Identifying factors contributing to annoyance from neighbourhood noise

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ABSTRACT

Studies have shown that neighbourhood noise is the second most annoying noise source in Germany, but little is known about the characteristics that affect the annoyance ratings of neighbourhood noise. In a population-representative survey commissioned by the German Environment Agency, we examined noise annoyance due to various noise sources in Germany. For neighbourhood noise, relevant characteristics and factors that potentially contribute to the annoyance ratings were examined.

In total, four representative areas in Germany were selected. Each area was stratified according to its density of agglomeration (inner city, urban fringe, rural area). A mixed-method design was used. First, neighbourhood noise was qualitatively assessed by means of focus groups. In a second step, a questionnaire study was conducted. In total, 1,973 questionnaires (online and paper-pencil) were filled in.

In this paper, we investigate the influence of different non-acoustical factors contributing to neighbourhood noise annoyance judgments, e.g. density of agglomeration, house type, relationship to neighbours, satisfaction with the neighbourhood, one's own perception as a causer of noise, and annoyance due to other noise sources. Results will be discussed.

INTRODUCTION

The German Environment Agency conducts a comprehensive environmental awareness study every 2 years, assessing, among other aspects, participants' annoyance due to several environmental noise sources [1]. 60 % of respondents state that they feel at least slightly annoyed/disturbed by neighbourhood noise, coming in second after annoyance due to road traffic noise with ca. ¾ of respondents [1].

Although neighbourhood noise is among one of the most annoying/disturbing environmental noise sources, relatively little research has been done so far on this topic. This might be

because neighbourhood noise is, as opposed to other noise sources, extremely heterogeneous in its potential causes and characteristics [2]. Defining neighbourhood noise and determining the specific sources that belong to it can be a relatively difficult task to accomplish. One of the reasons for this is that the judicial definition of neighbourhood noise can differ from the actual interpretation of residents experiencing noise in their residency. The loud laughing sound from a group of guests at a restaurant downstairs, for example, might be perceived as neighbourhood noise by a tenant living on the second floor. Legally, the sound originating from the restaurant is categorized as industry and business noise, though. Until now, the full extent of the conceptual understanding and interpretation of neighbourhood noise and its encompassing elements remains unclear.

However, there is some research examining factors that could contribute to people's neighbourhood noise annoyance ratings. These include attitudes (relationship with neighbours), housing conditions, time of the day as well as socio-economic status and age [e.g. 3, 4, 5].

In line with evidence found for other environmental noise sources (e.g. aircraft noise) [e.g. 6], people's attitudes towards the noise source have an impact on the degree of annoyance due to neighbourhood noise as well. For example, noise which is perceived as unacceptable and is caused by a negatively viewed neighbour was identified as one type of annoying/disturbing noises [7]. Other studies found that noise complaints can oftentimes be traced back to existing neighbourhood conflicts and cannot be attributed to the neighbourhood noise exposure alone [8, 9].

Another important factor to consider with respect to neighbourhood noise is the housing condition, such as density of agglomeration and type of house. With respect to the density of agglomeration it was found that less neighbourhood noise annoyance is experienced in rural areas compared to areas with a higher density of agglomeration [e.g. 4, 5]. It seems that high neighbourhood noise annoyance is particularly pronounced in metropolitan areas [3]. This is in line with another finding, considering the most prevalent house types within the different agglomeration densities. People living in multi-storey buildings more frequently state to be annoyed by neighbours than people who live in detached houses [3, 4, 5].

Ownership was also associated with neighbourhood noise annoyance. Tenants are more likely to report annoyance due to neighbourhood noise than home owners [4. 5, 8]. Further, neighbourhood noise seems to be especially annoying/disturbing during night time [7].

