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NORAH Knowledge No. 1

NORAH Noise Impact Study

Child Study: Effects of aircraft noise on children

Task and method

forum flughafen & region
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NORAH

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Task and method

"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 Child Study examines the chronic effects of aircraft noise on primary-school children. The study is concerned with the effects on the cognitive development of the children. It focuses on learning to reading acquisition and on certain language skills that are important for learning to read. In order to find out more about these skills, the scientists had the second-grade schoolchildren at 29 primary schools solve a series of tasks in tests. The study also explores how well the children feel at school and at home, and to what extent aircraft noise impacts on this well-being. The scientists surveyed not only the children themselves but also their parents and teachers. Now they are examining the links between the results of the tests and questionnaires on the one hand and the aircraft noise on the other.

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.

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The scientists' questions

Prof. Maria Klatte from the University of Kaiserslautern investigates the effects of aircraft noise on the cognitive development of primary-school children.

"Children's cognitive development, especially the acquisition of academic skills such as reading, depends on a wide range of factors related to the children's home and school environment. Educational research has shown this. Therefore, in order to examine the impact of aircraft noise, we also have to look at the children's learning environment at home and at school."

The psychologist Prof. Maria Klatte is responsible for this part of the NORAH Study. She is a scientist at the department of "Cognitive and Developmental Psychology" at the University of Kaiserslautern. For more than 15 years now, Prof. Klatte has been examining the effects of noise on cognitive performance, focusing on children for the last ten years. With her work for NORAH she wants 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?

Aircraft noise and learning to read: what do we already know?

Various studies have already examined how aircraft noise impacts on children. The knowledge gained up to now about this link can be summarised as follows:

- Some studies found a connection between aircraft noise and poorer learning performance of children. They were unable, however, to reliably rule out that other factors may have been responsible for this result, for example the socioeconomic status of the parents. This depends largely on the level of education, profession and income (glossary). In some cases the results were also contradictory (see section on the RANCH Study on page 10 f.).
- In those studies that established an influence of aircraft noise on learning performance, this was most likely to affect the ability to read.
- It is possible that aircraft noise does not influence the ability to read directly, but indirectly via so-called precursor skills (glossary), i.e. via language skills that the child needs to be able to learn to read well. This includes, for example, distinguishing between similar sounds, breaking down words into their individual elements and being able to store verbal information in the short-term memory.

The challenge: filtering out non-noise-related factors

PISA, IGLU and other educational studies have shown that there are a lot of different factors that affect how well a child learns at school. The reading performance of primary-school children depends, for example, on the educational level and income of the parents (the so-called "socioeconomic status" glossary), on a possible migration background or the abilities of the children to speak German. In addition to this, school-related factors such as the quality of the teaching and the class composition also play a role.

Some studies also point out that there are more people with a low education level or income living in the areas subject to the highest aircraft noise exposure than in the quieter residential areas. Scientists describe this kind of overlap of various influencing factors as "confounding" (glossary). Poorer reading performance in children exposed to high levels of aircraft noise can therefore only be reliably attributed to the aircraft noise if the socioeconomic status of the families is carefully considered in the statistical analyses. The NORAH Study used a parent questionnaire to gather all of the necessary information on the family situation of the children.

Alongside these "non-noise-related influencing factors", there are other types of noise that have nothing to do with aircraft. This is why NORAH also looked at road and rail noise at the home of the child and at the school. As a very reverberant classroom can increase the sound levels during lessons, this factor was also taken into account. Such factors can confound the effect of aircraft noise on children and thus falsify the results of the investigation.

The biggest challenge in the child module of the NORAH Study consists in identifying as precisely as possible the various influences on the learning performance of the children. This is the only way that the scientists can filter out which effects are caused by the aircraft noise alone.

"More influencing factors were taken into consideration within the framework of NORAH than in any other study about the impact of aircraft noise on children worldwide."

What exactly was investigated – and how?

