Quality of Life
Health
Development

NORAH Knowledge No. 7

NORAH Noise Impact Study
Quality of Life Study:
Annoyance and quality of life
in relation to traffic noise

Task and method

forum flughafen & region
umwelt- und nachbarschaftshaus

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 Study investigated the effects of aircraft, road and rail traffic noise on humans.

von Aichberger

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.

The NORAH Study examines the long-term effects of traffic noise on health, quality of life and early childhood development in the Rhine-Main Region. The initiator of the study is the Airport and Region Forum (ARF). The scientists have been 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 traffic noise, the NORAH scientists also looked at the medical histories of more than one million people, and reconstructed the noise exposure at around 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. In this edition of "NORAH Knowledge" we present the tasks and the methods of the Quality of Life Study, one of the five sub-studies.

Contents

Further information on the NORAH Study is available on the Internet at **www.laermstudie.de**. There you can also subscribe to the newsletter "NORAH Brief".

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ANNOYANCE AND QUALITY OF LIFE IN RELATION TO TRAFFIC NOISE

Most people prefer quiet to the noise of trains, cars or aircraft – traffic noises make it more difficult to relax or to concentrate on work. Not all people, however, perceive noise in the same way. One person might see his quality of life impaired by occasional planes flying by at a distance. Another person might choose to live in an apartment at a busy traffic junction because it is near to the bus stop and therefore the noise is easier to ignore. In other words: there are many individual answers to the question as to when sounds become intrusive noise. Science has identified several factors that have an influence on how severely people feel bothered by noise. These include:

- the noise level
- the time of day
- the type of noise source, e.g. cars or aircraft
- psychological factors such as noise sensitivity.

It is still unclear, however, how these factors work together and what influence each of them has on the noise annoyance. The Quality of Life Study seeks to close this gap in our knowledge.

Traffic noise from three perspectives

In order to identify how much different noises annoy people, the Quality of Life Study approaches the subject of traffic noise from three different perspectives. First, the scientists are carrying out a time comparison to investigate how the annoyance perceived by the persons concerned develops when an airport expansion is pending or has taken place. Second, the NORAH team is carrying out a location comparison to assess the quality of life and exposure of people living in the proximity of four German airports. And, third, in a comparison of sources, it will examine whether aviation, road and rail noise have different effects and what happens when they come together.

The director of the Quality of Life Study is the psychologist Dirk Schreckenberg, head of the research centre ZEUS GmbH – Centre for Applied Psychology, Environmental and Social Research in Hagen.

Director of the Quality of Life Study Dipl.-Psych. Dirk Schreckenberg of ZEUS GmbH in Hagen. Along with Prof. Rainer Guski, he is also overall director of the NORAH Study.

Schreckenberg

GOOD TO KNOW

Exposure and annoyance

When noise impact researchers talk about exposure, they are not talking about the same thing as annoyance. For the scientists, exposure is the acoustic energy that impacts on a person. It can be described in physical measurement values, e.g. the sound pressure level (glossary). The annoyance, on the other hand, cannot be measured with technical devices. This refers to the subjectively perceived annoyance caused in people by noise. The annoyance is also influenced by the feeling of being able to do very little or nothing at all against the noise.

NOISE IN THE TIME COMPARISON

Whenever an airport is expanded, a motorway planned or a train station relocated, a lot of things have to be calculated in advance – including the noise that the people in the region will be exposed to in the future. Only if the noise exposure is within the legally established limits will the project receive planning permission. The basis for the description of the annoyance effect is supplied by so-called exposure-effect graphs that noise impact researchers have drawn up in the past. The graphs show, for example, how bothered people feel when they are exposed to a certain level of noise.

The "change effect" phenomenon

More recent studies, however, indicate a psychological phenomenon which the long-established exposure-effect graphs do not take into account: the so-called "change effect", which can occur before and after a change in the noise. For example, people tend to feel more bothered by noise if they believe that the noise exposure is going to increase in the future. The opening of the north-west runway at Frankfurt Airport in October 2011 and the ban on scheduled flights between 11 p.m. and 5 a.m. as of the same month were taken as an opportunity to examine whether the established exposure-effect graphs are correct, or whether the people in the region feel more bothered in the long term than hitherto assumed.

