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Shooting noise annoyance in communities around German military training areas

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ABSTRACT

Shooting noise is characterized as impulsive, intermittent sound with high energy and low frequencies. Studies have shown that for given average sound levels shooting noise is regarded as more annoying than transportation noise, particularly road traffic noise. In comparison to transportation noise, responses to shooting noise are less frequently studied. The latest published German studies on community responses to shooting noise were conducted in the 1980ies and 1990ies. The study presented in this contribution aims to provide new data on shooting noise responses in communities around military training areas. Annoyance responses were collected using a survey with 1043 residents living around three military training sites in Germany. For the address of each resident, on the basis of shooting training in the year 2019 the average continuous sound levels and the sound exposure levels for day and night-time with the frequency weightings A, C, and Z were estimated for grid cells of 250 x 250 m. Results on the exposure-response relationship between these noise metrics and the percentage of highly annoyed persons (%HA) are presented. Among others, the results indicate that non-acoustic factors, particularly attitudes related to the source, have a strong impact on the annoyance.

1. INTRODUCTION

The World Health Organization (WHO) and the European Union (EU) recognize noise as one of the top most prevalent environmental health hazards in the European Union, pronouncing its potential harmful effects on physical and mental health as well as on overall well-being [1]. While many projects and funding have been dedicated to examining effects and intervention strategies for aircraft, road, railway and recently wind turbine noise, only a very small body of research has been examining the effects of shooting noise on human perception and response. The last study seeking to examine those effects in Germany dates back to 1986 [2]. Back then, Buchta et al. found three particularly prevalent effects:

1. Cannon fire was the dominant noise source around the training grounds
2. 50% of people felt strongly and highly annoyed
3. Noise annoyance was best predicted by noise exposure

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Since 1986 however, circumstances have changed in many ways. Most importantly the cold war blew over and during the nineties, troops from all over Germany have been relocated from the former inner German border to their home bases, resulting in considerably less military presence on and around almost all military training and administration sites. This trend continues until today: In 2012 the compulsory military service was dropped, and currently plans are being discussed to relocate 12000 US marines from Germany to Poland. These drastic changes make two things obvious: Likely, Buchta's et al. findings are somewhat out of date, and just as likely, population and all related empirical parameters around the training areas have changed.
In this contribution, we present our findings of a large cross-sectional study carried out in 2019 at three military training areas in Germany. We present dose-response relationships between different noise descriptors, psychosocial variables and noise annoyance. We discuss our findings and compare them to other international studies.

2. THEORY AND BACKGROUND

Environmental noise sources, their peak values and their acceptable continuous sound levels are all regulated by the German administration. The technical instruction on noise ("TA Lärm") prescribes noise thresholds for road, rail, aviation and industrial noise in different settings and further differentiates between day and night noise levels. Military shooting noise, however, is not considered or even mentioned throughout this instruction. Lenart, Bauerschmidt and Hirsch [3] assume there are two main reasons for not considering military shooting noise as an environmental noise issue:

1. The defence contract has a somewhat special status regarding noise regulation;
2. Due to many different physical implications and lack of physical knowledge specifics, a standard regulation cannot be imposed. (compare also [4])

Instead of being regulated by the above mentioned technical instruction, the German armed forces regulate themselves using cooperative noise management, self-imposing three main restrictions when practicing, as summed up by us in 2019 [4]:

- A daily average noise level of 70 dB(C) L_{den} in mixed zones and 65 dB(C) L_{den} in residential areas including all shots from large guns is not to be exceeded more than 5% of the days in a year
- The maximum level of 100 dB(C) L_{den} in mixed zones and 95 dB(C) L_{den} in residential areas for a single noise event is not to be exceeded more than 5% of the days in a year
- Both goals must be fulfilled for every inhabited grid cell with the dimensions 250 meters *250 meters.