Overview of investigated factors

Influencing factors	Method
Aircraft noise at school and home	Calculated data from the NORAH Consortium
Road and rail noise at school and home	Calculated data from the NORAH Consortium
Building and room acoustics of the classrooms	Screening methods for estimation of the reverberation time and noise insulation
Family-related influencing factors Socioeconomic status, migration background German-language skills in children with migration background	Preliminary survey of schools, parent questionnaire, assessment by teachers
School-related influencing factors Methods of teaching reading	Teacher questionnaire
Effect factors	**Method**
Reading ability and precursor skills Reading ability Long and short-term memory for verbal information Phonological awareness Speech perception Attention Non-verbal skills	Group tests in the class
Quality of life and environment Well-being in the school and at home	Child questionnaire, parent questionnaire, teacher questionnaire
Noise exposure in the school and at home	Child questionnaire, parent questionnaire, teacher questionnaire

Aircraft noise

It is easy to measure how loud it is at a certain time at a certain place. But the question for the NORAH Child Study was: can long-term exposure to aircraft noise lead to a permanent impairment of the cognitive development of children? In simple terms: the question is not how loud it is in the classroom when the children are learning the letter A, but whether long-term energy equivalent aircraft noise has such an influence on the cognitive development of the children that they learn to read more slowly than children growing up in a quieter environment.
This is why NORAH needs noise levels that describe the exposure of the children at home and in the school over a prolonged period of time. The team around Prof. Klatte received this data from their partners in the NORAH Consortium, who are responsible for acoustics and had evaluated radar data on all flight movements over the course of 15 years. This allowed them to calculate exact sound levels for various daytime and night-time periods at over 900,000 building addresses in the study region. Using anonymised code numbers of their participants, the Child Study team was able to link this noise data with their own results.

Building and room acoustics

The following values were measured directly in the classroom:

- **Reverberation time:** This is the time for which a sound reverberates in the classroom. In the case of long reverberation times, the sound level in the classroom increases, as all sounds reverberate for longer; in addition to this, it is more difficult to comprehend language (e.g. that of the teacher) due to the reverberation.

- **Insulation:** From the type and thickness of the windows and walls it is possible to deduce how well the classroom is protected against aircraft noise when the windows are closed.

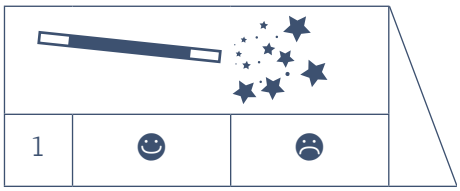
The acoustics were analysed to rule out the confounding of the aircraft noise exposure through poor classroom acoustics. The scientists examined whether the aircraft noise had a different effect depending on the acoustic quality of the classrooms, for example, whether negative effects were minimised or completely eliminated in schools with very good noise insulation.

Reading ability

In order to find out how well the children can read, they were asked to complete a standardised reading test which is also used in other studies. The test focuses on the speed of reading and the level of understanding when reading words, sentences and short texts.

Short-term memory

Verbal short-term memory plays an important role in reading. It ensures that by the time we reach the end of a sentence, we still know how it started. This applies in particular to children, who often still have to spell themselves through the words. But how can this be tested? The children listened through a headset to a made-up word spoken by a "sorceress" ("a magic word"), for example "Eulafing", "Strobagel" or "Krefensal". Immediately afterwards, they heard a "sorcerer's apprentice" repeating the word. On their work sheet the children then had to mark whether the apprentice had repeated the word correctly or incorrectly.



Long-term memory

The children listened to a story read out to them and had to answer questions on it. Earlier studies on the impact of aircraft noise on the long-term memory had yielded contradictory findings. In order to pursue this factor more thoroughly, it was also examined by NORAH.

Awareness of syllables and phonemes ("phonological awareness")

In order for a child to learn how to read, he or she must understand how language and script function. A monkey is a monkey; the child knows that already. Now he or she has to learn that the word "monkey" is made up of two syllables and these syllables are made up of different speech sounds. In order to test this ability, the children had to listen to three made-up words (e.g. bann – beck – dimm). Then they had to identify which words started with the same sound.

Speech perception

The precise perception of speech is also a prerequisite for the ability to read and write. NORAH examined this ability with a hearing test: the children saw on a screen three pictures of objects with similar-sounding names, e.g. "bee, flea, sea". Then they heard a word through a headset (e.g. "bee") spoken in a multitalker speech noise. Then they had to put a cross on their answer sheet by the picture that corresponded to the spoken word.

