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## **The impact of railway grinding on noise levels and residents' noise responses – Part II: The role of information**

Dirk Schreckenberg<sup>1</sup>, Ulrich Möhler<sup>2</sup>, Manfred Liepert<sup>3</sup>, Rudolf Schuemer<sup>4</sup>

<sup>1</sup> ZEUS GmbH

Sennbrink 46, 58093 Hagen, Germany

<sup>2,3</sup> Möhler + Partner Ingenieure AG

Paul-Heyse-Straße 27, 80336 Munich, Germany

<sup>4</sup> Elberfelder Str. 32, 58095 Hagen, Germany

### **ABSTRACT**

A socio-acoustical field survey (see Internoise 2013 paper of Manfred Liepert et al. for study design and acoustical results) was carried out to assess the impact of rail grinding on noise levels and noise responses of residents living along the grinded railway line. This contribution deals with the role of information about the potential noise reducing effects of rail grinding given to residents.

The rail grinding was done on a railway line connecting Baden-Wuerttemberg with Bavaria in South Germany. On the Baden-Wuerttemberg side communities were informed about the rail grinding and its noise-reducing effect before the grinding was done ('informed' area). On the Bavarian side this information was not given ('uninformed area'). 340 residents were interviewed about 3 months before and 1-2 months after the grinding. Noise levels were assessed for the address of each participant. The effect of grinding on noise levels was low because of technical problems:  $L_{Aeq}$  for daytime and night-time was reduced on average about 1-2 dB after grinding. Only residents from the 'informed area' showed a significant decrease in annoyance and disturbances, whereas noise responses of participants from the 'uninformed area' did not change significantly. The results indicate that informing residents considerably supports the impact of noise abatement measures on residents' noise responses.

Keywords: Noise, Railway, Noise abatement, Change effect, Non-acoustical factors, Information

### **1. INTRODUCTION**

Transportation noise is known as a widespread environmental burden causing annoyance, disturbances of daily life, and sleep disturbances, and it is found to be associated with cardio-vascular health diseases and impairments of children's cognitive performance [1]. Although general exposure-response curves for annoyance due to transportation noise [2][3] indicate that for equal average sound level (e.g.  $L_{dn}$ ,  $L_{den}$ ) railway noise is less annoying than road traffic noise, contradictory

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<sup>1</sup> schreckenberg@zeusgmbh.de

<sup>2</sup> ulrich.moehler@mopa.de

<sup>3</sup> manfred.liepert@mopa.de

<sup>4</sup> schuemer@zeusgmbh.de

results are reported in particular in Asian countries [4][5]. Recently published studies have shown that railway noise has a substantial impact on sleep (e.g. [6]), Lercher et al. [7] report subjective distress due to railway noise and an absence of a railway bonus (compared to road traffic noise) for night-time annoyance in a field study carried out in the Alpine Region.

A major part of noise emitted by passing trains is the rolling noise caused by the contact of wheel and (roughed) rail. Passing trains can emit up to 10-15 dB(A) higher noise levels on highly corrugated rail surfaces than on even ones [8]. The roughness of rail surfaces can be considerably reduced by periodical rail grinding leading to lower noise levels. Noise level changes due to rail grinding are considered as type 1 exposure changes according to Brown and van Kamp (in short: noise exposure changes at the source, i.e. rail grinding directly affects the development of rolling noise of passing trains).

In a pilot study the impact of rail grinding on changes in railway noise annoyance of residents living along a railway line in South Germany (railway line Munich – Rosenheim – Salzburg) was investigated [9]-[10]. 81 residents of one area (Vaterstetten) took part in three survey waves, the first measurement was carried out four weeks before the rail grinding (t1) the second about four weeks after the rail grinding (t2) and the third inquiry one year after the grinding (t3). Shortly before the third survey wave local newspapers informed about rail grinding as a measure done along the railway line in order to reduce the railway noise. The reduction of the equivalent sound level after the rail grinding at the second measurement was in total 8 dB  $\Delta L_{Aeq}$  for daytime and 7 dB  $\Delta L_{Aeq}$  for night-time. One year later at measurement t3 values of the equivalent sound levels were still the same than those at the second measurement. Railway noise annoyance was significantly reduced at t2 in comparison to t1 and at t3 compared to t1. For disturbances due to railway noise the results were mixed: communication disturbances outdoor was reduced at t2 compared to t1 but increased at t3, sleep disturbances increased from t1 to t3, disturbances of conversation and recreation was reduced at t2/t3 in comparison to t1. As the equivalent sound levels did not change between t3 and t2 but the annoyance responses of the participants slightly decreased, the authors concluded that the information given before t3 partly influenced the noise reactions. However, this could not be investigated systematically in the pilot study.

