Night-time Noise Annoyance: State of the Art

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The annoyance-reaction is one of the central variables in noise research. After an introduction to different concepts and definitions of noise annoyance different scales of how noise annoyance can be measured are shown. The question is discussed whether disturbance effects of noise at different times of day are given. To clarify this problem, the results of a series of actual German noise studies are reported. In these studies differences between day- and night-time annoyance are found depending on the sound sources. For the case of road traffic noise no differences between day and night-time annoyance were found. In contrast, annoyance reactions are related to the time of day for railway and air traffic noise. Especially for aircraft noise, above a Leq of 50 dB(A) night-time annoyance rises faster than day-time annoyance. The effects are discussed in the frame of a cognitive model of noise annoyance. It is argued that annoyance judgements are based on an internal representation of the noise situation. Part of this representation are the event characteristics of the sound sources and their estimated impacts for disturbances at different times of day.

Keywords: annoyance, road traffic noise, railway traffic noise, air traffic noise, cognitive model

Introduction

Annoyance is a central concept in international noise research. Within a lot of field studies, among the variety of measured responses due to environmental noise, the variable “annoyance” shows the highest correlations with acoustical parameters. But what is the exact meaning of annoyance? As Guski, Felscher-Suhr and Schuemer (1999) pointed out, noise annoyance can be seen as emotion, as a result of disturbance, as attitude, as knowledge, or as a result of rational decisions. The definition of annoyance as emotion focuses on affective processes related to the source of stimulation. The “disturbance approach” considers annoyance as secondary reactions produced by the interference of noisy events with intended activities. Annoyance as attitude relates to a set of evaluating cognitions about the source of the noise, the producer of the noise, or the noise itself. Within the concept of annoyance as knowledge, a person’s conceptual knowledge about the effects of a sound in a certain situation plays the major role. Annoyance as the result of rational decisions focuses on conscious judgements balancing the different aspects of a noisy situation. A semantic study with international noise experts, done by the authors mentioned above, revealed that the term noise annoyance is highly associated with nuisance, disturbance, and unpleasantness.

In general, two main aspects seem to be connected with noise annoyance:

1. Behavioural effects like disturbance or interference of noisy events with intended activities and
2. negative evaluations of the noise source.

For measuring annoyance reactions, different scales have been developed. Concerning to different demands, especially for achieving comparability of different studies, the distinction between global and specific, activity related annoyance reactions has become established. With global annoyance scales overall noise related annoyance judgements should be recorded. This type of scale range from annoyance-thermometers to the newest development, an international standardized annoyance scale having equidistant scale-units. The equidistance is achieved by selected verbal labels marking the different steps of the scale (see Figure 1).

The specific annoyance scales concern to the different activities performed at different times during the 24 hours of the whole day. For day-time annoyance, the scales relate in most cases to disturbances in communication, mental concentration, and recreation. For night-time annoyance, the scales relate to recreation and...
different aspects of sleeping quality. Of special
interest here are scales concerning to difficulties in
falling asleep and reported awaking responses.

In connection with annoyance reactions at different
times of a day, one of the important questions is
whether subjects respond to a stronger degree to
noisy events during night-time. Are subjects more
sensitive to noise when they want to sleep? Thus, the
empirical question is, whether dose-response
relationships are different for day- and night-times.
For comparing day- and night-time annoyance, the
recorded annoyance criterion should be kept
constant. One possibility is given by using global
annoyance scales to compare effects of noise for
different times of day. This is no easy task, because
the global annoyance scales are not standardized
across the different studies. Despite this problem, a
first overview of existing survey data was given by
Fields (1986). As a result of his analyses, Fields
concluded that the existing survey data till that point
in time do not provide valid and accurate estimates of
the relative importance of noise at different times of
day.

Empirical evidence that differences between day and
night-time annoyance depend on the quality of the
disturbing sound-sources comes from a series of
German noise studies. These studies concern to noise
from road, railway, and air traffic.

Differences in day- and night-time annoyance
Road and railway traffic
On behalf of the German railway association a
comparative noise study was carried out in 1996 and
1997 (Griefahn, Möhler and Schuemer, 1999). In the
western part of Germany 1690 subjects were
interviewed about the subjectively experienced
effects of road traffic and railway noise. The subjects
were selected according to a quasi-experimental
design. Within this design, noise levels of road and
railway traffic varied systematically. Some questions
of the used questionnaire concerned to global and
specific annoyance reactions. Especially day- and
night-time annoyance was recorded. Besides, data
were collected about self-reported sleeping quality.
From a subset of subjects physiological sleeping
measurements were taken.