Finally, sociodemographic factors were linked to neighbourhood noise annoyance. For example, studies indicate that younger people are more frequently annoyed/disturbed by neighbourhood noise compared to elderly people [3, 4, 5]. This could be associated with the type of houses people live in: younger people are more likely to be living in flats/apartments, thus multi-storey buildings, than elderly people [5]. In accordance with these previous findings, a lower socio-economic status is linked to higher noise annoyance due to neighbours [3].

Neighbourhood noise annoyance seems to vary between different living and housing conditions as well as depend, at least to some extent, on the relationship with the neighbour(s) causing the noise. To better understand and get a comprehensive view of the associations between neighbourhood noise annoyance and the above-mentioned factors, a population-representative survey was commissioned by the German Environment Agency. This paper reports on findings examining the role of different factors contributing to annoyance from neighbourhood noise.

METHOD

Study Design

The data was collected within a study commissioned by the German Environment Agency in two measurement waves (2018 and 2019). The study region encompassed four large residential areas in the North, East, West and South of Germany (the greater areas of Hamburg, Dresden, Stuttgart, and Dusseldorf, respectively). The areas were further differentiated according to the population density: 1) inner-city, 2) urban outskirt, and 3) rural area. The weighting of number of participants per region resulted from the population density in each area, e.g. in the rural area of Dusseldorf, 71 respondents were required.

Procedure

The participants of the study were recruited in 2018 and 2019. Potential participants received a cover letter including information about the study and were invited to participate in an online survey. During the assessment in 2019, participants were given the additional option to participate via filling in a paper-pencil questionnaire.

Variables

Noise annoyance for all noise sources, including neighbourhood noise, was assessed using the 5-point verbal ICBEN scale [10]. Of interest were several non-acoustic factors, which are thought to play a role in and contribute to neighbourhood noise annoyance: density of agglomeration, type of home (e.g. dwelling or house), residential satisfaction, relationship with the neighbours, satisfaction with neighbourhood, perception as causing neighbourhood noise oneself, and times of day one experiences the most annoyance due to neighbourhood noise. Items on the relationship with neighbours and satisfaction with the neighbourhood were developed using results of qualitative focus groups, which were conducted beforehand. In addition, participants' annoyance due to other noise sources (e.g. road traffic noise), demographics as well as noise sensitivity were included in the analysis as well.

For a detailed description of the methodology and the questionnaire see [2].

Analysis

Descriptive data analysis was performed in terms of the calculation of frequency, means, and standard deviations. Differences in annoyance ratings depending on distribution of characteristics were analysed with chi-Square tests for categorial variables with Cramers φ for effect size and F-Tests/ANOVAs for continuous variables. Further, correlation analyses were carried out in order to select relevant predictors for regression. To analyse the impact of several variables on the manifestation of annoyance due to neighbourhood noise linear regression models were performed using generalized linear models (GZLM) with the predictors age, density of agglomeration, residential satisfaction, relationship to neighbours, satisfaction with neighbourhood, annoyance due to other noise sources (road, food service industry), noise sensitivity.

Statistical analyses were performed using IBM SPSS version 27.0.

RESULTS

Descriptive statistics

In total, responses of 1,973 participants were included in the analyses (50.5 % online and 49.5 % paper-pencil responses). The following analyses were done with data of the respondents that answered the annoyance questions; i.e. the analyses are based on a sample of 1,940 respondents. The age range of the sample is 18-94 years, with a mean age of 57.1 years (SD=14.36). 55 % of the sample is female. On average, the sample rated their annoyance due to neighbourhood noise as slightly annoyed (M=2.03, SD=0.95). Table 1 presents the descriptive statistics by levels of annoyance ratings (see Table 1).