Aside from legislative differences when comparing military shooting noise to other environmental noise sources, there are of course many other differences that need to be considered when aiming to assess annoyance by shooting noise. The most important ones are probably the noise characteristics, differing substantially from other noise sources and are rather unique to military practice. Military shooting noise consists of low and high frequencies, some are quiet, others peak at 142 dB(C) [5, p. 3]. Shooting noise from military practice grounds accordingly has its own soundscape, made up of different acoustic phenomena, making it a lot more complicated to assess as compared to e.g. road traffic noise.

As a result, most literature focusses on either examining noise from small firearms [6, 7] or large weapon fire, which also considers blasts and explosions [8–10]. The latter in particular causes accompanying effects that again have been summarized by us in 2019 [4]:

1. Low frequencies: especially big gun blasts and explosions (assumed the explosive charge is

above a 1kg TNT equivalent) elicit deep frequencies at 1-100 Hz [6, 10–12]. Until today, findings suggest that groups of respondents may react particularly sensitive to low-frequency noise (e.g. 12).

2. Impulse noise: unlike a train or a plane that moves towards a receptor or a constant traffic flow, shots, blasts, and explosions occur suddenly and unpredictably. The impulse character of gunfire may cause people to jump and startle [8, 13, 14, 15, p. 21].
3. Vibration and rattle: [16–19] The so-called "rattle-factor" (as coined by Woodcock et al. [19]) is of importance whenever people experience sound derived vibration and rattle inside their homes [16, 20]. That is, people are likely induced with fear of structural damage to their dwellings and belongings, which - although very unlikely [21] - has potential to increase annoyance.

3. METHOD

Study regions were defined as five-kilometre radius around the limits of three practice grounds all of which are located in Germany. We used geographic information systems (GIS) to obtain geocoordinates, describing the borders of the research areas. Once determined, the coordinates were forwarded to the Agency for Digitisation, High-Speed Internet and Surveying, which in turn assessed a list containing all civil structures including their postal addresses. We identified a total of 19206 buildings in the research areas.

Having obtained all addresses in the research areas, we contacted all relevant registration offices and asked for submitting complete sets of personal data of residents living in the buildings, aged 18 and above.

The questionnaire consists of 145 questions, sorted in categories. Besides annoyance items it featured various scales and subscales aiming at closer investigating living conditions, personal attitudes towards the armed forces and the local military training areas, social status and a variety of psychosocial variables. For the assessment of noise annoyance we used the five-point verbal scale and the numeric eleven point scale from 0-10 with the verbal endpoints "0 = not at all annoyed" and 10 = "extremely annoyed" as recommended by [22].

3.1 Blast noise exposure

Metrics used in this study to describe the shooting noise exposure are in accordance to earlier studies. To account for the different sorts of noises as described above (compare paragraph 2) $L_{\mathrm{Aeq,day}}$, $L_{\mathrm{Ceq,day}}$ were determined, as also performed by [23] and [12]. Additionally we calculated the unweighted noise level $L_{\mathrm{Zeq,day}}$. In contrast to daytime sound level metrics for other noise sources in Germany, the sound levels for shooting noise exposure throughout the day are not calculated between 6am and 22pm but from 7am to 23pm. Further, for comparisons with results of the Swiss shooting noise study by Brink and Wunderli [12, 24] we also calculated the yearly sound exposure levels L_{AE} and L_{CE}.

3.2 Sample

We randomly chose 6000 people (2000 per practice ground), who were sent invitation letters and detailed information about the study as well as a statement about privacy protection. No incentives were paid. We aimed for sampling at least 800 subjects, and to increase response to the initital invitation letters, we sent out reminders two months after the initial invitations had been sent out.

In doing so, we were able to obtain 1043 completed surveys. A considerable amount of invitation letters couldn't be submitted, and due to different reasons, many letters were sent back to us without ever having reached their recipients. This decreased the sample to 5745 and ultimately resulted in a response rate of 18,15% overall.

