Perception of noise in suburban and urban areas

Elaine Paz and Paulo Henrique Trombetta Zannin

Federal University of Parana, Centro Politécnico - Setor de Tecnologia, Bairro Jardim das Américas, 81531-990 Curitiba, Brazil
paulo.zannin@pesquisador.cnpq.br

This work analyses, using a comparative approach, the environmental noise perception in the daily lives of inhabitants of a residential area, with that of a mixed (residential and commercial) area (downtown), in a large Latin America city. The goal was to confront an ideal urban environment with one acoustically polluted, as function of noise descriptors. Concomitant with the evaluation of noise perception (subjective analysis), noise levels were measured (objective analysis) in both areas. The single average equivalent noise level (*Leq*) found for downtown was 73 dB(A), and 53 dB(A) for the residential area. A random sample of the populations of both areas was taken, through a questionnaire. Questionnaire data was treated statistically through a factorial multivariate analysis. This analysis has generated 3 statistical indicators: time perception, atypical noise perception, and sources and disturbances. Over 50% of both populations sampled have the perception that high frequency noise levels are gradually increasing, with higher contribution from traffic noise. The dominant organic effects reported were irritability and loss of concentration ability, these last being precursors of hearing loss.
.

1 Introduction

Recent studies have shown significant effects of urban noise on humans [1,2,3]. The equivalent sound level (L_{Aeq}) of 65 dB(A) is considered the threshold of acoustical comfort. Continuous exposure to values above this limit can cause several psycophysiological disturbances, independent of age, such as sleeping disorders, reduction in labor performance, high blood pressure, and heart disease [4, 5]. Apart from these other patho-physiological effects cited above, hearing loss is the most likely result, being detected through audiometry. Qualitative evaluations can complement these direct assessments of health effects, for example when a representative sample of a population is submitted to a social survey, being evaluated concerning their noise perception [6, 7].

The World Health Organization [8] recommends a limit of L_{Aeq} = 55 dB(A) for the equivalent sound level measured in residential areas. It is assumed that a sound level of L_{Aeq} = 50 dB(A) can disturb, but still allows adaptation. With L_{Aeq} = 55 dB(A) or more, there can be slight stress and discomfort. The level of L_{Aeq} = 70 dB(A) is seen as the level already leading to organism suffering, increasing the risk of heart attack, brain hemorrhage, infections, arterial high pressure and other pathological conditions. At an equivalent level of 80 dB(A), endorphin release causes the sensation of momentary pleasure. However, levels of L_{Aeq} = 100 dB(A) can result in hearing loss.
A comparative analysis of subjective evaluation of inhabitants from zones with high and low noise incidence - for example, a residential zone and a central zone- can aid in the identification of potential hazardous effects for the health of the inhabitants exposed to noise pollution [7].

Some studies on this subject have already been developed in Brazil, where subjective and objective results were compared [9,10,11]. A statistical model appears to be an indispensable scientific tool to the study of noise perception. Guski [12] asserts that the incovenience caused by the noise in living areas is in part one of the acoustics factors and in part to the individual perception of the residents in these areas, where this perception embody social and personal aspects. The objective of this study was to make a comparative analysis of the perception of routine urban noise by the inhabitants of two distinct zones of the city of Curitiba. A subjective evaluation was performed, whereby a sample from each zone was submitted to a questionnaire. Classification and data treatment were performed statistically through a multivariate factor analysis.