To do this the scientists asked several thousand people in the Rhine-Main Region in three successive years how they would assess their quality of life and whether they suffer from the effects of aircraft noise. The first survey took place in 2011, before the new north-west runway went into operation. The second and third surveys followed in 2012 and 2013. Within the framework of NORAH, acoustic experts also calculated how much noise reached the exact addresses of the study participants – before and after the north-west runway was opened.

Fraport AG

After several years of planning, the north-west runway went into operation in October 2011.

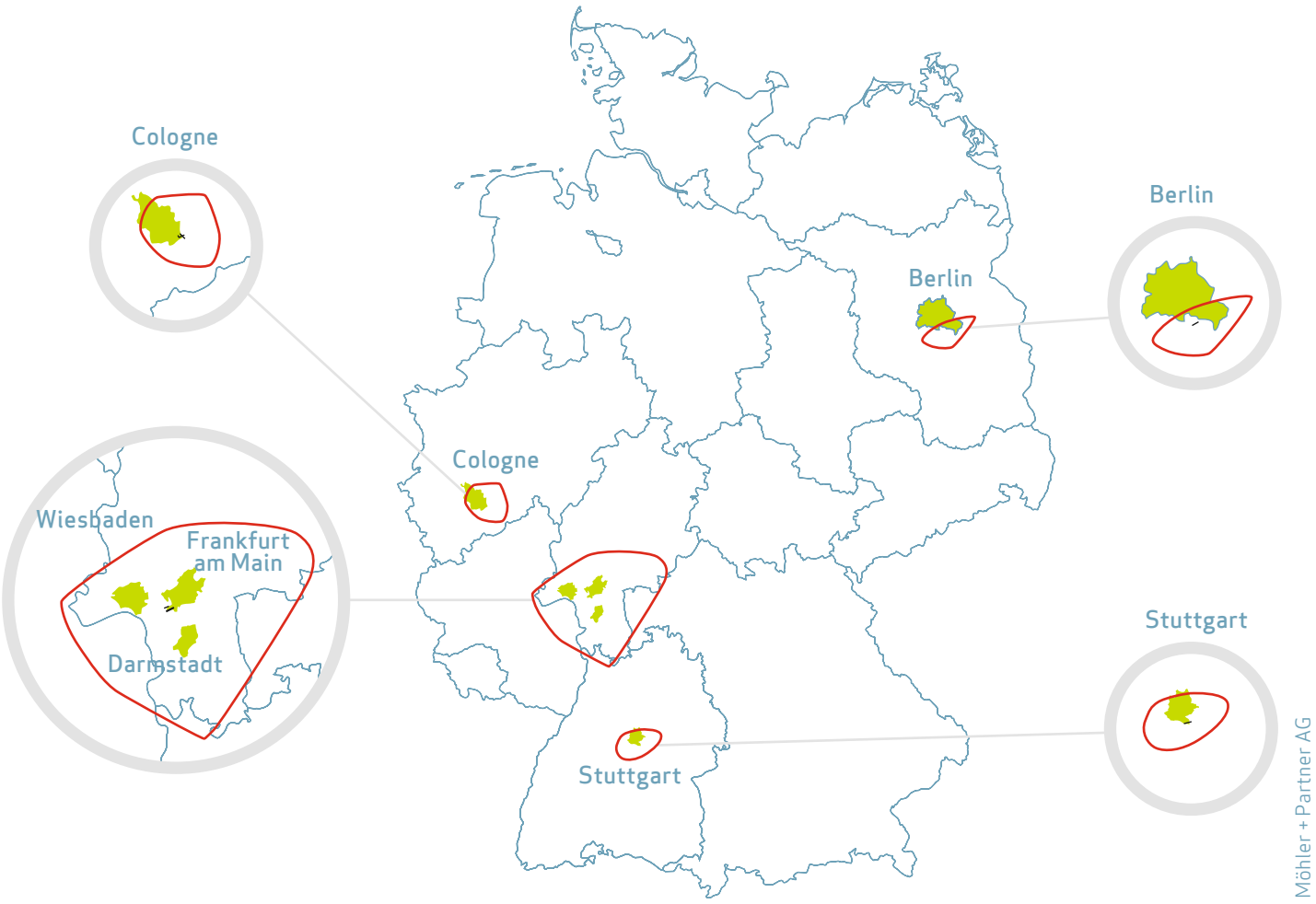
COMPARISON OF THREE-AND-A-HALF AIRPORTS

The time comparison is complemented by a location comparison within the NORAH Quality of Life Study. In this part of the study, the scientists want to find out whether the people living in the proximity of four German airports respond differently to noise, and which factors are responsible for this. Alongside Frankfurt Airport, these are Stuttgart and Cologne/Bonn airports, as well as the as yet uncompleted Berlin-Brandenburg Airport.