We used a mixed methods approach to enlarge response as much as possible. Participants were able to choose to either fill in the survey online or to use a printed questionnaire which was enclosed to the invitation letter. Participants additionally were supplied with a free of charge return envelope, to send their questionnaires back to us. 800 (76,7%) participants chose to fill in the paper form, 243 (23,3%) responded online. Between the three research areas, the numbers of participants were almost evenly distributed: 341 participants (32,7%) were located at military area A, 377 (36,1%) at military area B and 325 (32,2%) around military area C. Overall, mean age of participants in 2019 was 56.01 (SD = 15,98). 1026 participants indicated their gender, of those 583 identified as males, 438 as female, additional five as diverse.

4. RESULTS

Results described here only refer to the variables used in the assessment of the dose response relationships. As described above, the survey featured many more scales, but a complete description of all study items is beyond the scope of this manuscript. For all research areas annoyance by large weapons was higher than for annoyance by small weapons (Table 1).

1018 participants rated their overall annoyance by small firearms, mean was 1,69 (SD = 0,97). 1025 Participants also rated their annoyance by large weapons, the mean value here was 2,37 (SD = 1,2) and therefore considerably higher than annoyance by small weapons.

Table 1: Shooting noise annoyance ratings by research area

Area	**Noise Source**	**Annoyance by shooting noise**		
		N	*Mean*	*SD*
A	Small Weapons	334	1,85	1,12
	Large weapons	337	2,59	1,29
B	Small Weapons	308	1,58	0,86
	Large weapons	310	2,30	1,13
	Small Weapons	313	1,65	0,90
C	Large weapons	316	2,22	1,14
Total	Small Weapons	1018	1,69	0,97
	Large weapons	1025	2,37	1,20

This is also reflected by the %HA, calculated in Table 2 for each research area and for the whole sample, illustrating a much greater extend of residents being annoyed more by large weapon fire.

Table 2: Comparison of percentage HA for research areas, scales, small and large weapons.

Research area	**%Highly annoyed (%HA) by shooting noise in the research areas and overall**							
	Small weapons (5-point scale, values 4-5)		Heavy weapons (5-point scale, values 4-5)		Small weapons (11-point scale, values 8-10)		Heavy weapons (11-point scale, Values 8-10)	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*
A	32	9.5	89	26.3	34	10.2	106	31.6
B	13	3.6	67	18.5	16	4.4	63	17.4
C	15	4.8	47	14.8	18	5.8	50	15.9
Total	60	5.9	203	19.8	69	6.8	221	21.75

N = number, % = percent

Noise levels could be calculated for almost all households (N = 1042). Descriptive statistics differed significantly between $L_{\mathrm{Aeq,day}}$, $L_{\mathrm{Ceq,day}}$ and $L_{\mathrm{Zeq,day}}$: $L_{\mathrm{Aeq,day}}$ had a mean of 19.35 dB (SD = 5.57), with a minimum of 0,81 and a maximum of 33.14 dB, $L_{\mathrm{Ceq,day}}$ scored a mean value of 44.92 (SD = 4.98) and had a range from 30.41 and 54.56 dB. The $L_{\mathrm{Zeq,day}}$ had a mean of 56.29 dB (SW = 4.58) and a range from 44.56 to 65.25 dB, illustrating a prevalence of low frequencies on shooting noise emissions around the training grounds.

Between all noise descriptors and annoyance correlation were – at best – weak with lowest correlation between $L_{\mathrm{Aeq,day}}$ and small weapons (r = .085) and largest between $L_{\mathrm{Zeq,day}}$ and annoyance by large weapons (r = .130).

We started exposure-response analysis with single logistic regression models ('basic models'), describing the %HA based on the five-point scale as a function of only each of the different noise parameters (Table 3, see also Figure 1). Annoyance by small weapons was best predicted by measures of $L_{\mathrm{Zeq,day,}}$ as expressed by the lowest goodness of fit measure AIC = 292.1. The overall higher annoyance by large weapons, was as well best predicted by $L_{\mathrm{Zeq,day}}$ (AIC = 595.6). However, AIC values were overall higher for large weapon noise annoyance, indicating a lower goodness of fit of the prediction model.

Within small and large weapons all model differences were marginal, for small and large weapons we observed very small differences in in AIC, standard error, coefficient and odds ratio. As expected, based on findings from the correlation analysis, overall odds ratios suggest -if any- a very weak relationship of noise annoyance measures and noise descriptors, as regression coefficients only very slightly score above 1.