The impact of non-acoustical factors on noise annoyance is well known. In particular, attitudes towards the source and towards authorities regarded as responsible for reducing the noise, perceived fairness of the noise management procedure and information given to residents have been found to play an important role for transportation noise annoyance [11]-[13]. It is assumed that those factors are particularly contributing to the so called 'change effect' in annoyance, i.e. an excess in annoyance changes following changes in noise exposure (whether it is a decrease or increase in exposure) that cannot be predicted from steady-state exposure-response functions [14]. Study results which indicate that expectations about future noise annoyance and residential quality of life affect annoyance judgments before changes in noise exposure [15]-[16], suggest that the change effect in annoyance already starts after the announcement of upcoming plannings and before the change in noise exposure occurs [17]. This supports the assumption that the change effect in annoyance is affected by changes in (non-acoustical) factors modifying the exposure-response relationship (see [14] for further discussion of that hypothesis).

Information on upcoming noise mitigation given prior to the implementation of such measures might positively influence the expectations concerning future noise exposure and thus moderates the exposure-response relationship for noise annoyance. To test this assumption the study presented in this paper aims at investigating (a) the effect of rail grinding on noise annoyance of residents living along the grinded railway line and (b) the impact of information on residents' annoyance and disturbances due to railway noise.

The following hypotheses were tested:

(H1): It is assumed that in line with the decrease in noise exposure after rail grinding noise the responses of residents living along a railway line are lower after rail grinding than before.

(H2): In areas where residents receive information about rail grinding and its noise-reducing impact the decrease in railway noise annoyance and disturbances is stronger than in areas where residents do not receive such information.

## 2. METHODS

The design of the study is described in more detail in the INTER-NOISE 2013 paper of Liepert et al. [8], see also [18]. Thus, only main design elements are briefly mentioned here.

### 2.1 Procedure and sample

The study was carried out along a railway line in South Germany connecting Stuttgart (Baden-Wuerttemberg) via Ulm with Augsburg (Bavaria).

In a letter preceding the survey all residents in the study areas (301 in Uhingen, east to Stuttgart, 260 in Burlafingen/Unterfahlheim, east to Ulm) were informed about the study and were asked for participation. In addition, on the Baden-Wuerttemberg side residents in the study area (Uhingen) were informed about the rail grinding and its noise-reducing effect. Information was given in the form of individual letters to the participants, leaflets, press releases and radio interviews. On the Bavarian side (Burlafingen, Unterfahlheim) this information was not given. The repeated interviews after the rail grinding were justified in individual letters to the Bavarian participants by possible changes in noise exposure due to variations of traffic volume or weather conditions.

In total, 411 residents were interviewed in face-to-face interviews about three months before the rail grinding (t1), 340 of them took part again in the second survey (t2), one to two months after the rail grinding, 163 of them from the informed area, 177 participants from the uninformed area (Table 1).

Table 1 – Study design: Study area, sample

Study area	t1:	t2:
	3 months before rail grinding	1-2 months after rail grinding
With information		
(Uhingen, Baden-Wuerttemberg, railway line Stuttgart - Ulm)	n = 190	n = 163
Without information		
(Burlafingen/Unterfahlheim, Bavaria, railway line Ulm - Augsburg)	n = 221	n = 177
Total	n = 411	n = 340
Response rate	73%	83%

### 2.2 Questionnaire

The survey was introduced as an interview study on residential life. The questionnaire used for the face-to-face interviews before the rail grinding included questions on the residential conditions, residential satisfaction, annoyance (at daytime, night-time, in total), and disturbances (communication, recreation, sleep) due to railway and road traffic noise, loudness of railway and road traffic noise, measures against noise (coping), socio-demographic variables (age, gender, education, occupation). The questionnaire used for the repeated interviews after the rail grinding included questions on the railway and road traffic annoyance and disturbances and assessments of the perceived change in noise disturbances due to road traffic and railway noise.