2 Methods

At first, an objective evaluation of the urban noise (measurements *in situ*) was performed in both urban zones selected for the subjective evaluation. It was necessary to verify whether they matched the expectations with respect to their characteristic noise levels, identified in an earlier study conducted by Zannin *et al.* [11]. As in the previous study [11], 25 points in the controlled zone and 97 points in the non-controlled zone were acoustically evaluated. The evaluations *in situ* were done measuring the equivalent sound levels during daytime (from 7:01 a.m. to 10:00 p.m., in a period of 15 hours), on variable weekdays and times. This way, single values for each zone were generalized to a period of 16 hours and were considered representative of any day of the week. A total of 60 valid measurements have been performed this way, using BK 2260. The software Evaluator BK 7820 was used to obtain a single value for the equivalent level of each zone. Following the recommendation of the Brazilian Standard NBR-10.151 [13], measurements were conducted in the absence of rain or strong winds. Measurements had a duration of two minutes; the equipment was adjusted to fast operation mode. The equivalent sound levels measured were of 53.5 dB(A) and 72.9 dB(A), respectively for the controlled zone and noisy zone. The subjective evaluation of the noise by the people inhabiting each of the two zones was performed through the application of a questionnaire developed by the authors. The questionnaire contained questions that allowed the identification of the main sources of urban noise noticed by the population. It also permitted the people to manifest their reaction to the noise. Main roads in each zone were chosen for the application of the questionnaires. Subjects (both sexes, randomly chosen, aged 17-69 years old) living in residences on these roads received the questionnaire. In the controlled zone, a total of 104 residents were interviewed (63% men and 37% women). In the noisy zone, the sample of people interviewed (130 subjects) were composed of 52% men and 48% women. Questionnaires were filled up by the interviewed subjects in the presence of the researchers, from 7:01 a.m. to 10 p.m. For the quantitative evaluation of noise perception, multiple choice questions were posed, using the *Likert* schedule, with a scale of values ranging from 0 to 6: (0) nothing, (1) very little, (2) little, (3) medium, (4) a lot, (5) intense, (6) extreme. For the identification of psychophysiological disorders or the determination of which factor are considered the most inconvenient, a yes/no type of question was posed. Individuals were identified by the questionaire. Noise perception data were analysed statistically using the software *Statistica 5.0*. A multivariate factor analysis was performed with the data, as samples from both localities passed the test of normality (level of 5%). The extraction method used was the principal components method, where the selection criterion for the determination of the number of factors was the “Kaiser Criterium”, that is, the number of factors equals the number of autovalues higher or equal to 1. At first we sought to identify the level of noise perception by the population under investigation. The degree of annoyance produced by perceived noise was then classified into 2 variables. A univariate descriptive statistical method was thus applied at this moment. The step that followed was the application of a factorial multivariate analysis of the results, through the principal components method, employing normalized *varimax* rotation for the axes. The subjective evaluation at first counted with a total of 19 variables, for adequate characterization of noise perception by the surveyed individuals. For the factor analysis, variables were grouped in factors according to the value of the linear correlation coefficients among them (Table 1). Six main factors could be thus identified, to both zones. Those factors have been grouped into 3 main statistical indicators, as a function of their explainable variations (weights, communalities, specific variation, residuals matrix). These indicators have been named 1) temporal perception, 2) atypical noise perception, and 3) sources and disturbance produced. In the controlled zone, the indicators explain about 98% of the phenomena, while for the noisy zone (downtown), the value was of 81%. This result indicates that the sample model is representative for the analysis of the population under study.

3 Results

In the controlled and in the noisy zones, respectively 98% and 95.5% of the interviewed people believe that noise can bring them some health problems. However, a difference arises, in that about 50.5% of the controlled zone population and 94% of the noisy zone population feel annoyed by the noise. "Absence of disturbance" was reported more frequently in the controlled zone, while “extreme disturbance” was reported only by the residents in the noisy zone (Figure 1). In accordance, sensitivity with respect to increased levels of noise was of 78.2% between “increased” to “increased extremely” in the noisy zone, and 71.7% between “increased just a little” and “increased” in the controlled zone (Figure 1).

