Quality of Life
Health
Development

NORAH Knowledge No. 4

NORAH Noise Impact Study

Child Study: Impact of aircraft noise on children

Results

forum flughafen & region
umwelt- und nachbarschaftshaus

NORAH

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Results

"NORAH Knowledge" provides information on the methods and results of the NORAH noise impact study. The aim of this series is to communicate to as many people as possible what exactly NORAH researched. This is why there is an explanation in the glossary at the end for all terms marked "glossary".

If you would like to receive further issues of "NORAH Knowledge", please use the enclosed order form.

The NORAH Study examines the long-term effects of transportation noise on health, quality of life and childhood development in the Rhine-Main Region. The initiator of the study is the Airport and Region Forum (AFR). The scientists were accompanied from the start by an external Scientific Advisory Board for Quality Assurance (WBQ). This is what distinguishes NORAH from similar, predecessor studies. The study addresses some of the most topical issues currently being dealt with by international noise impact research. It also covers a wider range of investigation aspects than previous studies. In order to find out more about how human beings respond to transportation noise, the NORAH scientists also looked at the medical histories of more than one million people, and reconstructed the noise exposure over the last 18 years at 900,000 addresses in the Rhine-Main Region. A total of five sub-studies form the core of the NORAH Study. Each one builds on the current international state of research, and attempts to understand more precisely how transportation noise affects people. In this edition of NORAH Knowledge we present the results of the Child Study, one of the five sub-studies. The Child Study is an advance publication; the main part of the study will be published in autumn 2015. NORAH Knowledge no. 1 contains detailed information on the methods and tasks of the Child Study.

NORAH ("Noise-Related Annoyance, Cognition, and Health") is the most extensive investigation into the effects of exposure to aircraft, road and rail traffic noise that has ever been carried out in Germany. It was conducted by nine independent scientific institutes from all over Germany. The client was the Umwelt- und Nachbarschaftshaus, a subsidiary of the state of Hessen and part of the "Forum Flughafen und Region". Alongside the state of Hessen, communities, Fraport AG and Lufthansa were also involved in the financing.

Contents

Further information on the NORAH Study can be found on the Internet at
www.laermstudie.de.

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CENTRAL RESULTS OF THE CHILD STUDY – SUMMARY

What impact does aircraft noise have on children's cognitive development and quality of life? The NORAH Child Study attempted to find an answer to this question. To do this, the scientists on the NORAH team conducted tests, surveys and measurements in 85 classes at 29 schools, with 1,243 children, 1,185 parents and 85 teachers in the Rhine-Main Region. The study focuses on learning to read, the children's health and well-being at school and the noise annoyance at home and in school. It thus builds directly on earlier studies at other locations and attempts to answer some questions that remain open.

Aircraft noise reduces reading performance

In areas with high exposure to aircraft noise, primary-school children learn to read more slowly than children in quiet areas. In the 2nd grade children examined, an increase of the long-term energy equivalent sound level (glossary) by ten dB (glossary) delayed learning to read by one month. The connection is linear: the higher the exposure, the greater the negative effect on development. NORAH was unable to verify direct effects of aircraft noise on precursor skills for reading such as phonological awareness or listening comprehension. *More on this on page 6.*

Quality of life in terms of school and health slightly affected

The overall quality of life of the children surveyed in the Rhine-Main Region is high – most of the second-grade children feel very well; they are healthy and enjoy going to school. Children in areas with high exposure to noise do not feel quite as well as children in quieter areas. In addition to this, parents surveyed in areas with relatively high aircraft noise exposure stated more frequently that their child was taking prescribed medication or had been diagnosed with a speech or language disorder. The children concerned were not different, however, to the other children in terms of their reading performance.
For more on this see page 8.

Aircraft noise disturbs lessons

Teachers from areas with relatively high aircraft noise exposure reported unanimously that the noise causes considerable annoyances to lessons. Classes are interrupted in various ways by aircraft noise, often distracting the children's attention. More than one-third of the children from these schools are sometimes unable to hear the teacher properly due to aircraft noise. *For more on this see page 12.*

WHAT DID THE CHILD STUDY EXAMINE?

If children are permanently exposed to aircraft noise, this can have a negative impact on their cognitive development and their learning performance. Various previous studies have come to this conclusion. In particular, the ability to read appeared to suffer under the influence of aircraft noise. However, these older studies did not take into account several confounding factors (glossary) that might have influenced the result. Also, they were carried out in areas with very different and considerably higher noise exposure.