The four airports differ not only in terms of their size, but also in respect to their expansion and the regulation of air traffic at night:

- In Frankfurt there have been night flying restrictions on scheduled flights between 11 p.m. and 5 a.m. since the new north-west runway went into operation in October 2011.
- No major constructional changes are planned for Cologne/Bonn Airport. But there are no restrictions on night flying.
- No major construction measures are planned in Stuttgart but, unlike Cologne/Bonn Airport, there are night flying restrictions.
- Berlin-Brandenburg Airport is a special case and was originally scheduled to begin operation in 2012. The NORAH team had planned surveys here before and after the opening. As the opening has been delayed by about five years, it was only possible to realise the first wave of surveys.

For the location comparison, the NORAH team surveyed people living in the proximity of the airports Frankfurt, Cologne/Bonn and Stuttgart as well as in the region of the not yet completed Berlin-Brandenburg Airport. The cities are highlighted in green. The red lines mark the investigation areas of the NORAH Quality of Life Study.



Möhler + Partner AG

Tracking down annoyance:

Three important predecessor studies
Even before NORAH there were studies to investigate the annoyance caused by aircraft noise which, among other things, also found indications of the change effect. The NORAH team is building on three studies in particular and trying to enlarge upon previous results or find answers to unanswered questions. None of these studies, however, had the precise address information about the historical noise exposure of the participants.

1. A new take-off and landing runway went into operation at Amsterdam's Schiphol Airport in 2003. In 2002 a Dutch research team began a four-year investigation of how severely a group of 640 residents felt bothered by the aircraft noise before and after the new runway went into operation. The result: the annoyance grew more sharply than the aircraft noise. Two years after the new runway was opened, the annoyance in relation to the noise sank slightly. The scientists concluded from this that people react more sensitively to aircraft noise before and shortly after expansion projects at airports. Not all of the results, however, point in this direction. For example, the Dutch research team had asked the residents in each of the four years how they would assess their quality of sleep and health. It was not possible to derive any special reaction to the expansion of the airport from their answers.

2. The so-called RDF Study was named after and commissioned by the Regionales Dialogforum Flughafen Frankfurt, which later became the Forum Flughafen und Region. The scientists on the study had carried out a survey of 2,312 residents around Frankfurt Airport in 2005. One of the most important results was the finding that the study participants felt a lot more bothered by aircraft noise than the exposure-effect graphs used in the European Union had suggested.

3. The EU project COSMA ("Community Oriented Solutions to Minimise Aircraft Noise Annoyance"), which ran from 2009 to 2013, attempted to find technical solutions with the aim of building quieter aircraft. The international research team not only developed very precise models to calculate the propagation of noise over the communities in the proximity of the airports Cologne/Bonn, London-Heathrow, and Stockholm-Arlanda, but also took into account the annoyance of the people. The study was able to identify several physical and psychological factors which have an influence on how badly people feel bothered by aircraft noise.

CAR, PLANE, TRAIN – A COMPARISON OF SOURCES

Airports are often located near built-up areas with a high density of different types of traffic. This is why in many places there may be rail and road noise as well as aircraft noise. Before NORAH, several studies were dedicated to the question as to how severely people feel bothered by these three traffic noise sources. Most of the studies, however, observed the three noise sources separately, although the noise of cars, trains and planes often overlap in the everyday lives of many people.

The Quality of Life Study is thus following on from this with a comparison of noise sources in the lives of many residents in the proximity of airports, and examines how severely the people feel bothered when several types of noise occur simultaneously – so-called combined noise. Although physicists can calculate the sound level of several noise sources together, it has not been scientifically explained how severely people feel bothered when exposed to noise from different sources. The scientists on the Quality of Life Study are pursuing several hypotheses (glossary) – possible assumptions of how the interaction of various noise sources affects people.

