The Physical and Mental Effects of Noise

Jördis Wothge
Section I 3.4
Noise Abatement of Industrial Plants and Products, Noise Impact
Outline

1. Introductive remarks about noise effects
2. Physical and mental effects of noise
3. Implications
4. Conclusion
Noise Effects

Two basic distinctions:
- Aural versus extra-aural noise effects
- Direct versus chronic noise effects
Noise Effects I

- Impairment of hearing organs
- Cardiovascular disease
- Sleep disturbance
- Cognitive impairment
- Noise annoyance
- Mental illness
- Aural effects
- Extra-aural effects
Introduction

Noise Effects I

Aural effects caused by environmental noise are very unlikely

Cardiovascular disease
Sleep disturbance
Cognitive impairment
Noise annoyance
Mental illness

Extra-aural effects
Noise Effects II

Distinction of direct vs chronic effects:

Direct effects
• Decrease in quality of sleep (e.g. increase of wake-up reactions and motility, decrease of deep-sleep and dream-sleep phases)
• Interferences with the autonomous nervous system (e.g. increase in frequency of heartbeats)

Chronic effects
• Increased risk for hypertonia
• Increased risk for cardiovascular disease
Noise-Effect-Model: Stress – Cardiovascular Disease

- Noise
  - Inner ear
    - CNS / Hypothalamus
    - Adrenal medulla
      - organs e.g. heart
        - Cardiovascular disease
  - Acoustic nerve
  - Sympathicus
    - Adrenaline, Noradrenaline

Introduction
Physical and Mental Effects of Noise

- Cardiovascular Disease
- Sleeping Disturbances
- Cognitive Impairment
- Noise Annoyance
- Mental Illness
Physical and Mental Effects of Noise

- Cardiovascular Disease
- Sleeping Disturbances
- Cognitive Impairment
- Noise Annoyance
- Mental Illness
Cardiovascular Disease

Noise activates the autonomous and hormonal system. Thereby blood pressure and heart frequency can be altered.

Biological risk factors like blood sugar or the clotting of the blood can be influenced. This can result in arteriosclerosis and high blood pressure levels and eventually lead to a heart attack.

Potential diseases include:
- Hypertonia und hypotension
- Cardiac insufficiency
- Heart attack / Myocardial infarction
- Stroke and cerebral infarction
Cardiovascular Disease

Jarup et al, 2007 (HYENA)

- Study at 6 European airports, which examined the relationship between road- and aircraft noise and the prevalence of hypertonia
- Increase of 10 dB(A) $L_{\text{Night}}$ leads to a 10 – 14% higher risk to get hypertonia

Sörensen, et al 2012 & Gan et al 2012:

- Analysis of the impact of road traffic noise on heart attacks and strokes
- Increase of 10 dB(A) $L_{\text{Night}}$ leads to a 6 – 15% higher risk to get a stroke or heart attack

Significant increase in the risk to develop a cardiovascular disease from 65 dB(A) daytime and 55 dB(A) nighttime
Physical and Mental Effects of Noise

Noise Exposition to Traffic-Noise in Germany

Belastung der Bevölkerung durch Verkehrslärm nach Umgebungslärmrichtlinie
in der Umgebung von Hauptverkehrsstraßen, Haupteisenbahnen, Großflughäfen und in Ballungsräumen

Lärmbelastete Bevölkerung, Anzahl der Personen

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Source: Umweltbundesamt, 2016

Quelle: Umweltbundesamt 2016, Zusammenstellung der Mitteilungen der Bundesländer und der Eisenbahn-Bundesamtes entsprechend § 47c StumSchG
Physical and Mental Effects of Noise

- Cardiovascular Disease
- Sleeping Disturbances
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- Mental Illness
Sleep Disturbances

Noise induced sleep disturbances include:
- Wake-up-reactions and change of sleep-phases
- Modification of the configuration of sleep-phases
- Prolonged sleep-latencies (e.g. sleep-onset)
- Alteration of hormonal distribution and blood circulation
- Increase in heartbeat & breathing frequency and motility

Short-term consequences:
Increase in tiredness and decrease of productive efficiency

Long-term consequences:
Noise related sleep disturbances become a risk for the cardiovascular system and health in general
WHO Night Noise Guidelines

$L_{\text{night}}$

Up to 30 dB(A): No substantial biological effects

30 to 40 dB(A): Modes effects (some effects on sleep: e.g. more movements), greater effects for vulnerable groups, effects depend on characteristics of noise

40 to 55 dB(A): Adverse health effects, many people have to adapt their lives to cope with noise at night

above 55 dB(A): Increasingly dangerous situation. Adverse health effects occur frequently. Sizeable proportion of the population is highly annoyed and sleep disturbed. Risk of cardiovascular disease increases