The greatest difficulty in the investigation of learning performance under the influence of aircraft noise: we know from numerous educational studies that learning performance is determined by a wide range of different factors. Among other things, the socioeconomic status (glossary), for example the education level and the income of the parents, as well as their origins, can have a clear statistical influence on the learning performance of the children. The scientists have to take all of these factors into account and filter them out if they want to find out what impact aircraft noise has on learning to read.

The scientists in the Child Study tried to answer the following questions:

- Is it possible to identify a negative impact of aircraft noise on cognitive abilities such as learning to read, language skills, attention or memory of children in the Rhine-Main Region?
- How exactly does aircraft noise at school affect lessons?
- To what extent does aircraft noise affect the well-being of the children at home and at school?
- How great is the influence of aircraft noise relative to other factors?

The selection of schools and children

The scientists first divided up the Rhine-Main Region into different "sound level classes", i.e. into regions where a certain long-term energy equivalent sound level (glossary) prevails during the day. Schools in all four areas were asked to participate. A total of 1,243 second-grade boys and girls took part in the investigation. The schools with the lowest level of aircraft noise exposure had a long-term energy equivalent sound level during the day of 39 dB (glossary). In the schools with the highest level of exposure, the long-term energy equivalent sound level was 59 dB. At the time of the investigation, there were no primary schools in the Rhine-Main Region with higher exposure to aircraft noise than the primary schools in the highest sound level class.

In order to investigate how well the children can read, the scientists used standardised tests which are also used in other learning studies. The study also wanted to examine the thesis that exposure of children to aircraft noise has an effect on the precursor skills for reading, which normally develop at a pre-school age. These skills – for example listening comprehension – are important for learning to read later. The NORAH team also asked the children, their parents and the teachers about the well-being and the quality of life of the children and about the extent of the negative effect they feel aircraft noise has on them.

1,243 boys and girls in second grade, long-term energy equivalent sound level during the day between 39 and 59 dB (A)

Kirstin Bergström

Individual noise calculations

In order to identify a connection between the performance of the children and the noise exposure, it is important to know as precisely as possible which sound level each individual child is exposed to at home and at school. This is why the NORAH acoustics team carried out extensive noise calculations for the Child Study. Radar records of all aircraft movements in the Rhine-Main Region. These were used to calculate the individual aircraft noise exposures in the twelve months before the data collection for all the residential and school addresses of the children in anonymised form. In their analyses the NORAH scientists also took into account the sound insulation and the reverberation times in the classrooms. The acoustic team also calculated the exposure to rail and road noise at the children's homes and schools.

The current state of research

One of the most important studies carried out before NORAH on the impact of aircraft noise on children was the so-called RANCH Study. In 2001 this study investigated similar questions at the airports of Amsterdam, Madrid and London, and discovered a connection between aircraft noise and reading performance. Some of the results of the RANCH Study were contradictory, however. Also, they cannot be fully applied to the current situation in Germany because the sound levels in the RANCH Study were much higher. One important assumption of RANCH and other studies is that if aircraft noise has any impact on school performance, it is most likely to be on learning to read, because this has to do with language processing. This is why both RANCH and NORAH focused precisely on this aspect.

Overview: what did the Child Study investigate and how?

What was investigated?	Method
Aircraft, rail and road noise exposure at school and at home	Data calculated by the NORAH acoustics team
Building and room acoustics of the classrooms	Screening methods for estimation of the reverberation time and the noise insulation
Reading ability and precursor skills Reading skills Short and long-term memory for verbal information Phonological awareness Speech perception Attention Non-language skills	Standardised group tests in the class
Quality of life and environment Well-being at school and at home, noise annoyance, socioeconomic status	Child survey, parent questionnaire, teacher questionnaire
Noise exposure at school and at home	Child survey, parent questionnaire, teacher questionnaire

Kirstin Bergström

The scientists used standardised tests to examine the reading ability and the precursor skills of the second-grade children.

