher disturbance for active communication outdoors ($p = 0.023$).

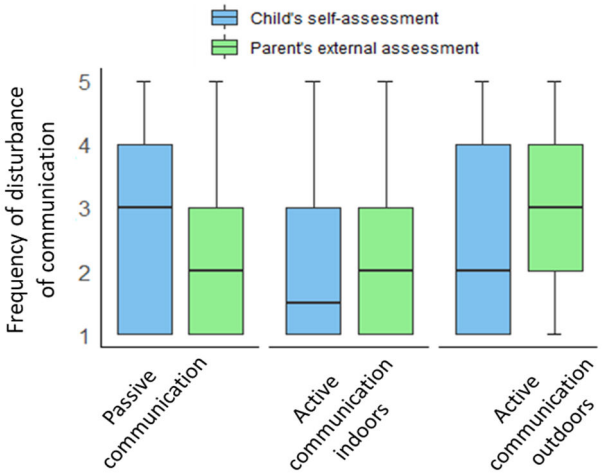

Figure 1: Frequency of the disturbance of communication at home during the past year, answer options: 1 = never, 2 = once a year or more often, 3 = once a month or more often, 4 = once a week or more often, 5 = every day. Boxes indicate the inter-quartile range; whisker boundaries indicate 1.5 times the inter-quartile range).

Among other daytime activities (Figure 2), children reported lowest disturbance for playing indoors and outdoors (*Mdn* = 1 „never disturbed"). Activities requiring a high amount of concentration (reading, doing homework, learning) and relaxation were disturbed more often (*Mdn* = 2 „once a year or more often"). However, variances were quite high, with the third quartile overlapping answer option 4 "once a week or more often". We did not find any significant differences between children's and parents' responses with respect to these other daytime activities (all $p > 0.18$).

With regard to sleep (Figure 3), children reported highest disturbance while trying to fall asleep (*Mdn* = 3 „once a month or more often"). Parents rated children's disturbance of falling asleep significantly lower ($p = 0.029$). Disturbance during night's sleep and while sleeping late on free days was less pronounced according to the children (*Mdn* = 2) and they rated disturbance (on a trend level) lower than their parents ($p = 0.052$ and $p = 0.038$, respectively).

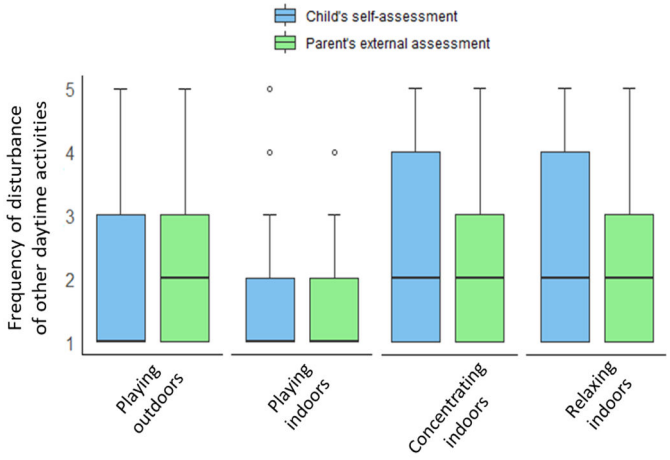

Figure 2: Frequency of the disturbance of other everyday-activities at home during the past year, answer options: 1 = never, 2 = once a year or more often, 3 = once a month or more often, 4 = once a week or more often, 5 = every day. Boxes indicate the inter-quartile range; whisker boundaries indicate 1.5 times the inter-quartile range).