Table 1: Descriptives by annoyance levels (5-pt verbal scale levels)

| | N | % | Scale | Annoyance due to neighbourhood noise | | | | | Total | Sign |
				not at all	slightly	moderately	very	extremely		
Total	1,940	100%		31,9%	43,2%	16,9%	6,1%	2,0%	100%	
Age	1,912		*M*	61,0	56,4	53,6	52,5	51,4	57,1	***
Gender										
female	584	55%	%	38,2%	39,7%	15,2%	5,1%	1,7%	100%	n.s.
male	487	45%	%	35,3%	43,3%	14,4%	4,9%	2,1%	100%	
Density of agglomeration										
inner city	1,207	62%	%	27,8%	43,7%	18,8%	7,1%	2,5%	100%	
urban outskirt	436	22%	%	39,0%	42,5%	13,4%	3,8%	1,4%	100%	***
rural area	307	16%	%	36,4%	43,0%	13,9%	5,6%	1,0%	100%	
House type										
detached house	151	8%	%	36,4%	49,0%	10,6%	2,0%	2,0%	100%	
end terrace house	61	3%	%	44,3%	41,0%	9,8%	3,3%	1,6%	100%	
mid-terrace house	87	4%	%	35,6%	48,3%	12,6%	3,4%	0,0%	100%	**
semi-detached house	84	4%	%	41,7%	45,2%	7,1%	4,8%	1,2%	100%	
apartment in multi-storey building	1,532	79%	%	29,9%	42,7%	18,3%	6,9%	2,2%	100%	
Ownership										
owner	762		%	32%	48%	15%	4%	1%	100%	***
tenant	1,170		%	31%	41%	17%	8%	3%	100%	
Residential satisfaction	1,910		*M*	4,3	4,1	3,8	3,3	2,8	4,0	***
Relationship to neighbours	1,933		*M*	4,2	4,0	3,7	3,4	3,2	3,9	***
Satisfaction with neighbourhood	1,933		*M*	4,3	4,0	3,7	3,2	2,8	4,0	***
Noise annoyance living environment in general	1,928		*M*	2,1	2,6	3,2	3,7	4,5	2,7	***

Noise annoyance road noise	1,864		*M*	2,0	2,4	2,8	3,0	3,2	2,4	***
Noise annoyance rail noise	1,818		*M*	1,3	1,4	1,6	1,5	1,8	1,4	***
Noise annoyance food service industry	1,872		*M*	1,2	1,3	1,6	1,8	2,1	1,4	***
Noise annoyance industry	1,888		*M*	1,1	1,2	1,4	1,5	1,6	1,2	***
Noise sensitivity	1,916		*M*	2,5	2,9	3,1	3,1	3,7	2,8	***
One's own perception as a causer of noise										
yes	586		%	27%	47%	17%	8%	2%	100%	*
no	1,295		%	34%	42%	17%	6%	2%	100%	

*** p < .001, ** p < .01, * p < .05 (χ^2 for categorial variables, F for rating scales), *M* = mean.

Significant differences in annoyance ratings for several characteristics were observed. The mean *age* of participants indicating lower annoyance due to neighbourhood noise was found to be higher than those indicating higher annoyance levels ($F_{(4,1907)}=21,796$, *p* < .001). By contrast, no significant difference was observed between *genders*. For the type of *density of agglomerations* it was observed that more people living in inner city areas seem to be moderately, very or extremely annoyed in comparison to people living in the urban outskirt or in rural areas ($\chi^2(8) = 32.20$, *p* < .001, φ = 0.09). Annoyance due to neighbourhood noise also seems to be higher in people living in apartments in multi-storey buildings than in people living in other house types ($\chi^2(20) = 44,338$, *p* < .01, φ = 0.08). With increasing noise annoyance levels a decrease in *residential satisfaction* ($F_{(4, 1905)} = 71,376$, *p* < .001) as well as poorer *relationship with neighbours* was observed ($F_{(4,1928)} = 70,968$, *p* < .001). The levels of noise annoyance due to other sources were also investigated for levels of neighbourhood noise annoyance. For higher levels of annoyance due to neighbourhood noise also higher levels of *annoyance due to road traffic* ($F_{(4,1859)} = 40,995$, *p* < .001), noise from *food service industry* ($F_{(4,1867)}=27,08$, *p* < .001) and *industry* ($F_{(4,1883)}=19,15$, *p* <.001) were observed.