The statistical indicator "Temporal Perception" revealed that 61.5% of the residents from the noisy zone and 57.1% of the residents from the controlled zone perceive an increase in noise levels during weekdays in the morning and in the afternoon, and in weekends during the night (Figure 2). The statistics of "Atypical Noise Perception" reveales that 70% of the population from the noisy zone and 30% from the controlled zone feel annoyed by noises arising from atypical sources. The "Source Indication and Disturbance" included the largest number of variables in this study, related to information concerning the types of sources in the urban environment, and the occurrence of the main psycho-physiological disturbances reported by the surveyed individuals. It could be detected that for both studied urban zones, irritability and decrease in the capacity to concentrate were the main organic effects (Figure 5). In addition, traffic noise was indicated as the most annoying source (Figure 6), followed by the sound of alarms, or from building construction routine activities. It is important to emphasize that to the controlled zone residents, the second noise source identified as the most annoying was that from airplanes.

4 Conclusions

Information about noise pollution is the precursor for the adoption of control measures, according to Stansfeld and Matheson [5]. At the beginning of the subjective evaluation it was already clear that most subjects were aware of the potential harm caused by noise exposure. From the subjective evaluation it could be observed that the population from the controlled zone shows an increased perception of urban noise. This result is in accordance with the data published by Zannin *et al.* [9]. In this paper, sound levels measured in the controlled zone in 1992 were compared to values measured in 2000 [9]. Consistent increases in sound levels have been demonstrated. This growth is represented by a larger number of sites within the controlled zones with levels $50 < L_{Aeq} \leq 55$ dB(A): in 1992, only 0.6% from a total of 25 points displayed such values of L_{Aeq}, while in 2000, the value rose to 7.4 % [9]. In the present study the value measured for the equivalent sound level L_{Aeq} was of 53.5 dB(A). At the noisy zone (downtown), measurements done in 2002 by Zannin *et al.* [10] in 97 points have shown L_{Aeq} = 73.4 dB(A). In the present study the value measured was of L_{Aeq} = 72.9 dB(A). This way, in the noisy zone, there is a permanent condition of potential risk to the health of the population who lives or works in this zone. Frequent exposure to L_{Aeq} = 70 dB(A) means that the person is under increased risk of heart attack, brain hemorrhage, infection, high blood pressure and other pathologies, according to WHO [8]. The limit established to downtown Curitiba by the Municipal Law 10.625 [14] of sound imission is of 65 dB(A) during the day (from 7 a.m. to 7 p.m.). It can be seen that the sound level measured downtown is above the one determined by the law. Therefore, the situation downtown with respect to noise pollution terms is very serious. Although the sound levels measured downtown have not increased substantially in the last years [11], the subjective evaluation showed that the residents pointed to a perceived increase in noise levels. This can be explained by the fact that Curitiba´s downtown is nowadays one highly sought for residential leasing, due to relatively lower rent rates. However, when the residents compare where they lived previously with their current downtown environment, they detect this difference in noise levels. According to the results shown here, L_{Aeq} = 72.9 dB(A) (downtown, noisy zone) against L_{Aeq} = 53.5 dB(A) (residential area, controlled zone).

According to Berglund *et al.* [1] the irritability caused by noise usually has a continuous effect in the organism, once its action is ongoing even after noise has terminated or at least attenuated. The low concentration and the irritability are in the group of organic effects of the second category (physiological or of attention). It was verified that for both zones under study, irritability and lower capacity to concentrate were the organic effects of larger occurence, such as it was verified in the Belojevic *et al.* [7] study of exposure to traffic noise. Then, according to Muzet´s classification [6], this population was found to be in an attention situation.

The noise from the traffic of vehicles was indicated as the kind of noise which mostly disturbs, in accordance with a previous study [7]. Traffic noise can thus be characterized as a factor of psyco-social stress, following Berglund *et al.* [1] and Muzet [6]. In addition to that, Guski [12] classifies the analysis of disturbance perception caused by urban noise as useful parameters for the evaluation of quality of life of a population.

Temporal Perception, Atypical Noise Perception, Source and Disturbance were useful indicators to characterize the perception of a population to continuous noise exposure, and also offer material for a putative evaluation of the quality of life of this population.