The results reported here concern to dose-response
relationships for day- and night-time annoyance. The
annoyance judgements were recorded by a 5-step
annoyance scale. Figure 2 shows the dose-response
relation on the basis of aggregated data for road
traffic.
As it can be seen from the figure, global annoyance judgements do not differ substantially for day and night-time.

For the sound-source railway traffic, the relationships are changing. As shown in Figure 3, the dose-response relations are different for day- and night-times.

For same noise levels, subjects are less annoyed during the night than during the day. The mean difference amounts on the 5-step scale about half a scale unit.

The difference between the two sources is also reflected in the dose-response relations for the self-reported sleeping quality. Figure 4 depicts that at same noise levels, subjects report less sleeping disturbances for railway than for road traffic.

What may be the reasons for these differences in night-time annoyance reactions between the sound sources? Before the effects are discussed and some ideas are presented, results of a German air traffic study should be reported.
Air traffic
The largest airport in Germany is Frankfurt. Because of the huge amount of air traffic around Frankfurt and some intentions to expand the airport, different research activities to examine the effects of aircraft noise are initiated by the government. The study reported here was carried out in 1998 (Kastka, 1999). 1147 inhabitants at different locations around Frankfurt airport were interviewed in the study. To achieve dose-response relations in annoyance, variations in noise levels were obtained by selecting subjects living at different distances to the airport. In contrast to the study reported above, the response criterion of the present survey was the percentage of highly annoyed subjects. Only those people were classified as highly annoyed, who respond on a 7-

Figure 4. Self-reported sleeping disturbances for road and railway traffic noise (from Griefahn et al., 1999).

Figure 5. Day-related dose-response relation for air traffic noise around Frankfurt airport (from Kastka, 1999, modified by the authors).
Figure 5 shows the percentage of highly annoyed subjects in relation to the noise level during the day. Each point in the graph reflects a geographic location with a certain noise level and a certain percentage of highly annoyed people. Figure 6 depicts the relations for the night-time.

An inspection of the diagrams makes nonlinear relationships more plausible than linear relationships. In addition to the regression lines a nonlinear curve is inserted into the graphs by the authors. This nonlinear relationship can be taken into account when instead the $L_{eq}$ the NAT70 measure is used. The NAT70 is the number of events above the threshold of 70 dB(A). This measure reports aircraft noise in the way that a person perceives it – as a series of noise events some of which are perceptibly intrusive (cp.}
Southgate, Aked, Fisher & Rhynehart, 2000). On the basis of nonlinear dose-response relationships it can be seen from the diagrams that night-time annoyance raises steeper at Leq levels above 50 dB(A). For the case of air traffic - above a noise level of about 50 dB(A) - subjects seem to be disturbed to a stronger extend during the night than during the day.

Figure 7 depicts for the existing Frankfurt-data the relation between the Leq and the NAT70.

A cognitive model of noise annoyance
Summarizing the results of the different studies it can be the following stated:
1. there is no substantial difference in day- and night-time annoyance for road traffic noise,
2. for air traffic noise, the dose-response relationship is non-linear,
3. the amount of night-time annoyance depends on the sound-source.

A comparison of the different types of noises leads to the assumption that annoyance reactions are influenced by the event characteristics of the sounds. Whereas road traffic noise is perceptually more or less continuous, railway and aircraft noise are mainly characterized by single events. Subjects know the impacts of such events for their annoyance reactions at different times of day. Because annoyance reactions are verbally coded measures, subjects refer - when they are interviewed - to their internal representation of the noise situation. Internal representations are influenced by a variety of factors (e.g. Neisser, 1976). Subjects use this internal data basis to elicit consistent and plausible responses to most different demands. A coarse cognitive model of noise annoyance is depicted in Figure 8.

Besides the sound source and its event characteristics, internal representations of the noise situation are influenced by psychological and social conditions. These factors which influence noise annoyance are discussed by Guski (1999) in detail and not matter of the present considerations.

Especially for different aspects of night-time annoyance like sleeping disturbances, the model fits to empirical data. The observation that physiological sleeping indicators do not correlate with self-reported sleeping quality (Griefahn et al., 1999) has presumably its cause that the verbal judgements refer to the internal representation, whereas physiological measures relate to actual physiological states. Thus, annoyance reactions reflect manifested impressions of the noise conditions.

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References