In particular, the following variables of responses to railway noise have been assessed before and after the rail grinding (Table 2):

Table 2 – Variables of responses to railway noise before (t1) and after (t2) rail grinding

Variables of responses to railway noise	Item	Scale	t1	t2
Overall annoyance and disturbances	<ul style="list-style-type: none"> <li>- Overall railway noise annoyance</li> <li>- Overall disturbances due to railway noise, day and night</li> </ul>	verbal 5-point scale: not – a little – moderately – rather – very	x	x
Disturbances at daytime	<ul style="list-style-type: none"> <li>- communication indoor (mean score of 3 items: disturbances when (a) listening to radio, music or watching TV, (b) phoning, (c) having conversation/convivial gatherings)</li> <li>- communication outdoor (1 item)</li> <li>- recreation indoor (mean score of 3 items: disturbances when (a) reading/meditating, (b) concentrating/working, (c) relaxing)</li> <li>- recreation outdoor (1 item)</li> </ul>	verbal 5-point scale: not – a little – moderately – rather – very	x	x
Disturbances at night-time	<ul style="list-style-type: none"> <li>- Sleep disturbances (mean score of 3 items: disturbances when (a) falling asleep, (b) during the night, (c) in the early morning)</li> <li>- Disturbances at night-time</li> </ul>	verbal 5-point scale: not – a little – moderately – rather – very	x	x
Psycho-vegetative disturbances	<ul style="list-style-type: none"> <li>- Psycho-vegetative disturbances (mean score of 3 items: (a) nervous/excited, (b) headache, (c) startled by/due to railway noise)</li> </ul>	verbal 5-point scale: not – a little – moderately – rather – very	x	x
Change in disturbances due to railway noise in last months	Change in disturbances <ul style="list-style-type: none"> <li>- overall, at daytime, night-time (3 items)</li> <li>- of communication indoor/outdoor (4 items)</li> <li>- of recreation indoor/outdoor (4 items)</li> <li>- of sleep</li> </ul>	3-point scale: decreased – unchanged – increased		x

### 3. RESULTS

The acoustical effects of the rail grinding along the investigated railway line are described in detail by Liepert et al. [8]. To summarize: Emission noise levels  $L_{Aeq}$  for daytime and night-time was reduced on average about 2 dB after grinding on the Bavarian side (areas without information) and about 1 dB on the Baden-Wuerttemberg side (area with information) whereas according to results of the pilot study [9] a higher reduction in railway noise levels was expected.

In the informed area only 29% of the participants reported to have noticed the grinding work whereas in the areas without information 63% of the subjects had noticed work done along the rail track (in these areas the wording of the question did not include the term "grinding"). The information about the rail grinding given in Uhingen reached most of the participants: 73% of all subjects in Uhingen read the leaflet, 70% of them rated on a 5-point scale from (1) not at all to (5) very informed that they felt to be rather (4) to very (5) informed by the leaflet. As further sources of information about the rail grinding the own family (21%), articles in the local newspapers (56%) and other sources of information (3%) were mentioned.

The results of the comparisons of responses to railway noise before and after the rail grinding are shown in Table 3. Figure 1 shows results with regard to the perceived change in disturbances due to railway noise in the last months as reported by the participants after rail grinding in the second interview (t2).

Table 3 – Means (standard deviations) of responses to railway noise before and after rail grinding

Responses to railway noise	Information about rail grinding (study area)							
	no - (Burlafingen/Unterfahlheim)				yes - (Uhingen)			
	N	t1: before	t2: after	Sign.	N	t1: before	t2: after	Sign.
noise annoyance – railway	176	2.49 (1.23)	2.35 (1.10)	*	162	2.88 (1.05)	2.65 (0.88)	**
disturbances – railway noise, overall	175	3.45 (2.73)	3.41 (2.61)		162	4.18 (2.42)	3.86 (2.40)	
disturbances – railway noise, daytime	174	1.99 (1.06)	2.05 (1.01)		160	2.52 (0.89)	2.45 (0.88)	
disturbances – railway noise, night-time	174	2.08 (1.18)	2.12 (1.13)		159	2.25 (1.02)	2.10 (0.94)	*
communication disturbances indoor	176	1.75 (1.16)	1.71 (1.06)		162	2.76 (1.16)	2.51 (1.04)	**
communication disturbances outdoor	176	2.49 (1.47)	2.64 (1.52)		160	3.75 (1.22)	3.57 (1.20)	
disturbances of recreation indoor	176	1.62 (0.96)	1.65 (1.01)		162	2.23 (1.04)	2.06 (0.98)	*
disturbances of recreation outdoor	176	2.36 (1.45)	2.40 (1.45)		162	3.06 (1.29)	3.10 (1.30)	
sleep disturbances	176	1.57 (1.05)	1.49 (0.88)		162	1.63 (0.85)	1.45 (0.77)	**
psycho-vegetative disturbances	176	1.34 (0.69)	1.31 (0.66)		162	1.54 (0.66)	1.40 (0.64)	**