- One hypothesis suggests that individual noise sources "overlay" others, so that, for example, in the perception of people, the constant noise of road traffic overlays the noise of aircraft.
- In another hypothesis the scientists make the opposite assumption: that the annoyance tends to increase when several noise sources come together. In concrete terms, this could mean, for example, that people feel more bothered when road noise is added to the aircraft noise – even if the road noise is quieter than the noise of the aircraft.

foto-rolf/istockphoto

Deutscher Verkehrssicherheitsrat (DVR)

Deutsche Bahn

INDIVIDUAL SOUND CALCULATIONS

Every noise impact study begins with acoustic calculations. Only when the noise exposure of all the study participants is known can the scientists find out how much noise can have which consequences. For the NORAH Study the acoustics experts had to calculate the exposure to aircraft, road and rail noise for every address in the whole investigation area. The aim was to reconstruct the noise over several months in this sub-study from October 2011 to September 2013. This is the only way that the study can draw conclusions on the consequences of several months of permanent noise exposure.

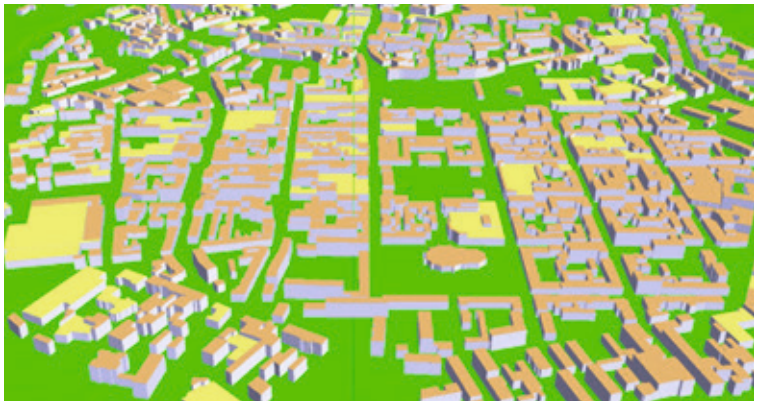
From the sound source …

In order to achieve this, the acoustics teams first had to find out where in the four investigation areas which traffic noise occurred in the past. The scientists obtained the necessary from three sources. The German air traffic control authority, Deutsche Flugsicherung, provided data on the flight movements of the past years around Frankfurt Airport. The other three investigated airports provided this data directly to the NORAH team. Information about the trains that passed through the investigations area was provided by the Deutsche Bahn and the Federal Railway Authority. The community administrations also made information available on the number and type of vehicles using the roads. With this data the acoustics team was able to calculate where in the past how much traffic noise occurred.

… to the noise exposure

It does not tell us much about the noise exposure at a particular address if we only know, for example, that a train passed by at a distance of 300 metres. The propagation of sound at any given location will depend on hills, dips and buildings: if rows of houses or hills separate a location from the rail track, there will be less noise there than in an open space. This is why the acoustics experts used a three-dimensional terrain model with a precise replication of all the houses and the terrain to calculate how the noise was propagated. The result: the NORAH acoustics database contains the individual noise calculations over several years for the addresses of all study participants. No other noise impact study has ever had such precise acoustic calculations at its disposal. For further information on the acoustic basis of the study, see *"NORAH Knowledge" no. 2 (order and download at www.laermstudie.de under "Knowledge").*

Terrain models show where hills, dips and buildings are located. With the aid of this, the acoustics team calculated how the rail and road traffic noise was propagated in the investigation area.



Möhler + Partner AG

THE PARTICIPANTS

The Quality of Life Study evaluated information provided by a total of 29,239 persons. Two-thirds of those surveyed were living in the Rhine-Main Region at the time of the survey, the rest in the proximity of the airports Cologne/Bonn or Stuttgart or the planned Berlin-Brandenburg Airport. A decisive factor in the selection of all participants was how much aircraft noise could be heard where they lived.

Selection criterion aircraft noise

In order to assess whether there is a connection between the measureable noise exposure and the subjective noise annoyance, the scientists had to know exactly how loud it was at the addresses of the participants in the time before the survey. They also required information from people who were subject to very different noise exposures. In order to achieve both, the NORAH acoustics team first went to work to calculate the aircraft noise exposures at all addresses in the Rhine-Main Region and at the other three airports. Places where the daytime or night-time long-term energy equivalent sound level (glossary) was at 40 dB mark the contours of the investigation areas. The acoustics experts call this "the surrounding contour of the daytime and night-time long-term energy equivalent sound level of 40 dB."