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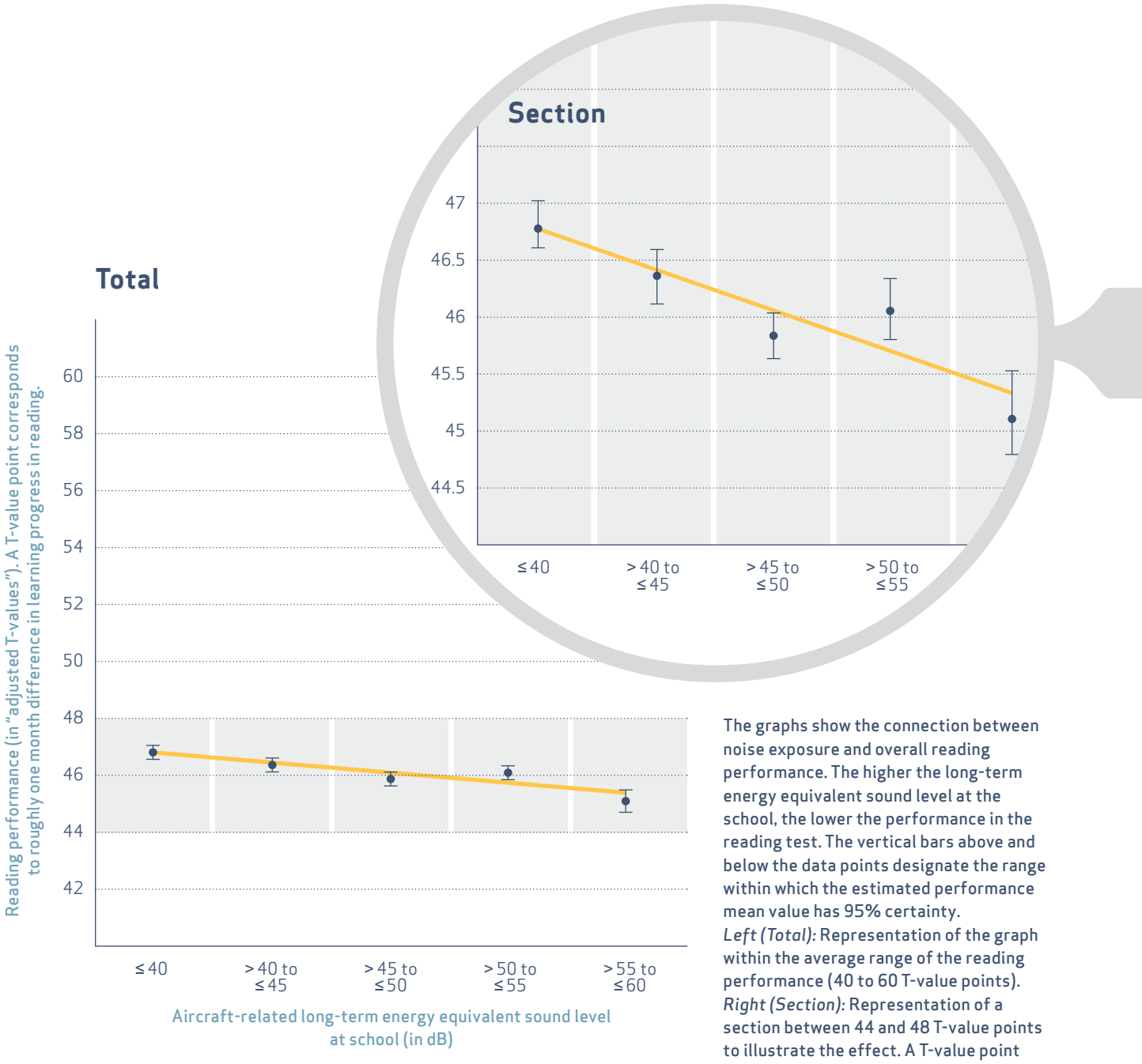
THE EFFECTS OF AIRCRAFT NOISE ON LEARNING TO READ

Aircraft noise has an effect on the reading performance of children who are still learning to read. The connection is linear: the higher the exposure, the greater the negative effect on learning to read. In the second-grade children examined in the study, an increase of the long-term energy equivalent sound level (glossary) by ten dB (glossary) delayed learning to read by one month. An increase of the long-term energy equivalent sound level by 20 dB led on average to a delay of two months. For the investigation area of the NORAH Study, this means that the delay is around two months in the areas with the highest exposure to aircraft noise.

What else has an influence on learning to read?

The NORAH Study not only investigated the effects of aircraft noise on learning to read but also other factors whose influence on learning is known – for example German-language skills or the number of children's books in the home. This was the only way to determine exactly the extent of the effect of aircraft noise on learning to read. With these data the scientists were also able to show that some of the factors investigated in the study had a greater impact than aircraft noise on learning to read. For example, children owning a lot of books were four months ahead in reading texts compared with children without their own books. It is not possible to make a direct comparison here, however, because parents can decide themselves how much help they want to give their children in learning to read, while they have no influence on the aircraft noise.