WHO-Recommendation: $L_{\text{night}} = 40$ dB(A)
Physical and Mental Effects of Noise

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Lärmbelastete Bevölkerung, Anzahl der Personen

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<th>Anzahl der Personen</th>
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Stand: 29.02.2016

Quelle: Umweltbundesamt 2016, Zusammenstellung der Mitteilungen der Bundesländer und des Eisenbahn-Bundesamtes entsprechend § 47c BibSchG

Source: Umweltbundesamt, 2016
Physical and Mental Effects of Noise

Physical and Mental Effects of Noise

- Cardiovascular Disease
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- Mental Illness
Cognitive Impairment

- Continuous noise exposition can have negative effects on cognitive performance
- Studies show that acute and chronic noise exposure can lead to decelerated response rates and increased error rates in reaction tests
- Children are a particularly vulnerable group, because their cognitive processes are less automatized than adults
  → especially reading capacity
Physical and Mental Effects of Noise

Cognitive Impairment

Klatte et al., 2014 (NORAH)

• study on the influence of aircraft noise exposure on reading capability of second grade students around Frankfurt airport

• Increase in 10 dB(A) $L_{Aeq,08-14h}$ lead to a delay of reading capability of one month

• In total children in noisy neighborhoods had up to two month delay in reading capacity in comparison to children from less noisy neighborhoods
Physical and Mental Effects of Noise

- Cardiovascular Disease
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- Noise Annoyance
- Mental Illness
Noise Annoyance

• Most common effect of noise exposure

• Due to its significance it is explicitly referred to in the German legislation (BlmSchG, Fluglärmenschutzgesetz)

• Is more than momentary feeling of subjective well-being: Continuous annoyance can be the onset for physiological stress reactions and thereby a pre-descent of various noise-related diseases

• Different noise sources vary in their degree of annoyance-capacity and vary in occurrence
Noise Annoyance

Source: German Environment Agency, Environmental Consciousness in Germany 2014
Differences in Noise Annoyance by Source

![Graph showing differences in noise annoyance by source.]

- Fluglärm
- Straßenverkehrslärm
- Schienenverkehrslärm

Quelle: European Commission Working Group on Dose-Effect Relations, 2002
Differences in Noise Annoyance by Source

Source: Ergebnisbericht NORAH Studie. Verkehrslärmwirkung im Flughafenumfeld. Band 7: Gesamtbetrachtung des Forschungsprojekts NORAH
Increase in Aircraft Noise Annoyance


Source: NORAH Wissen Nr. 13
Physical and Mental Effects of Noise

- Cardiovascular Disease
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- Mental Illness
Mental illness

Recent studies show that chronic noise exposure raises the chance to develop a unipolar depression.

Seidler et al., 2015 (NORAH)
An increase by 10 dB(A) average sound pressure level ($L_{aeq,24h}$) of traffic noise leads to a 4 - 8.9% higher risk to develop a depressive episode.

BUT: Only a small amount of studies so far.
  ➔ more research is needed!
Implications

• It can be regarded as scientifically proven that the risk for developing cardiovascular diseases rises significantly above an average sound pressure level of 55 dB(A) at night time and 65(A) at daytime.

• Almost all effect dimensions (esp. sleep disturbances) show that continuous exposition to nighttime noise can be particularly severe → thus, the German Environment Agency recommends a curfew for all airports between 22.00 at night and 6.00 o’clock in the morning

• Studies on cognitive development of children underline the importance of research of noise exposure on vulnerable groups
Implications

• Increase of aircraft noise annoyance in the last 10 – 15 years
  → refinement of the exposure-response curves that are used to support legislation is needed

• Mental illness is an important ‘new’ effect dimension. Existing studies show a relationship of noise exposure and depression
  → effects might still be underestimated, due to use of insurance-data
## Recommendations by the German Environment Agency

### Empfehlungen zu Auslösekriterien für die Lärmaktionsplanung

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<th>Zeitraum</th>
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<th>$L_{Night}$</th>
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*Quelle: Umweltbundesamt*
Conclusion

• Noise exposure is a serious environmental problem

• Continuous noise exposure can pose a serious threat to the physical and mental health of the population:
  – *Cardiovascular disease*
  – *Sleep disturbances*
  – *Cognitive impairment*
  – *Noise annoyance*
  – *Mental illness (esp. unipolar depression)*

• All possible measures have to be undertaken in order to improve the living conditions of the population with regards to environmental noise
Thanking you for your kind attention:

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https://www.umweltbundesamt.de/en