Then the scientists divided up all of the residential addresses within these areas according to the average noise exposure into different groups – the so-called noise level classes. Each noise level class covered a range of 2.5 dB: the lowest noise level class included addresses with a long-term energy equivalent sound level between 40 and 42.5 dB, the next highest class had a level between 42.6 and 45 dB, and so on. In the highest noise level class the long-term energy equivalent sound level for aircraft noise was from 62.6 to 65 dB. In the Rhine-Main Region the NORAH acoustics experts also calculated the long-term energy equivalent sound level for the road and rail noise in the same way. Here the highest noise exposures were at a long-term energy equivalent sound level of around 83 dB.

It was only when this preliminary work was completed that the scientists recruited people in the four investigation areas for participation in the study. They made the first contact with the aid of data from the resident registration offices. The aim of the NORAH team: to recruit around the same number of participants in each sound level class in order to be able to make well-balanced calculations as to how various noise exposures impact on quality of life and annoyance.

Participants in numbers

Most of the surveys were carried out in the area around Frankfurt Airport. For the first wave of surveys in 2011 – i.e. before the north-west runway opened – the NORAH team was able to recruit 9,244 people.

4,867 of these people also took part in the second wave of surveys in 2012. In 2012 the NORAH team also surveyed a further 7,113 persons at whose address rail and/or road traffic noise could also be heard in addition to aircraft noise.

In the third and last wave of surveys in 2013, the scientists surveyed 3,508 persons who had also participated in the two previous years. They were also able to recruit 2,400 new participants. The reason for this new group of persons: it is known from research that some people respond differently when they are asked the same questions several times in succession. By comparing the responses of a new group of persons with those of the participants taking part for the third time in 2013, the NORAH team was able to assess whether the multiple surveys had "distorted" the responses.

Overview of surveys and participant numbers in the Rhine-Main Region

2011	2012	2013	Sub-totals
1st wave of surveys 9,244 persons	**2nd wave of surveys** 4,867 persons from wave 1	**3rd wave of surveys** 3,508 persons from wave 1 and 2	**9,244 persons**
No additional survey	Survey on rail/road/ multiple-source noise: 7,113 persons	New group of persons: 2,400 persons	**9,513 persons**
			Total number of persons surveyed: 18,757

Unlike in the Rhine-Main Region, only one round of surveys was carried out at the other three airports. For the planned location comparison within the framework of the study it was not necessary to accompany the participants over a prolonged period.

Overview of participant numbers at the other airports:

Cologne/ Bonn	Stuttgart	Berlin	Total
2,955 persons	1,979 persons	5,548 persons	**10,482 persons**

Apart from the minimum noise exposure of 40 dB, there were no other criteria for participation in the Quality of Life Study. A minimum age limit of 18 years was necessary, however, mainly for data protection reasons.

QUESTIONNAIRE ON FOUR AREAS OF LIFE

Unlike all of the other NORAH sub-studies, the Quality of Life Study collected its data exclusively from questionnaires – apart from the fact that an acoustics team also calculated the noise exposures for each individual participant. A questionnaire took around 20 to 25 minutes to complete. The participants had the choice between an online questionnaire and a telephone interview. All of the questionnaires are scientifically established and are also used in other studies.

Issue 1: Traffic noise reactions and quality of life

The World Health Organization defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." The questionnaires used in the Quality of Life Study are based on this definition. The NORAH scientists wanted to find out not only whether the people suffer from illnesses, but also how well they feel and how satisfied they are with their life situation. The first set of questions thus focuses on the reactions of people to traffic noise and assessments of their quality of life. Among other things, the respondents stated at which times and how severely they felt bothered by aircraft noise, and at which activities the noise annoyed them. The NORAH team also wanted to know, for example, how well the respondents slept at night, and how they protected themselves from noise.

Staff of the Social Science Survey Center (SUZ) in Duisburg carried out the telephone surveys for the Quality of Life Study. Alternatively, the study participants also had the option of completing an online questionnaire.