The graphs show the connection between noise exposure and overall reading performance. The higher the long-term energy equivalent sound level at the school, the lower the performance in the reading test. The vertical bars above and below the data points designate the range within which the estimated performance mean value has 95% certainty.
Left (Total): Representation of the graph within the average range of the reading performance (40 to 60 T-value points).
Right (Section): Representation of a section between 44 and 48 T-value points to illustrate the effect. A T-value point corresponds to roughly one month's difference in learning progress.

The NORAH scientists were unable to establish any statistically significant connection (glossary "Significance") between aircraft noise and learning to read in children with a migration background. This result should not, however, lead to any hasty conclusions. The authors of the study suspect that it is due to a statistical effect: it is possible that there are so many risk factors confounded in this sub-group that it was no longer possible to reliably identify effects of aircraft noise. The result certainly does not mean that children with a migration background are insensitive to aircraft noise.

If we look at only the children without a migration background, an increase in the long-term energy equivalent sound level of ten dB led to a delay of 1.5 months in learning to read. This means that the difference between the children most exposed and the children least exposed in the investigation area was three months.

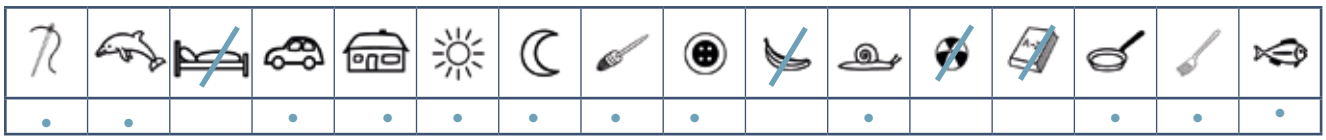
Still unknown: the reasons for the reading deficit

Up to now, researchers have not been able to explain exactly how aircraft noise impairs the ability to learn to read. Some scientists suspect that the noise exposure has an effect on the development of the so-called precursor skills – skills that children acquire at a preschool age. These include for example "phonological awareness", which allows us to identify the sounds in words, and good listening comprehension. NORAH Study examined this thesis. The result: the scientists were unable to identify any link between aircraft noise and the precursor skills.

THE QUALITY OF LIFE OF THE CHILDREN IN THE RHINE-MAIN REGION

The NORAH scientists were not only interested in the reading performances, but also in the general health and quality of life of the children. The questions they asked the children and their parents concerned, for example, sleep quality or mental and physical well-being. The results show that the quality of life of the children in the investigation area is generally very high. The children and parents with relatively high exposure to aircraft noise, however, assessed the health and quality of life of the children as slightly poorer than those with low exposure. Although the difference is small, it is statistically significant (glossary "Significance"): with an increase in the aircraft noise of ten dB, the quality of life fell on the three-to five-point assessment scales by an average of 0.1 scale points.

No effects verified on precursor skills



In the so-called picture test, the children were asked to put a line through everything that begins with B, and mark all of the other pictures with a dot. This allowed the NORAH scientists to examine how quickly children can call up words from their memory and make a decision based on the sound of the first letter (B or not B).

Noun fonts/ Eugen Traeger Verlag

The quality of life from the point of view of the children

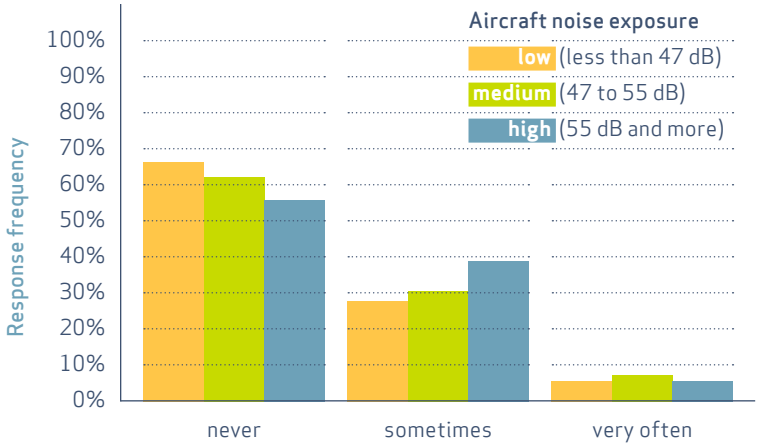
In order to find out how the children assess their physical and mental quality of life, the scientists asked them to answer various questions relating to the last week. Among other things, the children were asked whether they had suffered from headaches or tummy problems in this time, whether they slept well, and whether they had been bored. To answer the questions they could choose from "never", "sometimes", or "very often". It was shown that there was a statistically significant effect of the aircraft noise on the responses.