Table 3: Simple logistic regression models for L_{Aeq}, L_{Ceq} and L_{Zeq}, small and large weapons

	Small weapons						**Large weapons**					
Parameter	*AIC*	*B*	*SE*	*OR*	95 % CI OR *CI-*	*CI+*	*AIC*	*B*	*SE*	*OR*	95 % CI OR *CI-*	*CI+*
Intercept	297.4	-4.13	.54	.02	.01	.05	602.2	-2.32	.30	.10	.06	.18
$L_{\mathrm{Aeq,Tag}}$		.07	.02	1.07	1.02	1.12		.05	.01	1.05	1.02	1.08
Intercept	295.1	-6.86	1.53	.00	.00	.02	597.6	-4.29	.78	.01	.00	.06
$L_{\mathrm{Ceq,Tag}}$		.09	.03	1.09	1.03	1.17		.06	.02	1.07	1.03	1.10
Intercept	292.1	-8.91	1.90	.00	.00	.01	595.6	-5.50	1.02	.00	.00	.03
$L_{\mathrm{Zeq,Tag}}$		.11	.03	1.11	1.04	1.19		.07	.02	1.08	1.04	1.11

AIC = Akaike Information Criterion, *B* = Coefficient, *SE* = Standard Error, *OR* = Odds Ratio, *CI* = Confidence Interval, *CI-/+* = lower/upper limit of *CI*

Additionally, to estimate explained variance, we calculated Nagelkerke's R^2 [25] for all models. All pseudo determination coefficients are very low (max. $R^2_{\mathrm{Nagelkerke}} = .03$) and hence suggest that the most variance is explained with the model estimating noise annoyance by small weapons as a function of L_{Zeq}. Overall, based on the data, we assume our simple logistic regression models are not a suitable prediction procedure for military practice shooting noise annoyance. Accordingly, we built up extended models, aiming to explain more variety in the data. To do so, we included multiple other variables in the models, obtained from the surveys. For each variable correlation with 12 months shooting noise annoyance was calculated. Considered were only those variables, showing a correlation of r ≥ .10 with annoyance items, but no correlation with the A, C, and Z weighted yearly equivalent noise levels.