"Aircraft noise affects children not only in school."

Attention

For this task the children were shown a series of small pictures from which they had to cross out certain pictures in a short time.

Non-verbal abilities

For this task the children were shown patterns, from each of which a jigsaw piece was missing. The children were to select the part missing from the pattern from six alternatives. This task tests the ability to draw conclusions on the basis of non-verbal material. Such tasks are included in many intelligence tests. According to our present knowledge, aircraft noise has no effect on this type of ability. The task was included in order to be able to show that any effects of aircraft noise on the reading ability are not due to differences in the general cognitive performance of the various children.

Quality of life and effects on lessons

Aircraft noise affects children not only in school. It has effects on their whole lives and their well-being. This is why NORAH also examined the quality of life of the schoolchildren. The information for this came from two different points of view. On the one hand, the children themselves were asked how they would assess their well-being in different areas of their lives. On the other hand, the parents were asked how they would assess the children's situation. Teachers also provided information about how they assess the effects of aircraft noise on lessons.

"With the headset system we were able to exclude as far as possible factors that would hinder comprehension."

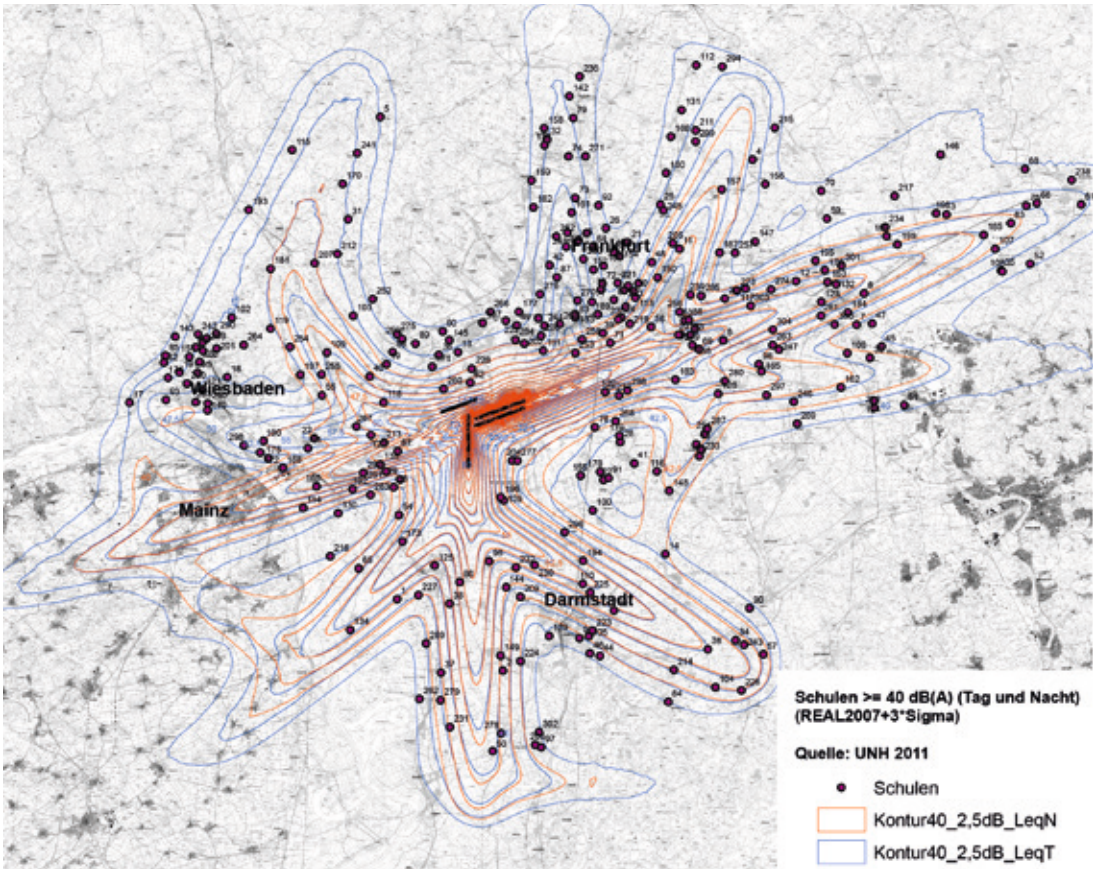
Photos: Bergström

Why tests with headphones?