In the group of children with the lowest level of noise exposure, 67 percent stated that they never had headaches or tummy aches. In the group of children with the highest level of noise exposure only 56 percent said this. The scientists were able to statistically rule out any other differences between the groups – e.g. different socioeconomic status (glossary) – that might have had an influence on the children's responses.

The results were similar when the children were asked whether they had slept well in the past week. In the group with the highest level of noise exposure, 20 per cent of the children stated that they "never" slept well – compared with 15 percent of the children with only low exposure to aircraft noise. The parents, however, gave a different assessment of the sleep quality of their children: their responses to the question about their children's sleep do not indicate any connection with aircraft noise.

To assess their mental well-being, the children were asked, among other thing, whether they had been bored in the past week. The result: the more aircraft noise, the more likely the children were to state that they had been bored in the last week. An increase in the aircraft noise of ten dB (glossary) led to a deterioration of 0.14 on a three-point scale. Only around 40 percent of the children with high noise exposure stated that they were never bored, compared with 53 percent of the children in areas with low aircraft noise exposure.

"In the last week I had headaches or tummy ache."



Responses of the children to the statement "In the last week I had headaches or tummy ache" in the groups with low, medium and high aircraft noise exposure. Children in the areas with high exposure were less likely to state that they had "never" suffered from headaches or tummy ache.

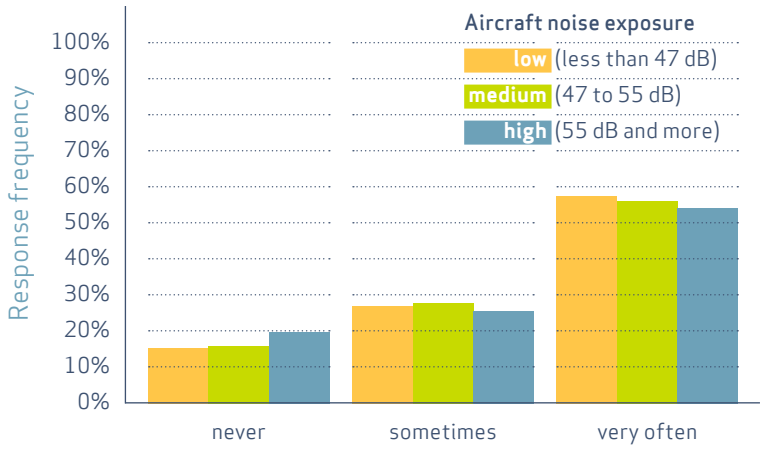
More medication and speech or language disorders

A total of 1,185 parents answered the scientists' questions about the health and the well-being of their children. They also provided information on the disorders suffered by their children and about absence times from school. In most of these answers the scientists were unable to identify any differences that could be attributed to aircraft noise.

For two questions, however, there proved to be a connection between the parents' answers and the aircraft noise exposure. Ten percent of the parents in areas with relatively high noise exposure state that their children are currently taking prescribed medication. In the residential areas with medium exposure it was only four percent, and in the regions with low exposure just under six percent.

In areas with relatively high noise exposure, 14 percent answered "yes" to the question. "Has a doctor ever diagnosed a language or speech disorder in your child?" In areas with low noise exposure, only 10 percent gave this answer, in the residential areas with medium exposure it was 8 percent. These results are statistically unequivocal. It was not asked, however, what the exact nature of the disorder was. By comparison: in Germany as a whole the frequency of speech or language disorders in children ranges between 2 and 15 percent, depending on the diagnosis criterion. The connection should therefore be made the subject of further investigation. It is important to know that the children described as being diagnosed by their parents did not differ in their reading performance to the rest of the group.

"In the last week I slept well."



Responses of the children to the statement "In the last week I slept well" in the groups with low, medium and high aircraft noise exposure. Children in the areas with high exposure stated somewhat more frequently that they were "never" able to sleep well in the last week.

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How happy are the children at school in the Rhine-Main Region?

Some studies show that a high level of noise exposure at school can also influence the attitudes of the children to school and learning. This is why the NORAH Study also looked at the "school-related quality of life". For this purpose the children responded to statements such as "I am happy learning new things" and "I feel well at school". The result showed a statistically significant (glossary "Significance") but very low influence of aircraft noise on the responses. Children exposed to relatively high levels of aircraft noise are slightly less positive towards learning and school. The difference amounts to just one-eighth of a scale point on a four-point scale.

The parents and teachers were also asked about the school satisfaction of the children and about the atmosphere in the classroom. The answers did not reveal any significant connection with aircraft noise.

DOES AIRCRAFT NOISE DISTURB LESSONS?