SUZ GmbH

Issue 2: Possible influencing factors

Former studies have shown that the personal domestic and life situation can have a lot to do with how severely someone feels bothered by traffic noise. It can depend, for example, on how many hours a day someone is at home, or on how well the apartment is noise-insulated. Attitudes towards the source of the noise or towards the responsible institutions can also influence how bothered someone feels by traffic noise. The scientists asked, for example, how positively or negatively the people regarded airport operation, or whether they felt that they were treated fairly on the issue of noise protection. In addition to this, some of the questions addressed the individual noise sensitivity of the participants.

The NORAH team also collected information about attitudes, individual noise sensitivity and sociodemographic data.

Issue 3: Questions on health

Certain illnesses can have an influence on how people react to traffic noise. Studies suggest that illnesses such as diabetes, depression or cardiac disorders can be linked with chronic noise exposure. This is why the NORAH team also asked about a series of disorders which played a role in earlier studies. The scientists also wanted to know how healthily the respondents lived, for example whether they smoked or got regular exercise.

Issue 4: Sociodemographic data

Just as in every larger survey, the scientists in the Quality of Life Study also asked for some background information. This included gender and age, family status, education level, income and the number and age of the children in the household. The NORAH team also asked whether the respondents had a migration background. This so-called sociodemographic data was important, for example, to examine whether the respondents reasonably represented all social groups, and whether people of different ages or income classes possibly react differently to traffic noise.

Additional questions on combined traffic noise

7,113 persons in the Rhine-Main Region responded to a somewhat different questionnaire in 2012. The additional investigation on the multiple exposure to aircraft, road and rail noise included some further questions about how bothered people felt by different noise sources, and how they assessed their overall noise annoyance.

DATA PROTECTION: APPROVED BY FOUR FEDERAL STATES

Legislation supports scientists in the conduct of major health studies. But it also regulates very carefully how research institutes have to protect the personal data of study participants. The NORAH team was only able to start work after the data protection officers in Hessen, Baden-Württemberg, North-Rhine Westphalia and Brandenburg had confirmed that all of the bodies involved in the Quality of Life Study were in compliance with the legal stipulations.

Obliged to secrecy

In order to protect the data of the study participants, all persons involved in the study had to sign data protection declarations. They are obliged to secrecy and confidential handling of all personal data. The project staff also informed the respondents exactly about their data protection rights. Only persons who declared their express consent were allowed to take part in the survey.

Everything on a "need to know" basis

Each of the institutes involved in the study only had access to part of the data. The NORAH team assigned a random number ("ID") to each respondent. The scientists link all of the other information with this ID. Only a very small number of persons can trace an ID back to a specific respondent.

Overview of institutes involved and their data access:

- The Munich engineering office Möhler und Partner along with the company AVIA Consult in Strausberg were responsible for the noise calculations in the study. The acoustics engineers calculated the road, rail and aircraft noise exposure at all addresses, but did not know who lived there.

- The Social Science Survey Center (SUZ) in Duisburg conducted the surveys. The staff knows the names, addresses and health data of the respondents. This is the usual procedure in studies of this kind – otherwise it would not be possible to conduct the interviews. However, the SUZ stored the personal data and the answers on separate computers.

- The survey data and the calculated noise levels of the respondents came together in the ZEUS GmbH in Hagen, which is directing the Quality of Life Study. The scientists here have no access to the names and addresses of the participants – all of the evaluations were made on the basis of the IDs.

In order to protect the data of the study participants, all of the persons involved in the study had to sign data protection declarations.

Glossary

You will find further explanations 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 the 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 act – 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

The decibel – "dB" or "dB(A)" – is a measure of the sound pressure level and thus of the loudness. The decibel scale from 0 to 120 dB(A) reflects the range from the absolute threshold of hearing to the pain threshold. The scale is not linear. We perceive an increase of ten decibels as roughly a doubling of the loudness – in the lower and at the upper ends of the range.

Hypothesis

A hypothesis is an assumption or a supposition. Science consists largely in the examination of hypotheses. Scientists set up their research in such a way that they can test their hypotheses. As long as the hypotheses are not refuted by the research, for example by measurement values or survey data, the scientists continue working on the basis of the hypotheses.

Maximum noise level

The physical value which best describes how strongly nocturnal aircraft noise impacts on sleep is the maximum noise level. It shows to what extent the aircraft noise stands out from the existing background noises. The annoyance effect overall depends on the height and the frequency of occurring maximum noise levels.

Sound level

This shortened expression generally refers to the sound pressure level, the physical value that describes the strength of the sound waves.

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