



Effects of aircraft noise exposure on reading and quality of life on primary school children in Germany: Results from the NORAH-study

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ABSTRACT

Prior research has shown that chronic exposure to aircraft noise is associated with lower reading performance and decreasing quality of life in children. In the NORAH-study, the effects of aircraft noise on children's reading and quality of life were investigated in 1,243 second-graders from 29 schools around Frankfurt/Main Airport in Germany. Although exposure levels at schools were below 60 dB and thus considerably lower than in previous studies, multilevel analyses revealed that, after full adjustment for potential confounders on individual and class level, increasing aircraft noise exposure was linearly associated with less positive ratings of quality of life and decreasing reading performance. A 20 dB increase in aircraft noise was associated with a decrease in reading scores of one-fifth of a SD, corresponding to a reading delay of about two months. Teachers' reports indicate that severe disruptions of classroom instruction due to aircraft noise may contribute to the effect on reading.

Keywords: Aircraft Noise, Children, Reading, Quality of Life, Annoyance

1. Introduction

Prior studies proved negative effects of aircraft noise exposure on children's quality of life, noise annoyance, and cognition [1,2,3]. The hitherto most comprehensive study in this field, the cross-sectional RANCH (road-traffic and aircraft noise exposure and children's cognition and health) study [4] included children (N = 2844) living in the vicinity of huge international airports in the UK (Heathrow), the Netherlands (Schiphol), and Spain (Barajas). With socioeconomic status (SES) being controlled, the authors found no effect of aircraft noise exposure on sustained attention, working memory, and delayed recall of orally presented stories, but a linear exposure-effect relationship between aircraft noise and decreasing reading comprehension.

Despite the existing evidence, our knowledge concerning effects of chronic aircraft noise exposure on children is still limited and, for reasons stated elsewhere [5], does not allow well-founded predictions for children from specific noise-exposed areas such as the Rhine-Main-Region surrounding Frankfurt/Main Airport in Germany,. The current study was performed in the context of the NORAH (Noise-Related Annoyance, Cognition, and Health) project, an interdisciplinary research project on the effects of transportation noise on citizens of Rhine-Main. Here we summarize the NORAH-subproject concerning effects of aircraft noise exposure on reading, reading-related abilities, and quality of life in primary school children in the Rhine-Main region. A full report of this study is provided elsewhere [5].

2. Methods

2.1 Participants

A total of 1,243 second-graders and 84 class teachers from 29 primary schools participated in the study. For cognitive performance, complete data from the parent questionnaires and the test battery were available for 1,090 children. For quality of life and noise annoyance, complete data were

available for 1,058 and 1,106 children respectively. Mean age was 8 years and 4 months (SD 5 months), and 60% of the children had a migration background.

2.2 Assessment of Noise Exposure

Aircraft noise levels (L_{Aeq}) at school and at the children's homes for the time period of 12 months before data acquisition were calculated on the basis of radar data from the Flight Track and Aircraft Noise Monitoring System (FANOMOS), provided by German Air Traffic Services. Road traffic and railway noise were calculated using a combination of information provided by local authorities. Classroom reverberation and insulation were assessed through screening procedures [7].

2.3 Tasks and Materials

Reading and reading-related abilities (speech perception, short-term memory, phonological awareness, story comprehension, reasoning) were assessed through standardized paper-and-pencil tests administered in groups of whole classes. Children's noise annoyance and quality of life were assessed via questionnaires for the children and parents. In the children, each statement was read aloud by the experimenter. The children marked their response on answer sheets equipped with age-appropriate pictorial rating scales. Socioeconomic status (SES), migration background, main language spoken at home, and parental support in school learning were assessed through parent and teacher questionnaires. For children with a migration background, individual ratings of proficiency in German language were obtained from the class teachers. In addition, the teachers filled out a questionnaire on methods of reading instruction and annoyance due to noise at school.

The questionnaire scales representing children's annoyance and quality of life had sufficient to good reliability (Cronbach's α .76 - .88).

2.4 Procedure

The tests were performed in groups of whole classes. The speech materials were presented via wireless headphones, in order to ensure perfect signal quality at each working place in the classroom. Each task was carefully explained to the children and practiced with examples. All in all, the testing session in the classroom took about 2 hours.

2.5 Statistical Analyses

In order to account for the hierarchical structure of the data (Level 1: children; Level 2: classes), the associations between aircraft noise exposure and children's abilities were assessed through multi-level analyses using Mplus 7 [6]. The unadjusted model included only aircraft noise. The fully adjusted model was adjusted for the L2-variables sound insulation, road traffic noise, and railway noise, and for a range of L1-variables, i.e., age, gender, nonverbal abilities, SES, migration background, number of books at home, and German language proficiency. When reading scores were considered as outcome variables, story comprehension, and phonological awareness were also included as L1 predictors. Teachers' annoyance ratings were analyzed via univariate analyses of variance and analyses of response frequency distributions. For this aim, the teachers were assigned to one of three groups according to the distribution of aircraft noise levels at school ($L_{Aeq, 08-14}$): low exposure: 39 to 46 dB; medium exposure: 48 to 53 dB; high exposure: 55 to 59 dB.