Sign. (t-Test): \* p < .05; \*\* p < .01

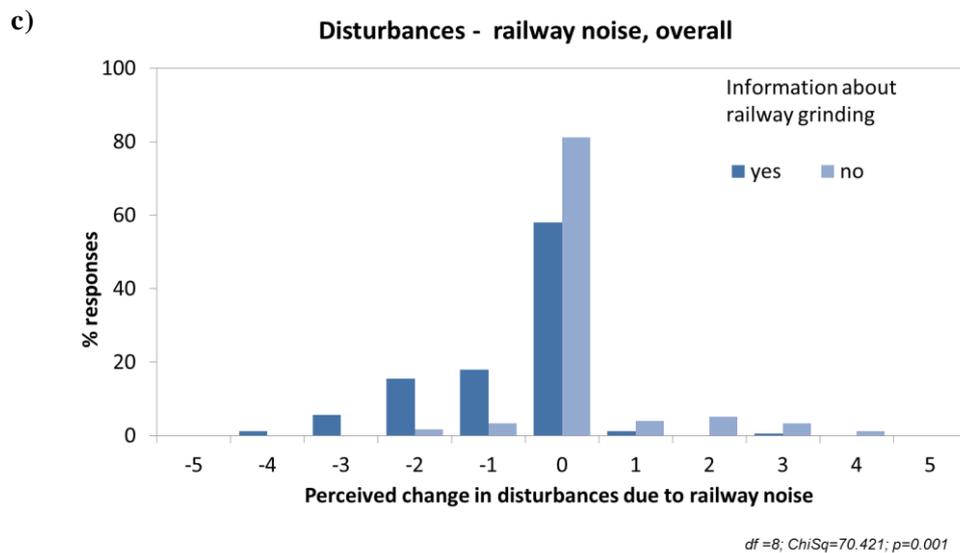
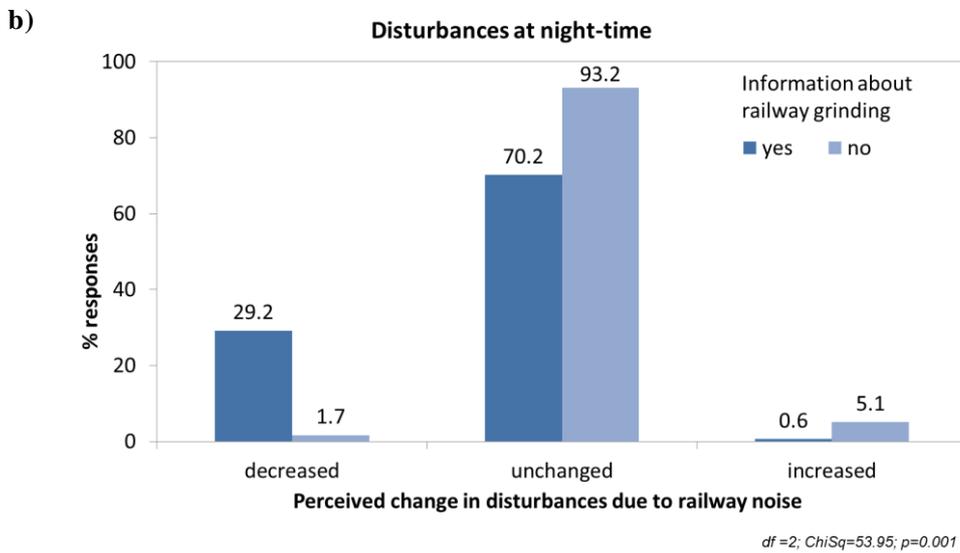
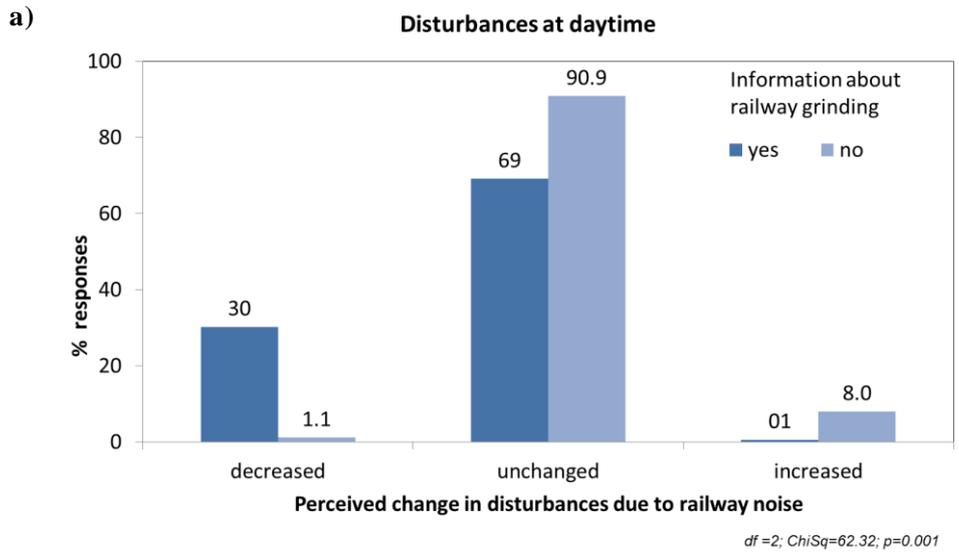