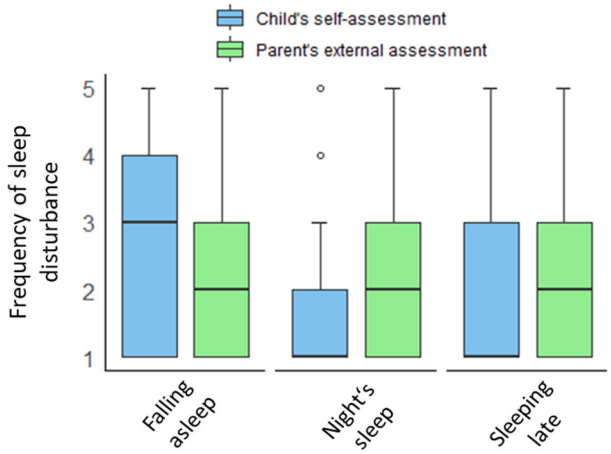

Figure 3: Frequency of the disturbance of sleep at home during the past year, answer options: 1 = never, 2 = once a year or more often, 3 = once a month or more often, 4 = once a week or more often, 5 = every day. Boxes indicate the inter-quartile range; whisker boundaries indicate 1.5 times the inter-quartile range).

Annoyance

Annoyance due to aircraft noise during the past 12 months was compared between children and their parents both concerning the children's annoyance (Figure 4a) as well as regarding the self-reported annoyance (Figure 4b). Children described themselves as "little" to "moderately annoyed" ($M = 2.29$, *Mdn* = 2). Children's self-reported annoyance and parents' external assessment did not differ ($M_{diff} = 0.04$, $p = 0.776$) and were related ($r = 0.39$, $p = 0.004$). In contrast, children's and parents' self-reported annoyance differed significantly ($M_{diff} = -0{,}96$, $p < .001$) with higher annoyance responses for parents.

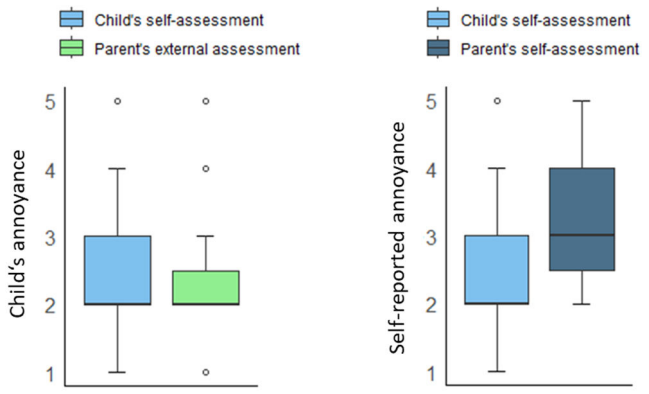

Figure 4a and 4b: Overall annoyance due to aircraft noise during the past 12 months reported for the child (4a) and self-reported annoyance, answer options: 1 = not, 2 = little, 3 = moderately, 4 = fairly, 5 = very disturbed or annoyed. Boxes indicate the inter-quartile range; whisker boundaries indicate 1.5 times the inter-quartile range).

Predictors of children's annoyance

Several acoustical and non-acoustical factors have been found to be significant contributors in previous studies [9, 10] on adult's annoyance due to aircraft noise. They were tested in the present study, too. Table 1 shows the results on the influence of these variables on children's self-reported annoyance.

Table 1: Association between acoustical and non-acoustical factors, respectively, and annoyance due to aircraft noise at home during the past 12 months reported by children.

Factor	Correlation coefficient (r or r_s with p-value)
L_{den}	r_s = -0.07 (p = 0.643)
L_{night}	r_s = -0.28 (p = 0.843)
General sensitivity to noise (1 = not sensitive – 5 = very sensitive)	r = 0.17 (p = 0.221)
Attitudes described as agreement to the following statements: Aircraft are …	
… useful	r = -0.10 (p = 0.468)
… hazardous for health	r = -0.07 (p = 0.615)
… hazardous for environment	r = -0.01 (p = 0.924)
… dangerous	r = 0.19 (p = 0.189)
… dispensable	r = -0.07 (p = 0.620)
(1 = not true – 5 very true)	
Fear for aircraft crash (1 not afraid – 5 = very afraid)	r = 0.26 (p = 0.063)
(Dis-)Satisfaction with living environment (1 = very good – 6 unsatisfactory)	r = -0.21 (p = 0.143)

Only fear for aircraft crash was on a trend level related to annoyance. Contrasting our expectations, we found not even a slight trend for an association between noise exposure (L_{den} / L_{night}) and annoyance.