In some of the tests the investigation team worked with a set of wireless headphones especially developed for children. The headset system was provided by the Hörzentrum Oldenburg. Some of the parents were surprised by this and asked whether it would falsify the results. After all, the children do not usually have headphones in the classroom. Scientists always welcome such questions, as they represent an ideal opportunity to explain their work. This is what study director Prof. Klatte has to say:

"In the NORAH Study we are investigating the chronic effects of aircraft noise on the cognitive development of children. Chronic effects are permanent impairments that can arise as a result of long-term exposure to aircraft noise in the school and home environment. In short: how well will a child learn if he or she is taught for years in a school continuously exposed to the noise of low-flying aircraft? To test such chronic effects, e.g. on learning to read, it does not have to be loud in the test situation. In order to identify chronic effects, we have to compare the test results from children exposed to various levels of aircraft noise with each other. We can only do this if we are certain that all of the children can understand the spoken words and syllables in the tasks equally well. By using headphones we can eliminate as far as possible factors that hinder comprehension, such as acute aircraft noise, noise from adjacent rooms, reverberation time in the classrooms, or the distance of the child from the teacher's desk. To what extent the aircraft noise disturbs the lessons in a certain classroom is examined by asking the children and teachers. One of the questions to the children was, for example: 'Sometimes it is hard to hear the teacher because of the aircraft noise.' The child had to choose one of four options from 'absolutely wrong' to 'absolutely true'."

How were the schools selected?



Schools in the study region. The outermost blue line marks the study region with a long-term energy equivalent sound level in daytime of at least 40 dB (A). Moving inwards, the long-term energy equivalent sound level increases with every contour line by 2.5 dB (A).

Scientists work with random samples. An ecologist takes water samples without having to analyse the whole lake. An educational researcher tests a selection of schoolchildren and extrapolates for the totality. In both cases, where and how the sample is taken plays a decisive role.

"Matching": selection of the schools

The aim was clear: to find schools that had different levels of exposure to aircraft noise but were otherwise as similar as possible in terms of other factors. As it was not possible to achieve this for all possible influence factors, the scientists had to set priorities. First they established four aircraft sound level classes, to each of which seven or eight primary schools were to be assigned. First the most highly exposed schools in the study area were selected, because these were always going to have to be taken into consideration. Proceeding from there, matching schools were selected from the other sound level classes according to the following criteria:

1. Proportion of children in second grade with a migration background;
2. Proportion of children in second grade with a poor knowledge of German (this proportion could not be taken into account where the schools did not have the data);
3. No very high exposures to other noise sources;
4. Number of children in second grade per school >40;
5. Estimation of the socioeconomic status (glossary) in the catchment area of the school;
6. Broad spatial distribution of the selected schools in the study area;
7. As far as possible, a positive estimation of the significance of the study by the school.

The following overview of the first two criteria shows that a good balance was achieved between the various aircraft noise exposure levels:

	Sound level class*	Proportion of children in second grade with a migration background	Proportion of children in second grade with a poor knowledge of German
4	> 55 dB	53%	19%
3	50 – 55 dB	53%	17%
2	45 – 50 dB	53%	18%
1	40 – 45 dB	52%	15%

* Long-term energy equivalent sound level L_{eq} (glossary)

A total of 29 schools in the four sound level classes were selected in this way. This also included the two most highly exposed schools in sound level class 4.