Figure 1 – Proportion of residents perceiving change in disturbances to railway noise after rail grinding: disturbances at daytime (a), at night-time (b), overall (c)

Although the noise level reduction after rail grinding was low, particularly in the area where information about the noise-reducing effect of rail grinding was given to the residents a decrease in responses to railway noise was observed for part of the noise annoyance and disturbances variables (see Table 3): for overall railway noise annoyance, disturbances to railway noise at night-time, communication disturbances indoor, disturbance of recreation indoor, sleep disturbances, and psycho-vegetative disturbances.

Most participants reported that they do not have perceived any change in disturbances due to railway noise in the last months before the second interview (after rail grinding). However, in Uhingen, the 'informed area', interviewed residents reported more often decreased disturbances due to railway noise at daytime and night-time as well as overall (Fig. 1). This is also true for all other assessed disturbance changes (disturbances of communication, recreation, sleep).

Although the reduction in noise exposure after rail grinding was far less than expected due to technical problems of the rail grinder the results indicate that the observed changes in noise responses and the perceived change in disturbance of participants in the study area Uhingen seem to be affected by the information about the rail grinding and its noise reducing effect given to the residents before the rail grinding.

#### **4. CONCLUSIONS**

Rail grinding is a measure to reduce the roughness of rail surfaces with the consequence of lower noise levels emitted by the wheel – rail contact of passing trains. According to the categorization of changes in noise exposure proposed by Brown and van Kamp [14] changes in noise level due to rail grinding are considered as type 1 exposure changes.

A total of 340 residents living along the railway line Stuttgart – Ulm – Augsburg in South Germany took part in a before-after study on the effects of rail grinding on noise levels and on residents' noise responses. 163 of the interviewees from the study area Uhingen (Baden-Wuerttemberg) were informed about the rail grinding and its noise-reducing effect in individual letters, by leaflets dispatched within the area, and by local press releases and press conferences. The 177 interviewed residents from Burlafingen and Unterfahlheim (Bavaria) did not get such information. Face-to-face interviews were carried out three months before the rail grinding along the railway line Stuttgart – Augsburg and again one to two months after the rail grinding.

Unfortunately, with an average noise level reduction of about 1 dB (Uhingen) and 2 dB (Burlafingen/Unterfahlheim) the change in noise exposure was far less than expected. Nevertheless, significant decrease in noise annoyance and part of the reported disturbances due to railway noise was observed in the 'informed' study area Uhingen. That is, overall, the hypotheses H1, assuming that a decrease in noise exposure due to rail grinding would lead to a decrease in railway noise annoyance and disturbances, could not be adequately tested in our study. However, the hypotheses H2, indicating that apart from changes in noise exposure information about the noise-reducing effect of rail grinding given to residents prior to the grinding might positively affect the responses to changes in railway noise, is supported by the data.

Note, that, of course, this does not mean that for minimizing noise annoyance and disturbances leaflets and press releases can replace technical noise abatement measures. Rather it is likely that information about planned abatement measures given to exposed residents and transparency of implementation considerably support the impact of the technical/acoustical noise abatement measures on residents' noise responses and, thus, should become common practice in noise control.