For the selection of relevant potential predictors of neighbourhood noise annoyance correlation analyses were carried out. Variables/predictors with correlations higher than *r* = +/- .200 were included in further analyses. All correlations between neighbourhood noise annoyance and potential predictors were significant, except with the variable *own's perception as causer of noise*. Correlations between neighbourhood noise annoyance and other variables ranged between -.432 < *r* < .280. This resulted in the selection of *age* (*r* = -0.200), *annoyance food* service (*r* = 0.232), *noise sensitivity* (*r* = 0.242), *annoyance road* (*r* =0.280), *residential satisfaction* (*r* = -0.353), *relationship with neighbours* (*r* =-0.357) and *satisfaction neighbourhood* (*r* = -0.432) as predictors in the model. Additionally, *density of agglomeration* was taken into account in the analysis due to the focus of the study, although correlation was lower than .2 with *r* = -.106.

In the next step the predicting influence of the selected variables on neighbourhood noise annoyance was analyzed. Generalized linear models procedure was used with neighbourhood noise annoyance as dependent variable. Regression results are presented in Table 2. The likelihood ratio chi-square test indicates that the full model was a significant improvement of in fit over a null model (*p* < .001).

Table 2: Results of GZLM regressions for the analysis of predictors on neighbourhood noise annoyance

Predictors	B	SE	Wald	p	Exp(B)
constant	3,865	0,1869	427,75	0,000	47,690
agglomeration density					
inner city	0,122	0,0560	4,78	0,029	1,130
urban outskirt	-0,037	0,0649	0,32	0,570	0,964
rural area	*Ref.				
residential satisfaction	-0,126	0,0260	23,41	0,000	0,882
satisfaction with neighbourhood	-0,309	0,0359	74,07	0,000	0,734
relationship with neighbours	-0,127	0,0398	10,14	0,001	0,881
road noise annoyance	0,089	0,0185	22,79	0,000	1,093
noise annoyance from food service industry	0,082	0,0251	10,63	0,001	1,085
age	-0,006	0,0014	17,45	0,000	0,994
noise sensitivity	0,132	0,0201	42,86	0,000	1,141
B = regression coefficient, Wald = Wald Chi-square, SE = standard error, p =significance level.					

For the categorial predictor *agglomeration density* only living in the inner city area in reference to living in a rural area had a significant positive effect on neighbourhood noise annoyance, i.e. higher neighbourhood noise annoyance was predicted (B= .122; *SE*= .056; *p* < .001).

All continuous predictors had significant effects on neighbourhood noise annoyance. The highest impact was found for the predictor *satisfaction with neighbourhood* (B= - .309; *SE*= .036; *p* < .001): with increasing satisfaction a decrease in neighbourhood noise annoyance was observed. Further, significant negative effects were found for *residential satisfaction* on neighbourhood noise annoyance (B= -.126; *SE*= .026; *p* < .001) and *relationship with neighbours* (B= -.127; *SE*= .040; *p* < .001). Thus, with higher residential satisfaction and a better relationship with neighbours annoyance due to neighbourhood noise was lower. In addition, higher *noise sensitivity* was associated with higher levels of neighbourhood noise annoyance (B= .132; *SE*= .020; *p* < .001).

Annoyance from other noise sources was found to have smaller predicting effects on neighbourhood noise annoyance with B= .089 (*SE*= .019; *p* < .001) for *road noise annoyance* and B= .082 (*SE*= .025; *p* < .001) for *noise annoyance due to food service industry*. The factor *age* was significant with only a marginal/small effect on neighbourhood noise annoyance (B= - ,006; *SE*= .001; *p* < .001).