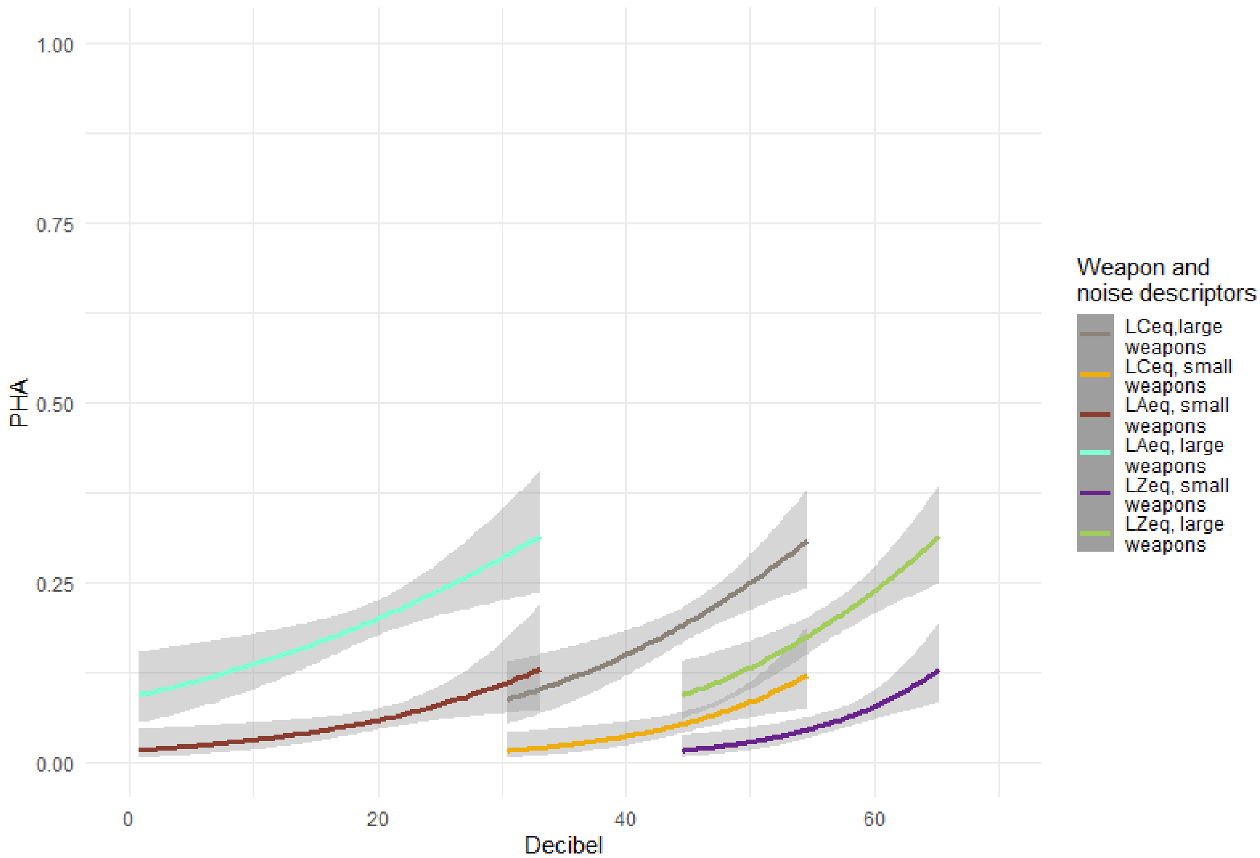

Figure 1: Exposure-response curves for the probability of being highly annoyed (p(HA)) due to large/small weapons in dependency of shooting sound levels (L_{Aeq}, L_{Ceq}, L_{Zeq}) for daytime – based on single regression models ('basic models')

A short description of the relevant variables added on the basis of further correlation analysis will be given in the following paragraph:

Satisfaction with housing: The survey featured various questions regarding overall living conditions, one of which targeted satisfaction with participants housings. Participants were asked to rate on a five-point scale how satisfied they are with their housing, low values indicating low satisfaction and high values high satisfaction. This item showed moderate correlations with noise annoyance ($r_{small\ weapons} = -.442$, $r_{large\ weapons} = -.56$) while not at all correlating with any of the sound level metrics and was hence included as a co-determinant.

Noise sensitivity: Noise sensitivity varies between subjects. One question was asked to assess participants' general noise sensitivity on a five-point Likert-scale. Correlations with noise annoyance were moderate ($r_{small\ weapons} = .328$, $r_{large\ weapons} = .413$).

State of ill-health: This single question asked participants for an estimation of their overall state of ill-health. It was rated on a verbal five-point scale (1 = very good to 5 = very bad), i.e. with increasing values indicating a lower state of health. Correlations with annoyance were the weakest of all variables to be included in the full models ($r_{small\ weapons} = .135$, $r_{large\ weapons} = .144$), however, there was also no correlation between state of ill-health and sound levels.

Measures taken against shooting noise: A checklist of ten different items with yes/no checkboxes. The variable again describes a score. For each measure taken, people scored one point, resulting in a score with a minimum of zero and a maximum of ten achievable points. The higher the score, the more measures had been taken by participants to protect them from shooting noise. The items consisted of questions like political involvement, filing complaints, engagement in organizations, and also structural changes to housing like installing noise protection of different sorts or relocating rooms. We found large positive correlations between the amount of measures taken and shooting noise annoyance by both, small and large weapons ($r_{small\ weapons} = .592$, $r_{large\ weapons} = .652$).