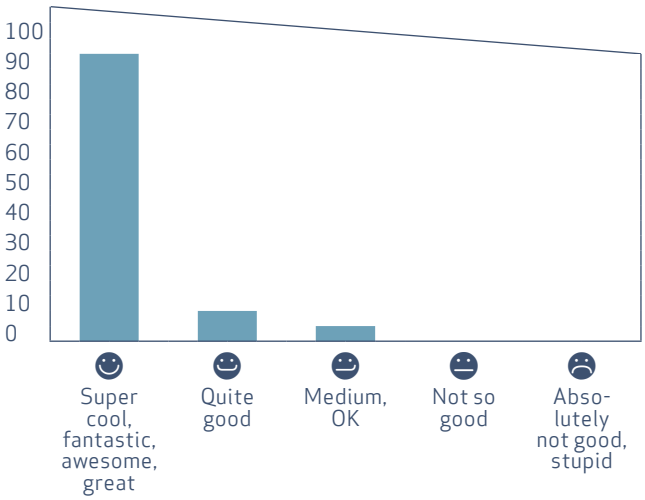
The Child Study in numbers

- 1,243 children from 85 second-grade classes at 29 schools took part
- 90% of the parent questionnaires were completed
- Information material for parents was drawn up in nine languages
- The group test took an average of four school lessons (45 minutes each) in each class
- The NORAH study teams spent around 300 school lessons in the classes
- The survey was carried out between 19.04 and 20.06.2012

The scientists were pleasantly surprised by the great response to the parent questionnaire. 90% came back completed – well above the average for similar studies. "We have obviously succeeded in convincing the parents about the significance of our study, because many were willing to answer even sensitive questions, for example about their income. I would like to take this opportunity to thank all of those who participated," says Prof. Maria Klatte, director of the NORAH Child Study.

Super cool, fantastic, awesome, great

And how did the children themselves evaluate the test? 85% awarded the best grade "super cool, fantastic, awesome, great"; 10% found it "quite good" and just a few "medium, OK".



A predecessor: the RANCH Study

In 2001 a major study with similar questions to the NORAH Child Study was conducted at airports in Amsterdam, Madrid and London: the RANCH Study (Road traffic and Aircraft Noise exposure and Children's cognition and Health).

This study established a connection between aircraft noise and reading ability: higher aircraft noise exposure was associated with a slight reduction in reading performance. The result was statistically significant (glossary). Nonetheless, the study is the subject of controversy among scientists, because it also discovered with the same statistical certainty contrary effects in the evaluation of the impact of road traffic noise, which could not be satisfactorily explained.

The biggest challenge in studies on the effects of aircraft noise on the reading development of children consists in carefully separating the effects of other influence factors from the effect of the aircraft noise. In the NORAH Child Study these influence factors were more precisely scrutinised than in earlier studies in order to be able to attribute any performance differences between children from areas subject to different levels of aircraft noise exposure to the aircraft noise. The following overview shows the differences between NORAH and the RANCH Study:

	RANCH Study	NORAH	Explanations
Investigation period	2001	2012	
Number of schools	89 (in England, the Netherlands and Spain)	29 in the proximity of Frankfurt Airport	
Age of the school-children	Ca. 9 – 12 years (average: 10.5 years)	Ca. 7 – 10.5 years (average: ca. 8.3 years)	NORAH: younger children because learning to read in German is faster than in English
Class grades	Mixed	Only Year 2	NORAH: children were examined in the same phase of learning to read (less scattering)
Source of the aircraft noise data	Estimation of the aircraft noise exposure at school and at home based on noise maps from periods of three to 13 months	Calculation of sound pressure levels at the exact addresses in different time phases (morning at the school, afternoon and night at home) over a period of 12 months before the tests	