To explore further and, so far, not yet considered factors contributing to annoyance, we examined whether a) parents' self-reported annoyance response during the past 12 months, b) certain activities disturbed by the aircraft noise, and c) the perceived loudness of aircraft flying over the children's homes have any effect on children's annoyance. In addition, we examined the association between a) to c) and the noise exposure in order to screen for potential indirect effects of the noise exposure on children's annoyance.

Parents' self-reported annoyance was not related to children's response (r = 0.004, p = 0.980), however, we observed a trend for a relation between parents' self-reported annoyance and the L_{den} (r_s = 0.25, p = 0.082). Among the activities already examined in terms of their disturbance by aircraft noise, we found that the reported disturbance while relaxing indoors (r_s =0.53, p < 0.001), falling asleep (r_s =0.61, p < 0.001) and sleeping late (r_s =0.58, p < 0.001) contributed significantly to the children's annoyance response. However, neither the L_{den} nor the L_{night} were associated with children's activity disturbance responses (all p - values ≥ 0.20). The reported perceived loudness of aircraft flying over the children's homes (answer options: 1 = "not loud" to 5 = "very loud") was significantly related to the annoyance response (r =0.58, p < 0.001), but not to the L_{den} (r_s = -0.13, p =0.344).

Discussion

This survey exploratively examined the perception of aircraft noise and its impacts with a focus on disturbance and annoyance among 51 healthy children aged 8 to 10 years from the vicinity of Cologne/Bonn Airport.

Concerning the perception of disturbance of typical daily activities, passive communication (watching TV, listening to radio) as well as falling asleep were most often disturbed. While parental assessments aligned with children's responses for some activities (e.g., for playing, relaxing, concentrating), parents tended to underestimate children's annoyance during their attempting to fall asleep and passive communication. Disturbance of other activities (e.g., night's sleep, active communication) outdoors was overestimated by parental assessments. Parents' external assessments moderately predicted children's overall annoyance due to aircraft noise during the past 12 months. In line with previous findings, parents self-reported higher annoyance levels than children [2]. Yet, this perceived higher annoyance was not mirrored by the children's responses.

Regarding the predictors of children's annoyance, results suggest that existing annoyance models designed for adults [9, 10] do not fully capture children's annoyance responses. Notably, noise exposure characterized by the L_{den} extracted from noise maps in 5 dB(A)-steps did not appear to be a reliable predictor of annoyance. Neither direct effects nor indirect effects (e.g. via perceived loudness of aircraft or higher disturbance of activities) played a significant role. While this may partly stem from the limitations of a coarse aircraft noise exposure assessment, a substantial misclassification is unlikely since parents' self-reported annoyance was at least on a trend level positively associated with the L_{den}. Moreover, the study sample consisted only of participants with moderate to high noise exposure resulting in limited variation in the exposure

which may have underestimated the true association between aircraft noise exposure and children's annoyance responses.

Non-acoustical factors found to contribute to overall annoyance in adults, such as general sensitivity to noise, attitudes or the satisfactions with the living environment did not influence children's annoyance responses. Only, the fear for aircraft crashes proven to be a relevant contributor of aircraft annoyance in adults [9] showed, at least, on a trend level also an effect on children's annoyance. Besides, the perceived loudness of the aircraft at home as well as the perceived disturbance while relaxing, falling asleep, and sleeping late contributed the most to children's overall aircraft noise annoyance. It should be noted that also reciprocal associations between annoyance and perceived loudness and activity disturbance, respectively, are conceivable: Children who are more annoyed may perceive aircraft as louder and report more often disturbed everyday-activities. As already found for overall annoyance, we did not observe an association between perceived loudness of aircraft and activity disturbance, respectively, and the L_{den}. The deficiencies of equivalent sound pressure levels as proxy for the noise exposure have been discussed before [e.g., 10]. This may be pronounced in children: Few, but salient and loud aircraft fly-over may be more represented in the children's reflections about the past months than a higher number of fly-overs at moderate levels – even though the L_{den} would be equal in both scenarios. Future surveys should apply a stratification in terms of L_{den} and the number of as well as the maximum sound pressure levels of the overflights in the area.