Positive affective evaluation: Another score. Factor analysis revealed three constructs within a larger item battery. The whole battery featured negatively connotated items towards shooting noise as well as generally more positively connotated ones. While the negative affective evaluation showed significant correlations with sound levels and is hence to be regarded more as a reaction to noise than a co-determinant of annoyance, only positive evaluation was included in the dose-response functions. This mean score consists of five questions, e.g. "shooting noise is relaxing" and "shooting noise is exciting". Of all variables, this showed the smallest correlation with annoyance items ($r_{small\ weapons} = -.105$, $r_{large\ weapons} = -.232$).

Habituation to shooting noise: This is another score found in the affective evaluation battery. Besides positive and negative evaluation, factor analysis revealed a third construct, somewhat implying effects of habituation to shooting noise annoyance. Here, questions were combined asking for shooting noise being "reasonable" and "familiar". Habituation correlates moderately to an almost equal amount with both noise annoyance items ($r_{small\ weapons} = -.402$, $r_{large\ weapons} = -.481$).

Attitude towards the Bundeswehr (German armed forces): A score yet again. Four items were used to asses overall attitude towards the German armed forces. An inspection of scale homogeneity revealed a great extent of item interrelation (Cronbach's $\alpha = .79$). Accordingly, all four items were combined into a mean score. Descriptive statistics were impressive: the vast majority of participants had a very positive attitude towards the Bundeswehr, which is observable from the score mean being located at 4.01 out of five (SW = .79). Here, we again found moderate negative correlations with noise annoyance items ($r_{small\ weapons} = -.416$, $r_{large\ weapons} = -.487$). Correlations found with the sound levels were significant, but very small (all $r < .04$).

Attitude towards the local training area: The last variable to be included in the multiple regression models is closely related to the previously described. Besides the general attitude towards the Bundeswehr, we also assessed the attitude towards the local training area. Initially, we asked five questions relating towards the attitude. However, a test of homogeneity suggested to exclude two of the items before calculating the score. The score consisted of three items (Cronbach's $\alpha = .85$). We measured rather high positive attitudes towards the local training area, which did not reach the levels of attitude towards the Bundeswehr, but still scored a mean of 3.48 (SD = 1.15) on the five-point scale. Correlations with noise annoyance were also negative but scored a little lower than the afore described correlations ($r_{small\ weapons} = -.335$, $r_{large\ weapons} = -.419$).

All scores reported had at least an "acceptable" homogeneity (all Cronbach's $\alpha > .70$) and were identified by using either factor analysis, or are based on existing and established scales. Independent variables in the regression models have been added using the forced-entry method, as we had no theoretical reason to assume a hierarchical sequence to be advantageous. The multiple logistic regression models revealed a much better fit than the basic models with one acoustic predictor only. In the following results of the model with the overall best fit is described. This is the model for the probability of HA, p(HA), by both small and large weapons by L_{Zeq} as acoustic predictor. Differences between the models again were marginal.

Indeed, the proportion of variance explained was almost 30 times higher as in comparison to the single regression models. While Table 4 still suggests a small, meaningful effect of the L_{Zeq}, non-acoustic factors contribute a lot more to explaining variance in p(HA) due to small and large weapons. While, at least for noise annoyance by small weapons, noise sensitivity appears to be not a statistically significant predictor, it has the largest OR of both models, which at least in the model for large weapons is also highly significant.

We further have reason to believe that both attitudes towards the Bundeswehr and the training area have important influences on annoyance by both weapon types. The better the attitude towards the Bundeswehr and the training area, the smaller the noise annoyance. This difference is again subtler in the model containing the variable for small weapons but becomes highly statistically significant when annoyance from large weapons is used as the dependent variable.

Another strong effect appears to be found in habituation to shooting noise. This variable is almost unaltered by changing the dependent variable in the models ($\Delta OR_{Habituation}$ = .001), while the significance level remains very high.

Results of the multiple logistic regression models for the prediction of the probability of being HA are presented in Table 4 for noise from small weapons and Table 5 for noise from large weapons.