Aircraft noise exposure at the school during the day (long-term energy equivalent sound level L_{eq})	30 to 77 dB (A) (7 a.m. – 11 p.m.)	39 to 59 dB (A) (8 a.m. – 2 p.m.)	In RANCH the aircraft noise exposures were much higher
Aircraft noise exposure at home during the day (long-term energy equivalent sound level L_{eq})	31 to 76 dB (A) (7 a.m. – 11 p.m.)	36 to 61 dB (A) (6 a.m. – 10 p.m.)	
Which cognitive abilities and learning achievements were examined?	Reading, attention, short and long-term memory	Reading, attention, short and long-term memory, verbal precursor abilities of reading such as "phonological awareness" (glossary)	
Other factors examined	Quality of life, impairment due to aircraft noise	Quality of life, impairment due to aircraft noise, well-being at school	
How was the socio-economic status (glossary) of the children estimated?	Various yes/no questions in the parent questionnaire, e.g. "Free lunch at school?", "Living in your own home?", "Father unemployed?"	Calculation of the so-called "Scheuch-Winkler Index" (SWI) from information on net income, education and qualification and professional position in the parent questionnaires. The SWI is an index commonly used in social research	
Consideration of different insulation and room acoustics of the schools	Schools with good noise insulation (triple glazing) were excluded. More than half of the schools had only single glazing	Sound insulation and room acoustics were examined. Well-insulated schools were not excluded because the aim was to examine the real situation in the study region. There were no schools with single glazing in the random sample	
Conduct of the tests	Without headphones. The sound pressure level during the tests was measured. Any influence of noise during the testing was then "calculated out" during the evaluation	Comprehension tests with headphones to rule out acute noise effects on the test (focus on chronic noise effects). The acute sound pressure level in the classroom was also measured	

NORAH overview

The noise impact study NORAH (Noise-Related Annoyance, Cognition and Health) is so far the most extensive study internationally on the effects of noise from aircraft, road and rail traffic on the health and quality of life of the population. Several acclaimed research and technical institutes in the fields of medicine, psychology, social science, acoustics and physics are collaborating in the NORAH research consortium. The investigations are being carried out mainly in the Rhine-Main Region, and to some extent also in the regions around the airports Berlin-Brandenburg, Cologne-Bonn and Stuttgart.

Overview of the NORAH sub-studies

Quality of Life Study

Over a period of three years, this study is examining how people who live near airports suffer from aircraft, road and rail traffic noise, what sound levels they are exposed to, what changes in the noise exposures mean to them, and how they would assess their health and quality of life. A total of around 27,000 people at four airports are taking part in the surveys.

Sleep Study

Very early or late flights take place when a lot of people are asleep. How well they manage to do this despite the noise is the subject of the sleep study. Like in a sleep laboratory, the sleep patterns of the study participants are recorded electronically several nights in a row. Parallel to this, a sound level meter direct at the participant's ear measures every sound in the course of the night.

Illness Study

Using the health insurance data of 1.5 million insured persons in the Rhine-Main Region, the NORAH team is examining how frequently various illnesses, including heart disease and depression, occur in the region, and which noise the persons concerned were exposed to. Special focus is being placed on the cardiovascular disorders: the scientists are also asking study participants with newly contracted disorders about other risk factors such as excess weight or smoking.

Blood Pressure Study

Can our blood pressure also react to exposure to aircraft, rail and road traffic noise? What happens when the noise exposure changes? The Blood Pressure Study is pursuing these questions in a monitoring process: participants from regions with different noise exposures measure their blood pressure every morning and evening over a period of three weeks. More than 1,300 persons have taken part in the first measurement phase; the second phase runs until May 2014.

Child Study

Does noise have an effect on the development of children? This is what the scientists want to find out in the Child Study. Investigations with more than 1,200 Year 2 grade pupils in the Rhine-Main Region illuminate the connection between noise and cognitive development. Surveys also provide information about the quality of life of the children.

Module Quality of Life
Module Health
Module Development

Glossary

We feel it is important to explain the main technical terminology of the NORAH noise impact study in a manner that is comprehensible to laypersons. Terms that are not covered by the glossary will soon be available in the wiki which is currently being prepared.
wiki.umwelthaus.org

Precursor skills

These are skills that are responsible for children's success in learning to read. They develop before the child actually begins learning to read. Precursor skills include, for example:

- **Phonological awareness:** Refers to an individual's awareness of the phonological structure, or sound structure, of spoken words (see below).
- **Attention:** The ability to concentrate sufficiently on a text.
- **Verbal short-term memory:** The ability, for example, to remember at the end of a sentence how it started.

Phonological awareness

Awareness that language is made up of different building blocks: sentences, words, syllables, sounds. Phonological awareness also means that a child can detach him or herself from the meaning of the word "cat", for example, and recognise that it starts with the same letter as "cake".

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.

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.

Long-term energy equivalent sound level

The long-term energy equivalent sound level (in short: L_{pAeq}) is a measure of 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 aviation 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.

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.

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