A general limitation of this study that may have underestimated the true relation between both acoustical and non-acoustical factors and children's annoyance was the exploratory nature of the survey and the small sample size. Moreover, the main theoretical concept used in this study, i.e. annoyance, has not yet been validated in children, before. Annoyance questions and scales were designed and standardized for adults, but not for (primary school) children. Unlike for adults, there are almost no validated survey instruments for non-acoustical contributors of children's aircraft noise annoyance, such as the general sensitivity to noise. Although we tested our questions and scales in a pre-test plus providing an answer option "do not know" and even though 90% of the children reported in the final interview that they understood all questions, we cannot fully rule out that children had difficulties to fully comprehend the nature of these theoretical concepts as well as the applied answer scales.

Conclusion

Based on the present study results, we conclude that children appear less affected by noise-related annoyance compared to adults. However, findings highlight the importance of the perception of noise and disturbance during shoulder hours of the day (while trying to fall asleep or sleeping late). Children's higher susceptibility due to their longer sleep duration covering also busy hours in the evening and morning should always be taken into account. To gain a comprehensive understanding, studies on noise effects in children should survey children's own perspectives whenever possible instead of relying to parental assessments. For this purpose, future research should focus on the development and validation of adequate instruments for both groups, in particular with regard to annoyance and its contributing factors, (e.g. noise sensitivity, attitudes).

Acknowledgement

We would like to thank the participating families for their interest as well as our DLR colleagues who have played a key role in this study: Eva-Maria Elmenhorst, Uwe Müller, Matthias Putzke, Iris Rieger, Manfred Schulze and Helene Majewski in grateful memory.

References

[1] Kempen, E.V., et al.: WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cardiovascular and Metabolic Effects: A Summary. Int J Environ Res Public Health, 2018. 15(2).

[2] Stansfeld, S.A. and Clark, C.: Health effects of noise exposure in children. Current Environmental Health Reports, 2015. 2(2), 171-178.

[3] WHO: Environmental Noise Guidelines for the European Region. 2018, Copenhagen, Denmark: World Health Organization.

[4] Grelat, N., Houot, H., Pujol, S., Levain, J.P., Defrance, J., Mauny, F.: Noise annoyance in urban children: A cross-sectional population-based study. Int. J. Environ. Res. Public Health, 2016. 13(11), 1056.

[5] Quehl, J., et al.: Effects of Nocturnal Aircraft Noise and Non-Acoustical Factors on Short-Term Annoyance in Primary School Children. Int J Environ Res Public Health, 2021. 18(13).

[6] Fields, J.M., et al.: Standardized general-purpose noise reaction questions for community noise surveys: Research and a recommendation - Community response to noise team of ICBEN. Journal of Sound and Vibration, 2001. 242(4), 641-679.

[7] Rohrmann, B.: Empirische Studien zur Entwicklung von Antwortskalen für die sozialwissenschaftliche Forschung. Zeitschrift für Sozialpsychologie, 1978. 9, 222-245.

[8] Ministerium für Umwelt, Naturschutz und Verkehr des Landes NRW: Umgebungslärm in NRW, Lärmkarten 4. Runde, 2022. URL: https://www.umgebungslaerm-kartierung.nrw.de/

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

[10] Bartels, S., D. Rooney, and Müller, U.: Assessing aircraft noise-induced annoyance around a major German airport and its predictors via telephone survey – The COSMA study. Transportation Research Part D: Transport and Environment, 2018. 59, 246-258.