Table 4: Exposure-response relationships between the probability of HA by shooting noise from small weapons and L_{Zeq}

				95 % *CI* for *OR*	
Effects	***B***	***SE***	***OR***	***CI-***	***CI+***
Intercept	-11.961***	3.173	0	<.000	.002
$Lz_{eq,day}$	.137**	.054	1.147	1.037	1.281
Satisfaction with housing	-.237	.193	.789	.541	1.169
Noise sensitivity	.467*	.249	1.596	.991	2.654
State of ill-health	-.100	.221	.905	.578	1.384
Measures taken against shooting noise	-.088	.26	.916	.521	1.382
Positive affective evaluation	.392	.286	1.480	.806	2.511
Habituation	-.962***	.295	.382	.210	.675
Attitude towards the Bundeswehr	-.626**	.256	.535	.322	.879
Attitude towards training area	-.242	.29	.785	.441	1.384

B = Coefficient, *SE* = Standard Error, OR = Odds Ratio, *CI* = Confidence Interval, *CI-/+* = lower/upper limit of *CI*, *** p < .001, ** p < 0.01, * p <.05. $R^2_{Nagelkerke}$ = .749, Akaike Information Criterion *AIC* = 168.72.

Table 5: Exposure-response relationships between the probability of HA by shooting noise from large weapons and L_{Zeq}

				95 % CI for OR	
Effects	***B***	***SE***	***OR***	***CI-***	***CI+***
Intercept	-7.178***	1.631	.001	<.000	.017
$Lz_{eq,day}$	.089***	.028	1.093	1.35	1.157
Satisfaction with housing	.009	.130	1.009	.783	1.308
Noise sensitivity	.614***	.145	1.848	1.399	2.468
State of ill-health	.132	.128	1.142	.888	1.468
Measures taken against shooting noise	.221**	.098	1.247	1.01	1.497
Positive affective evaluation	.128	.169	1.137	.805	1.565
Habituation	-.961***	.162	.383	.276	.523
Attitude towards the Bundeswehr	-.692***	.165	.501	.361	.690
Attitude towards training area	-.325**	.159	.722	.528	.985

B = Coefficient, *SE* = Standard Error, OR = Odds Ratio, *CI* = Confidence Interval, CI-/+ = lower/upper limit of *CI*, *** p < .001, ** p < 0.01, * p <.05. $R^2_{Nagelkerke}$ = .790, Akaike Information Criterion *AIC* = 406.98.

State of ill-health and satisfaction with housing both remain insignificant, with odds ratios (OR) only slightly surpassing “1”, suggesting only very small contribution to the model fit. Indeed, a quick glimpse into backwards directed variable selection reveals those variables could be deleted in favour of a slightly better model fit, however, this will not be further investigated here. The full models also confirm what has already become apparent during presenting analysis of the basic models: L_{Aeq} is the worst predictor for noise annoyance from shooting noise. For the basic as well as extended models, best model fits have been found in L_{Zeq} followed by L_{Ceq} followed by L_{Aeq}.

5. DISCUSSION AND CONCLUSIONS

In this study, we see higher noise annoyance ratings for large weapons than for small weapons. This appears reasonable, considering that the Z-weighted equivalent sound levels are higher for large than for small weapons.

Our study illustrates that sound levels are a weak predictor of noise annoyance due to shooting noise, which has been shown before for L_{AE} and L_{CE} levels and annoyance, as reported in a study by Brink and Wunderli [12]. However, a comparison of the exposure-response relationship for %HA related to L_{AE} and L_{CE} as found in this study with regard to noise annoyance due to large weapons are considerably similar to the results of the Swiss study on shooting noise annoyance (Figure 2).