3. Results

Aircraft noise levels at school ranged from 39 to 59 dB ($L_{pAS,eq,A,08-14}$), with mean $M = 50$ and $SD = 6$. Aircraft noise levels at home ranged from 40 to 61 dB ($L_{pAS,eq,A,06-18}$), with mean $M = 49$ and $SD = 6$. Strong correlations were found between aircraft noise at school and at home ($r = .96, p < .001$).

Aircraft noise exposure at school was significantly associated with a decrease in children's reading after full adjustment. A 20 dB increase of aircraft noise at school was associated with a decrease in children's global reading scores by one fifth of an SD , corresponding to a two-months reading delay in this test. No effects of aircraft noise on reading-related verbal abilities (short-term memory, phonological awareness, listening comprehension) were found. There were small but significant effects of aircraft noise on children's quality of life, assessed through child and parent questionnaires. Aircraft noise exposure was associated with less positive judgments of the children's

psychological and physical health and well-being at school, and with increasing annoyance responses in children and parents. For each of these outcome variables, the associations between aircraft noise was best described as a linear function. Multilevel model statistics and exposure-effect curves are provided in [5].

Teachers from highly exposed schools reported stronger disturbances when compared to teachers from medium and low exposed schools. Out of 21 teachers from the highly exposed schools, 20 (95%) reported high or severe annoyance due to the presence of aircraft noise during instruction. The ratings were strongly correlated with aircraft noise levels at school ($r = .85$; $p < .001$).

Inspections of single items addressing concrete effects of aircraft noise on instruction showed that, out of 21 teachers from highly exposed schools, 11 (52%) reported frequent interruptions of classroom discourse and observable distractions of the children due to aircraft noise. In the less exposed groups, frequent interruptions of discourse and distractions of the children were reported by just one out of 63 teachers (2%). For each item, the group differences in response frequencies were significant ($p < .001$).

4. Discussion and Conclusion

In the current study, detrimental effects of aircraft noise exposure were found for children's reading and quality of life with exposure levels not exceeding 60 dB. Special care was taken to rule out potential confounders such as socioeconomic status and children's proficiency in the language of instruction. It should be kept in mind that, in the current study, children's aircraft noise exposure was considerably lower when compared to prior studies. For example, in the RANCH-study [4], aircraft noise levels at school reached 77 dB (LAeq 06-23). In the Munich longitudinal study [3], schools with aircraft noise levels of 59 dB (LAeq, 24h) were included as "unexposed" controls. To the best of our knowledge, the current study is the first that addressed the effects of comparably moderate levels of aircraft noise on children.

Despite considerable differences in exposure levels, orthography, and age groups, the effect on reading found in the current study is comparable to that found in the RANCH study. This consistency provides strong evidence for a causal, linear association between aircraft noise exposure and decreasing reading performance in children. The findings are of relevance for policy of environmental noise and child health.

REFERENCES

1. Hygge, S., Evans, G. W., & Bullinger, M. (2002). A prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science*, 13(5), 469–474. doi:10.1111/1467-9280.00483
2. Clark, C., Martin, R., van Kempen, E., Alfred, T., Head, J., Davies, H. W.,...Stansfeld, S. A. (2006). Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: The RANCH Project. *American Journal of Epidemiology*, 163(1), 27–37. doi:10.1093/aje/kwj001
3. Clark, C., & Sörqvist, P. (2012). A 3 year update on the influence of noise on performance and behavior. *Noise and Health*, 14(61), 292–296. doi:10.4103/1463-1741.104896
4. H Stansfeld, S. A., Berglund, B., Clark, C., Lopez-Barrío, I., Fischer, P., Öhrström, E., ...Berry, B. F. (2005). Aircraft and road traffic noise and children's cognition and health: A cross-national study. *The Lancet*, 365(9475), 1942–1949. doi:10.1016/S0140-6736(05)66660-3
5. Klatte, M., Spilski, J., Mayerl, J., Möhler, U., Lachmann, T. & Bergström, K. (2016). Effects of Aircraft Noise on Reading and Quality of Life in Primary School Children in Germany: Results from the NORAH Study. *Environment and Behavior*; first published on April 13 as doi:10.1177/0013916516642580.
6. Muthen, L., & Muthen, O. (2014). *Mplus User's Guide. Seventh Edition*. Los Angeles, CA: Muthen & Muthen.
7. Möhler, U., Liepert, M., Mühlbacher, M., Beronius, A., Nunberger, M., Braunstein, G., Gillé, M., Schaal, J., Bartel, R. (2015). *Erfassung der Verkehrsgeräuschexposition*. In Gemeinnützige Umwelthaus

gGmbH (Ed.), NORAH (Noise related annoyance cognition and health): Verkehrslärmwirkungen im Flughafenumfeld (Bd. 2), Kelsterbach, http://www.norah-studie.de/dl.pl?typ=pub&id=1446116917_71891, Abruf am 15.04.2016.