References

[1] B. Berglund, T. Lindval, DH Schwela. *Guidelines for Community Noise*, World Health Organization - WHO (Stockholm, Stockholm University and Karolinska Institute), 21 p, 1990.

[2] RFS Job. "The Influence of Subjective Reactions to Noise on Health Effects of the Noise". *Environment Internacional*, **22**, 93-104 (1996).

[3] C. Maschke. "Preventive Medical Limits for Chronics Traffic Noise Exposure". *Acustica*. **85**, 444-448 (1999).

[4] W. Babisch, H. Ising, JEJ Gallacher. "Health status as a potential effect modifier of the relation between noise annoyance and incidence of ischaemic heart disease". *Occupational & Environmental Medicine*. **60** (10), 739-745 (2003).

[5] SA Stansfeld, MP Matheson. "Noise Pollution: non-auditory effects on health: British Medical Bulletin". *Impact of Environmental Pollution on Health: Balancing risk 2003*. **68**, 243-257 (2003).

[6] A Muzet, "Noise Exposure from Various Sources – Sleep Disturbances Dose-Effect Relationships on Adults". *Technical Meeting on Exposure-Response Relationships of Noise on Health – WHO*, Strasbourg-France, 1-18 (2002).

[7] G Belojevic, B Jakovleviac, O Alesksc O. "Subjetive Reactions for Traffic Noise with Regard to Some Personality Traits". *Environment International* . 23, 221-226 (1997).

[8] World Helth Organization (WHO). Résumé D'orientation Des Directives De I'oms Relatives Au Bruit Dans I'environmental. (2003).

[9] Zannin PHT, Calixto A, Diniz FB. Environmental noise pollution in residential areas of the city of Curitiba. Acustica 2001; 87: 625-628.

[10] PHT Zannin, FB Diniz, "Environmental noise pollution in the city of Curitiba, Brazil". *Applied Acoustics*. 63, 351-358 (2002).

[11] PHT Zannin, FB Diniz, JA Ferreira. "A Survey of Urban Noise Annoyance in a Large Brazilian City: The Importance of a Subjective Analysis in conjunction with an Objective Analysis". *Environmental Impact Assessment Review*. **23,** 245-255 (2003).

[12] R Guski, "Personal and social variables as co-determinants of noise annoyance". *Noise and Health* . **1** (3), 45-56 (1999).

[13] Associação Brasileira de Normas Técnicas-ABNT (Brazilian Association of Technical Norms). NBR-10,151 (in portuguese), ABNT, 1-4, (2000).

[14] Secretaria Municipal do Meio Ambiente-Curitiba (Municipal Secretary of Environmental-Curitiba). Law No. 10,625 02/19/2002, (in portuguese), SMMA, 1-9, (2002).

Table 1 – Variables and Factors

Var.	Attribute	Factors for the areas	Indicatives
1	Perception of the gradation of the noise	1	Temporal Perception
2	Classification of the daily occurrence of the noise	1	
3	Classification of the intensity of the noise in the daily occurrence	1	
4	Classification of the weekly occurrence of the noise	1	
5	Classification of the intensity of the noise in the weekly occurrence	1	
6	Perception of sources in other edifications that are inconvenient	2	Atypical Noise Perception
7	Perception of sources of sporadic occurrence	2	
8	Perception of annoyance of the noise	3	Source Indication and Disturbance
9	Classification of annoyance of the noise	3	
10	Perception of the damage induced by the noise	3	
11	Perception of the noise in your dwelling	4	
12	Classification of the intensity of the noise in your dwelling	4	
13	Classification of the noise in your workplace	4	
14	Classification of the intensity of the noise in your workplace	4	
15	Perception of the effects of the noise	5	

16	Perception of inconvenient environmental sources	6
17	Perception of sources in your dwelling that are inconvenient	6
18	Verification of your behavior to the external noises	6
19	Verification of your behavior to the noises in your dwelling	6

Table 2 – Indicatives

	F1 Temporal Perception	F2 Atypical Noise Perception	F3 to F6 Source Indication and Disturbance
	Acoustically controlled zone		
% Expl	0.35	0.18	0.45
	Noisy zone		
% Expl	0.27	0.16	0.38