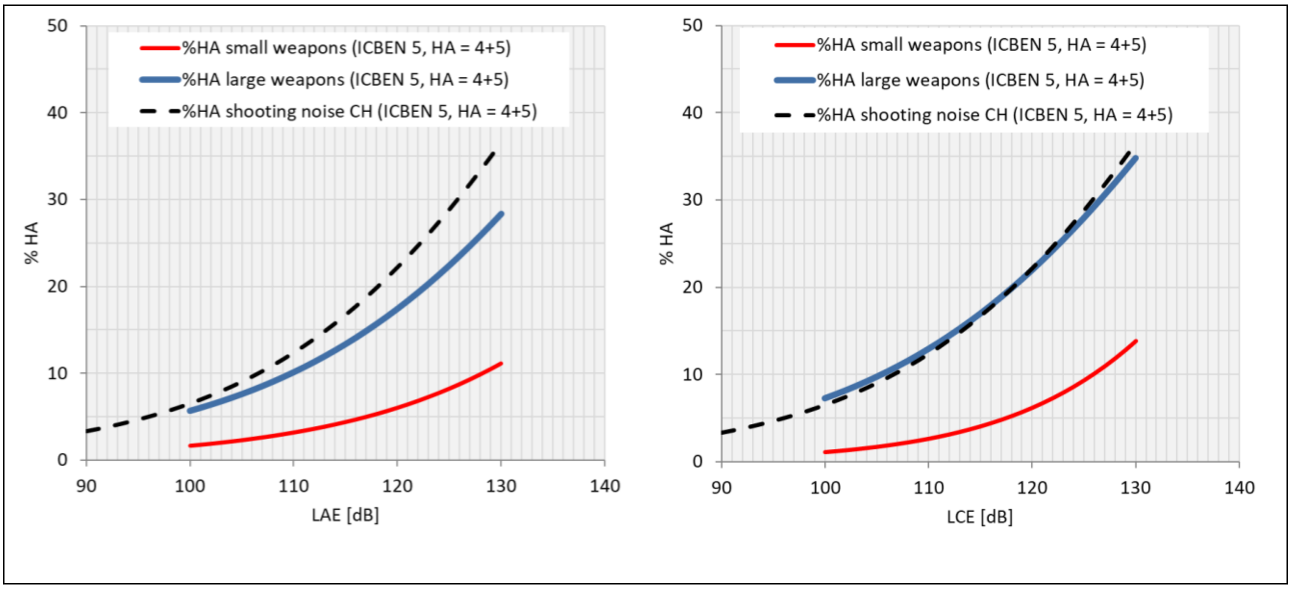

Figure 2: Exposure-response curves for %HA for shooting noise by L_{AE} (left) and L_{CE} (right). Comparison of results of this study (blue, red curves) with those of the Swiss shooting noise study [12] (dashed black curve "CH"). HA (high annoyance) refers to responses on the upper two categories ("very", "extremely") of the ICBEN five-point scale.

There are other studies on community responses to shooting noise showing a much better relationship between indoor/ outdoor noise levels and shooting noise annoyance [9] and [23, 26]. We found only weak correlations between all acoustic metric and shooting noise annoyance, which was confirmed in single logistic regression models and further supported by building up multiple logistic regression models, containing sound levels as well as different non-acoustic (personal and psychosocial) variables. This suggests a much smaller proportion of variance in noise annoyance by shooting noise is explained by noise levels from military practice than for other environmental noise sources.

Differences in model fits were very small when comparing different A, C and Z- weighted equivalent sound exposure levels. However, the Z-weighted sound exposure level – which does not weight for high or low frequencies – always turned out to be the best sound metric for predicting %HA. In comparison to A- and C-weightings, the Z-weights therefore more accounts for the low frequencies, which we regard as a possible explanation for better fit indices by these models.

Adding non-acoustic factors as predictor variables to the exposure-response models resulted in a considerable jump in model fit measures, e.g. increasing pseudo R^2. Considering the noise annoyance both from large and small weapons the most influential factors turned out to be the attitudes towards the local military training area and the German armed forces (*Bundeswehr*) in general. The more positive the attitudes were the less annoyed by shooting noise were the residents. Also, we found the factor "habituation" to be an important contributor to the prediction of shooting noise annoyance. Noise sensitivity showed the highest OR indicating higher sensitive people to be more annoyed by shooting noise, however, this was only statistically significant with regard to noise from large weapons. Altogether, we were able to illustrate the importance of non-acoustical, in particular attitudinal factors for the prediction of noise annoyance. This finding is very much in line with the literature (e.g. [27]).

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