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## REFERENCES

- [1] WHO - World Health Organization, *Burden of disease from environmental noise. Quantification of healthy life years lost in Europe* (WHO Regional Office for Europe, Copenhagen, Denmark, 2011).
- [2] H.M.E. Miedema and H. Vos, "Exposure-response relationships for transportation noise," *J. Acoust. Soc. Am.*, 104(6), 3432-3445 (1998).
- [3] H.M.E. Miedema and C. Oudshoorn, "Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals," *Environ. Health Persp.*, 109(4), 409-416 (2001).
- [4] J. Kaku and I. Yamada, "The possibility of a bonus for evaluating railway noise in Japan," *J Sound Vib.*, 193(1), 445-450 (1996).
- [5] T. Yano, T. Sato and T. Morihara, "Dose-response relationships for road traffic, railway and aircraft noises in Kyushu and Hokkaido, Japan", *Proc INTER-NOISE 2007*, in07\_180, CDROM (2007).
- [6] E.M. Elmenhorst, S. Pennig, V. Rolny, J. Quehl, U. Mueller, H. Maaß and M. Basner, "Examining nocturnal railway noise and aircraft noise in the field: Sleep, psychomotor performance, and annoyance," *Sc. Total Environ.*, 424, 48-56 (2012).
- [7] P. Lercher, M. Brink, J. Rüdissler, T. Van Renterghem, D. Botteldooren, M. Baulac, and J. Defrance, "The effects of railway noise on sleep medication intake: results from the ALPNAP-study," *Noise Health*, 12, 110–119 (2010).
- [8] M. Liepert, U. Moehler, D. Schreckenberg and R. Schuemer, "The impact of railway grinding on noise levels and residents' noise responses – Part I: Study design and acoustical results," *Proc. INTER-NOISE 2013*, Innsbruck, Austria (2013).
- [9] U. Moehler, A. Hegner, R. Schuemer and A. Schuemer-Kohrs, "Effects of railway-noise reduction on annoyance after rail-grinding," *Proc. INTER-NOISE 97*, 1021-1026 (1997).
- [10] A. Hegner, U. Möhler, G. Prestele, A. Schümer-Kohrs, and R. Schuemer, *Lärmbelästigung durch Schienenverkehrslärm vor und nach dem Schienenschleifen – Pilotstudie (Annoyance due to railway noise before and after rail grinding – pilot study)* (Moehler + Partner, Munich, 1997).
- [11] R. Guski, "Personal and social variables as co-determinants of noise annoyance," *Noise Health*, 3, 45-56 (1999).
- [12] J.M. Fields, "Effect of personal and situational variables on noise annoyance in residential areas," *J Acoust Soc Am*, 93(5), 2753-63 (1993).
- [13] H.M.E. Miedema and H. Vos, "Demographic and attitudinal factors that modify annoyance from transportation noise," *J Acoust Soc Am*, 105(6), 3336-3344 (1999).
- [14] A.L. Brown and I. van Kamp, "The importance of response to change in intervention studies," *Proc. INTER-NOISE 2013*, Innsbruck, Austria (2013).
- [15] D. Schreckenberg, R. Schuemer and U. Moehler, "Railway-noise annoyance and 'misfeasance' under conditions of change," *Proc. INTER-NOISE 2001*, No. 344, CD-ROM (2001).
- [16] D. Schreckenberg, M. Meis, C. Kahl, C. Peschel, T. Eikmann, "Aircraft noise and quality of life around Frankfurt Airport. *International Journal of Environmental Research and Public Health*", 7, 3382-3405 (2010).
- [17] R. Schuemer and D. Schreckenberg, "Änderung der Lärmbelastung bei Massnahme bedingter stufenweise veränderter Geräuschbelastung - Hinweise auf einige Befunde und Interpretationsansätze (The effect of stepwise change of noise exposure on annoyance)," *Z. Laermbek.* 47, 134–143 (2000).
- [18] M. Liepert, A. Hegner, U. Moehler, D. Schreckenberg, A. Schuemer-Kohrs, R. Schuemer, *Lärmbelästigung durch Schienenverkehrslärm vor und nach dem Schienenschleifen – Hauptstudie (Annoyance due to railway noise before and after rail grinding – main study)* (Moehler + Partner, Munich, 1999).