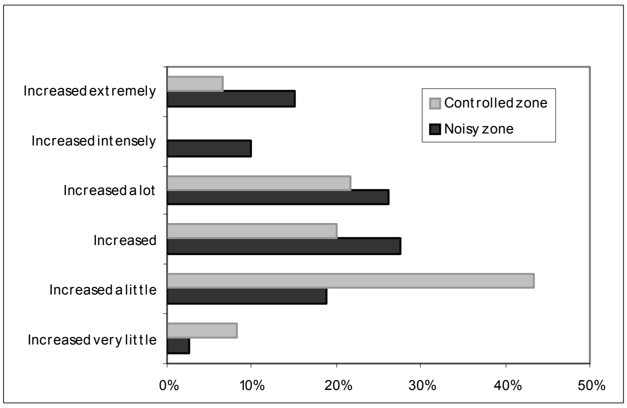

Figure 1 – Perception of noise.

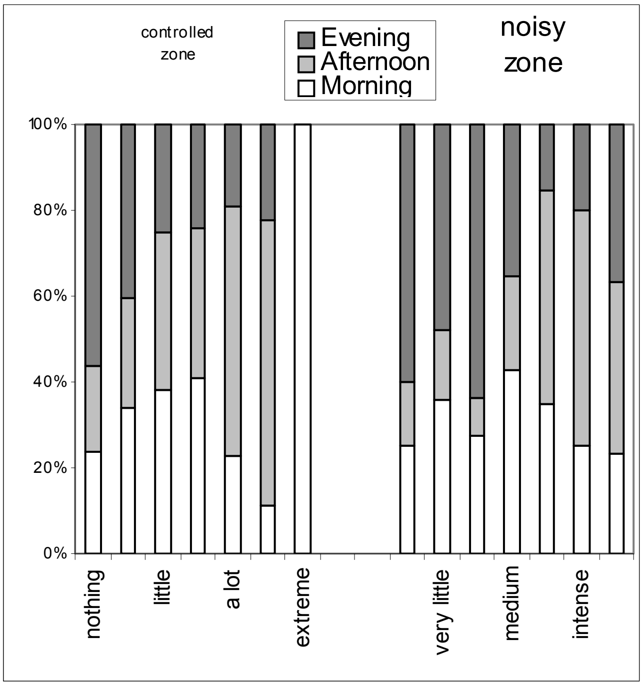

Figure 2 – Temporal perception of noise.

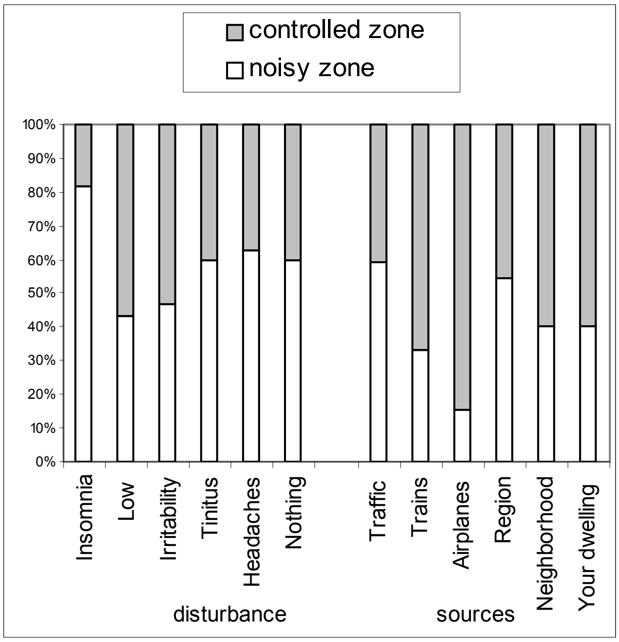

Figure 3 – Perception of disturbances and noise sources.

.