The degree of annoyance caused by noise is subjective: the same sound can bother one person more than it does another. This is why it is not possible to deduce from the sound level alone how annoyed people feel by aircraft noise. In order to find this out within the framework of the Child Study, the scientists asked parents, children and teachers whether and, if yes, to what extent, the aircraft noise annoyed children when learning.

Noise exposure from the point of view of the children

In order to find out whether the children felt annoyed by aircraft noise, the scientists asked them several questions. For example, the NORAH team asked the second-grade pupils to assess the statement "When learning at school, I am annoyed by aircraft noise." They could choose from four possible answers: "strongly disagree", "partly disagree", "partly agree" and "strongly agree". In the group of children whose schools were exposed to a relatively high level of aircraft noise, 27 percent stated that the noise disturbs their lessons. Only 7 percent of the children in the group with low noise exposures gave the same answer. Communication in the classroom also suffers from aircraft noise: 38 percent of the children – i.e. more than one-third – at the schools with high exposure stated that they were sometimes unable to hear the teacher properly due to aircraft noise.

The point of view of the teachers

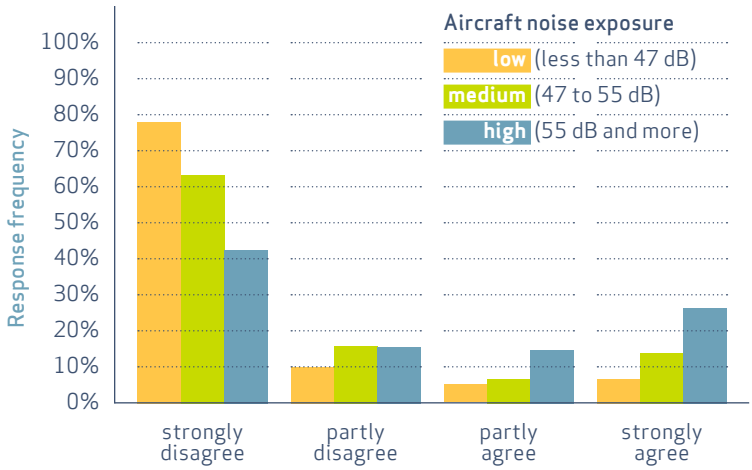
From the teachers the NORAH scientists wanted to know how aircraft noise affects classroom instruction – for example, how often it leads to interruption of lessons. The teachers in the areas with relatively high aircraft noise exposure reported unanimously that the noise causes a considerable annoyance of lessons: 24 percent stated here that they have to interrupt lessons due to aircraft noise "very often"; a further 29 percent answered with "often". In the areas with low noise exposure, nobody chose the answers "very often" or "often" or "sometimes".

Questions regarding the teaching process showed a strong connection with aircraft noise exposure at school: 52 percent of the teachers in the areas with high exposure said that the children were "often" or "very often" distracted from their lessons due to aircraft noise; 57 percent said they always keep the windows closed even when the weather is warm. 76 percent stated that aircraft noise could be heard "often" or "very often" even with the windows closed. Outdoor activities at schools with high aircraft noise exposure are also less common: 38 percent of the teachers in these areas agreed fully or partly with the statement "Due to aircraft noise I am less likely to undertake outdoor activities with the class" – compared with 3 percent at the schools with medium exposure. Nobody chose these answer options at the schools with low exposure.

Aircraft and other noise sources

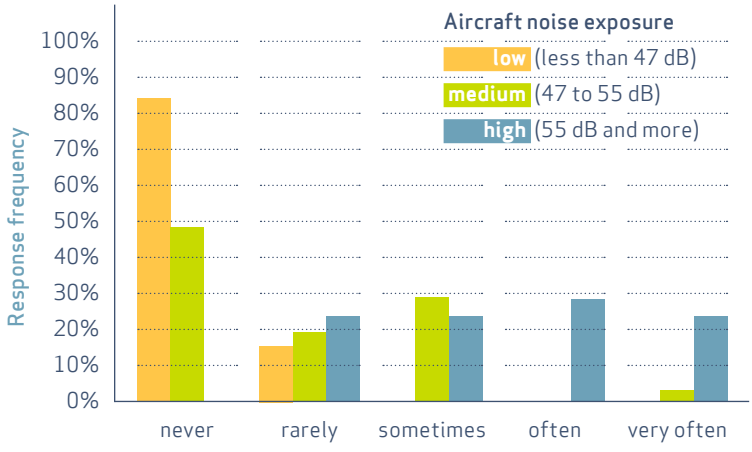
Even where there is no aircraft noise, schools are not quiet places: sounds penetrates into the classroom from the playground and from the other classrooms. In order to estimate the role aircraft noise plays compared with other noise sources, the scientists asked the teachers to estimate which types of noise their classes are exposed to and to what extent. For each source of noise the teachers estimated the degree of class annoyance on a five-point scale, where 1 stood for "no annoyance" and 5 for a "very high annoyance". The result: teachers perceive sounds from the playground or from the other classrooms as annoyances of their class. However, at schools with relatively high aircraft noise exposure, from the point of view of the teachers the greatest annoyance by far is aircraft noise: on the five-point scale the answers for this type of noise reach an average value of 4.5. In order to make the clearest possible statements about the impact of aircraft noise, the NORAH Study did not include any schools with very high exposure to road or rail transportation noise. This is why the teachers assessed the annoyance of classes due to these types of noise as relatively low. This, however, cannot be generalised. In the Rhine-Main Region there are also schools with very high exposure to road or rail noise.