DISCUSSION & CONCLUSION

The current study investigated if and to what extent different factors contribute to the levels of neighbourhood noise annoyance in a sample of participants living in different types of agglomeration densities.

In line with previous studies [3, 4, 5] an effect of *density of agglomeration* on annoyance from neighbourhood noise was found. People living in the inner city area showed higher rates of noise annoyance due to neighbourhood noise than people living in rural areas, however, the observed effects in the current study are rather small. Proximity to the inner city is associated with denser housing and a higher number of people living in apartment buildings, which often translates into a higher number of neighbours in a smaller area that are potential noise sources.

From the selected factors *satisfaction with neighbourhood* had the biggest impact on annoyance from neighbourhood noise in the model. Furthermore, *residential satisfaction* had an effect on annoyance due to neighbourhood noise. It can be argued that there might be a recursive relationship as annoyance due to neighbourhood noise could directly affect the satisfaction with the neighbourhood as well as residential satisfaction. Additionally, *residential satisfaction* and *satisfaction with neighbourhood* might activate similar concepts with respondents focusing on slightly different aspects: whereas *satisfaction with neighbourhood* might rather be associated with social aspects of the people living in the neighbouring environment, *residential satisfaction* might instead be linked to a broader perspective of the physical features and practical options of the adjoining environment. The different altitude of the influence on neighbourhood noise annoyance indicates that the terminology of neighbourhood and residence reflect different understandings.

In line with this, the *relationship with/to neighbours* was found to have an effect on the neighbourhood noise annoyance, i.e. a better *relationship to neighbours* was linked to a lower annoyance due to neighbourhood noise. Having positive or negative attitudes towards a noise source can influence one's tolerance/acceptance of a generally negatively valued behaviour, such as causing noise, i.e. a good relationship to someone can influence how much noise from this person is tolerated. Further, it can be argued that the *relationship to neighbours* in the noise context might be conceptually similar to the non-acoustical factor 'attitude toward a given noise source'. The influence of attitudes towards a noise source on annoyance ratings has been found for other noise sources. Positive attitudes towards a noise source were linked to lower annoyance ratings [11] and negative attitudes were associated with higher levels of annoyance [e.g. 12].

Noise sensitivity was a predictor of noise annoyance, which confirms findings from studies on other noise sources that individual's general susceptibility to noise has an impact on noise annoyance [13, 14].

Noise annoyance from other sources had only a small effect on neighbourhood noise annoyance. For *road traffic noise annoyance* this result implies that neighbourhood noise annoyance is related to road traffic noise, but the effect is differentiated after all. Further, there was only a small influence of *annoyance due to food service industry* on neighbourhood noise annoyance. This can be explained by an unequal distribution of gastronomy depending on residential area and density of agglomeration. Here it could be interesting to examine this in inner city areas or densified areas where there is more gastronomy.

Limitations of the study include the type of data as cross-sectional data do not allow drawing conclusions about the causality. Due to the heterogenous nature of neighbourhood noise

modelling of average exposure to neighbourhood sound could not be implemented. Thus, no exposure estimations for neighbourhood noise were included in this study.

The heterogeneity of neighbourhood noise should be taken into account when addressing the explanation of neighbourhood noise annoyance. In contrast to transport noise there are many different components of neighbourhood noise, i.e. the different subtypes of neighbourhood noise could influence annoyance ratings to a different extent. Thus, future studies should investigate the type of neighbourhood noise sources that explain variance in neighbourhood noise annoyance. In this sense further sound features should be examined (features in the sound, e.g. sharpness, type of sound e.g. tools, children, voices, music, and time of day).

Furthermore the social component of the neighbourhood relationship with neighbours should be investigated in more detail as the social aspects have shown to have a moderate influence on annoyance from neighbourhood noise.

With tendency of rising numbers of densely populated areas in urban context it is crucial to intensify research on factors influencing noise annoyance in order to inform designing and planning processes/policy of such urban areas.

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