"When learning at school, I am annoyed by aircraft noise."



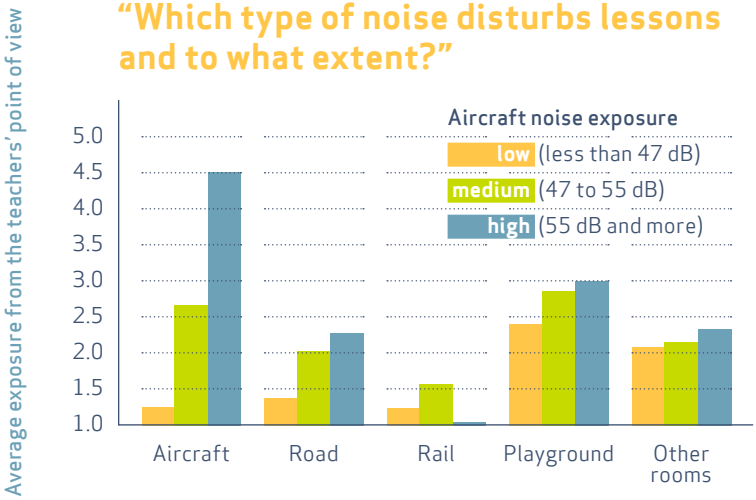
Responses of the children to the statement "When learning at school, I am annoyed by aircraft noise." in the groups with low, medium and high aircraft noise exposure.

"Due to the aircraft noise I have to interrupt the lesson/my speech for a moment."



Responses of the teachers to the statement "Due to the aircraft noise I have to interrupt the lesson/my speech for a moment" in the groups with low, medium and high aircraft noise exposure at school. Almost one-quarter of teachers in high-exposure areas state that they have to interrupt lessons due to aircraft noise "very often".

"Which type of noise disturbs lessons and to what extent?"



Teacher assessment of the annoyance of lessons due to various noise sources at schools with low, medium and high exposure to aircraft noise (mean values: 1 = no burden, 5 = very high burden). According to the teachers at schools with high exposure to aircraft noise, this is more disruptive of lessons than sounds from the playground or other rooms.

INTERVIEW WITH THE STUDY DIRECTOR PROF. MARIA KLATTE

Thomas Schinauer

Director of the Child Study: Psychologist Prof. Maria Klatte from the University of Kaiserslautern

Prof. Maria Klatte is the director of the Child Study. In an interview with "NORAH Knowledge" the psychologist from the University of Kaiserslautern talks about her assessment of the results.

Did any of the results of the NORAH Child Study surprise you?

There is already a number of studies on this issue. The children in prior studies, however, were subject to much higher levels of exposure to aircraft noise, spectacularly higher levels. Nonetheless, only very minor effects could be identified. With this pre-knowledge we were not sure at the start of the study whether we would even be able to detect any effects on the reading performance of the children. We had not expected that statistically significant effects could be verified consistently despite the low levels of exposure.

Were the other results as you expected?

No. For example the increased frequency of medically diagnosed speech and language disorders and intake of medication: that is a result of the parent survey. We did not expect that this would show up so clearly. This is something we really need to pursue further to find out what exactly is behind it.

In your opinion, how serious are these speech and language disorders?

We do not know exactly which type of disorders led to the differences shown in our study. But we did examine whether the children who, according to their parents, had a speech or language disorder differ from the other children in terms of their reading performance. This is not the case. This is why we do not believe that we are looking at very serious disorders here. But we do not know exactly, and this is why there have to be follow-up investigations.

If parents hear about your study and start asking themselves whether their child is worse off than children in quieter areas: what would you tell them?

We asked the parents and the children about the latter's physical and mental well-being. This was represented as very positive by both groups. Children exposed to aircraft noise do not feel bad, but they do feel a tiny bit less good. Other factors certainly have a greater influence on the well-being of the children. Nonetheless, the effect is statistically significant. And we cannot tell how that will develop in the long term if the children have to live and learn under the influence of aircraft noise.

You identified a delay in learning to read of up to two months in second-grade pupils. Does this mean that children living near an airport are less likely to complete A-levels or generally have fewer chances?

It is not possible to answer that with any certainty because we do not know how the relatively small difference in the second-grade pupils will turn out in the long term. First we have to say that the identified statistical effect on the reading performance is small. There are other influencing factors that are far more important. But we do not know how that will develop. We also surveyed the school directors of the participating schools. We asked them what proportion of the children in their school go on to grammar school from primary. We did not find any difference here: in the participating schools exposed to high levels of aircraft noise, on average the same proportion of children went on to grammar schooll as in the schools with lower exposure.

Monkey Business Images/Shutterstock

You also spoke to teachers…

Yes, the clarity of the results of the teacher survey was a surprise. We know that interruptions of the teaching flow are very unfavourable for children at this age. Up to now, research has focused mainly on reading performance. But these frequent interruptions can, of course, also have an unfavourable effect on other subjects.

Pressmaster/Shutterstock

OUTLOOK: WHAT HAPPENS AFTER THE CHILD STUDY?

The Child Study within the framework of NORAH delivered several important insights which will help us to understand how aircraft noise affects the cognitive development and the quality of life of children. We now know, for example, with very high probability, that aircraft noise impairs learning to read. But the Child Study also threw up some new questions. Further studies are necessary to provide the answers to these.

One of the unanswered questions is: in what way exactly does aircraft noise affect learning to read? The NORAH Study was unable to confirm that the important precursor skills for reading develop less well under the influence of aircraft noise. This is why scientists now have to postulate new theories and examine them in suitable studies.

Another question that has arisen within the framework of NORAH concerns the health and quality of life of the children. Parents from the residential areas with high exposure to aircraft noise stated more frequently that their child was taking prescribed medication at the time of the survey or had been diagnosed as having a speech or language disorder. The Child Study did not, however, investigate which medication was being taken or whether certain language or speech disorders are particularly frequent. These questions – which have never been raised by any previous study – must also be made the subject of further studies.

We also have to answer the question as to the further development of the children concerned – in particular if they continue to be exposed to aircraft noise. Will the effect of the aircraft noise get worse, will it remain the same, will it become less or disappear altogether? The NORAH Study cannot make any statement on this because it has not followed the progress of the children concerned. A so-called longitudinal study which would register the performance of the same children at various points of time in the future – for example in a few years – could provide answers to these questions.

Glossary

Further explanations can be found in the glossary at **www.laermstudie.de**.

Long-term energy equivalent sound level

The long-term energy equivalent sound level (in short: L_{pAeq}) is a measure for the average noise exposure over a certain period in which frequency, duration and level of individual sound events are taken into account. The L_{pAeq} is the basis for the determination of noise protection zones pursuant to the aircraft noise laws – separated according to day (6 a.m. – 10 p.m.) and night (10 p.m. – 6 a.m.). The L_{pAeq} is stated in dB.

Decibel

Decibel (dB) is a physical unit of measurement used, among other things, for the sound pressure level. The NORAH Study uses the so-called A-weighted sound pressure level. This means that when the sound event was measured, frequencies were weighted with a filter designed to replicate human hearing. The "A" in the expression L_{pAeq} is a reference to the use of the A-weighting.

Significance

In statistics we speak of a significant result if there is only a very low probability (usually less than 5%) of it being a random effect. The significance can be checked using statistical methods.

Socioeconomic status

Socioeconomic status is an artificial term that attempts to summarise an individual's economic and social position in society. In the NORAH Study the socioeconomic status was determined with the aid of the so-called "Scheuch-Winkler Index". This is calculated from three factors: net income, education and qualifications, and professional position.

Confounding

Confounding occurs when a phenomenon depends on two or more conditions that are mutually influential. If, for example, we want to investigate whether frequent tooth brushing prevents tooth decay in children, it would not be sufficient merely to examine the brushing behaviour and the dental status. This is because children who frequently brush their teeth are most likely actively encouraged to do so by their parents (few of them do it of their own accord). The same parents will probably allow their children fewer sweets. It could be that the healthier teeth are not due to frequent brushing but to a healthier diet. We can only find this out by examining both.

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