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ENVIRONMENTAL NOISE ANNOYANCE IN VALENCIA (SPAIN). NOISE CLASSIFICATION ACCORDING TO PHYSICAL APPROACHES AND PSYCHOACOUSTICS.

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ABSTRACT

We seek in this investigation, to make a study of the different sources of noise or external sounds of the city of Valencia (Spain), by means of physical describers and psychoacoustics. We contribute improvements but there of the classic LeqA like parameter fundamental describer adopted in the European Community. Leq is not representative of the subjective impression and contextual evaluation. Psychoacoustic measures versus time for loudness, sharpness, roughness, fluctuation strength and others, overall and versus frequency; generally represent subjective auditory evaluations better than conventional level based measurements. Heven in 1970, Murray Schafer's message about noise –abatement legislation brought awareness of the necessity and opportunity to considerer but also its perception by experts who are affected by noise.

INTRODUCCIÓN

When we make acoustical evaluation of a soundscape, we can distinguish three main approaches depending on the preferential shade of meaning, according to the focus on physical aspects, individual psychological ones or on sociological and cultural.

Physical Aspects

It is the most dominant aspect in the soundscape (sound environment), being the most used in the environmental management field. The fundamental objective is centred on the identification of the "black points", for decrease noise or noise dampering. The soundscape is associated to noise pollution. Intensity is quantified as the basic element to take into account to set the value or quality of the soundscape. One of the specific actions derived from the results from the studies is the implementation of acoustic barriers for the correction and control of the noise. Other actions to know the 'objective' reality in the city related to the noise pollution degree are the 'acoustical maps', in order to measure and analyse the sound level in many points in the city (levels, frequencies, noise sources) at different hours and days. For example, in municipalities over 100000 inhabitants, the average equivalent level was 69,5 dBA. Without any doubt these studies are very valuable in the environmental management field.

Psycophysical Aspect

This is devoted mainly to determinate the existing relationship between noise exposition and subjective response of the measured population in annoyance terms. This aspect reduces the analysis to two unique variables: sound intensity (physical variable) and annoyance (subjective variable). The sound environment is associated to noise, a environmental pollution factor, which

is defined as “a undesired sound” or “the acoustical energy which is able to change the physiological or psychological comfort”. The annoyance due to the noise is understood as “an unpleasant feeling or a negative attitude produced by an undesired or unnecessary considered noise in the human’s living space” or as displeasure feeling which arises when considering that noise can affect negatively to health. From this point of view, the soundscape is considered as an aggressive or stress factor. Several investigations have produced results which prove that existing correlation between noise exposition level (sound intensity) and annoyance is quite low. Noise just explains 16% of the variability of the annoyance reaction, which confirms the existence of individual broad differences in the response to this environmental factor.

Perceptive Aspect

From this point of view, the soundscape is not considered as an oppressive element which isolate from the environment, but it is considered as an information element and related to itself. The main aim of these studies deals with the identification and description of the psychological processes bases which explains the sound differences as well the most relevant attributes which affect these processes. The soundscape quality is defined not as much in physical aspects but depending on the feelings and perceptions that cause the listening of a fixed sound or soundscape.

Taking this into account, it is possible to understand the reason for psycho-acoustics necessity and development. This branch of the psychophysics studies the existing relation between the physical stimulus and the psychological response that causes this stimulus. It studies the relation between the physical properties of sound and the interpretation that brain extracts from them. Psycho-acoustics is an empirical discipline and its results are obtained statistically from experiments done with experimental individuals. Another important component is the model design which helps to explain the experimental results. Different authors have proposed several models and many of them seem to explain the obtained results from the actual knowledge in this area. The main psycho-acoustic descriptors are: LOUDNESS, SHARPNESS, FLUCTUATION, ROUGNESS, TONALITY, etc.

EXPERIMENTAL METHOD

We have chosen 7 places in Valencia, which are considered as representative and we have selected several interesting sounds to analyse, as traffic, underground, tram, people walking and speaking, places for leisure time, etc. In each selected place, we set up the experimental equipment. This equipment consists in a silicone head with a ½ inch omni directional microphone in each ear to simulate a human head, a 1’60 m height tripod, as shows fig 1. The sounds are recorded with a portable DAT during 10 minutes each one approximately. Each microphone has been calibrated with a calibrator with a 94 dB at 1000 Hz signal. After we took 10 characteristic seconds for each signal. We have done the analysis of the main psycho-acoustical and acoustical parameters by means of the ARTEMIS™ software.

Figure 1.- Experimental set-up

MEASUREMENTS DONE

PLACE	DATE	RECORDING TIME	SOUNDS
ÁGORA at the UPV	Fryday 16H	10 MINUTES	People, laugthers, birds murmur, mopeds, sound of crockery from bars, dog, bike, heel and curios people asking.
TRAM STOP "LA CARRASCA".	Fryday 16:30 H	16 MINUTES	Mainly it is listened traffic at the 'Avenida de los Naranjos'. CAR HORNS, A PERSON COUGHING, MUSIC FROM CARS, WIND, SOUND FROM TRAM WIRES. TRAM'S BRAKING AND START, a person whispering to the head's ear, sound of a bus picking up a handicapped person, lorries, bikes, birds, ambulance with a siren, runner
MALVARROSA's BEACH	Fryday, May 10th, 17:30	12 minutes	WIND in the beach has been rejected in the recording. People walking, skating, playing volley-ball in the sand, kids, curious people, birds, marine breeze, mopeds, sea waves, a plane, the movement of the palm trees leaves
Calatrava's bridge	Tuesday, March 28th, at 17:25H	12 minutes	Buses, cars, mopeds braking and starting, the helix of a helicopter, the horn of a car, the siren of an ambulance in the background, barks of a dog, crane. Wind
Underground Stop in Valencia. ALAMEDA Stop	Tuesday, March 28th, 17:48H	12 minutes	It can be distinguished the underground's braking and starting action, kids speaking, underground's doors, background music which points out the arrival and departure of a tram
La Paz Street	Tuesday, March 28th, 18:20H		It can be distinguished cars passing through, horns, stop of a taxi near the head, a Harley motorbike, the continuous pass of buses

MAIN SOUND SOURCES SELECTED AND PARAMETERS

Archive	dBA	L(sones)	S(acum)	R(asper)	F(vacil)	T(tu)	annoyance	pleasure
Tram Starting	90,60	54,30	3,09	3,74	0,0304	0,0824	117,56	0,0032
Traffic 1	84,20	47,00	3,38	3,78	0,0228	0,0536	107,27	0,0023
Heels	81,10	32,30	2,87	3,16	0,0524	0,0642	69,00	0,0061
Traffic 2	95,10	85,00	4,71	5,14	0,0281	0,0725	242,75	0,0002
Brakes	86,60	60,30	4,32	3,99	0,0786	0,0760	154,89	0,0007
Background sound	71,20	21,80	2,59	2,48	0,0250	0,0381	43,66	0,0133
Whistle	88,20	57,00	3,31	3,92	0,0579	0,0827	128,26	0,0022
Lorry	89,50	56,20	3,59	3,96	0,0702	0,0406	131,51	0,0016
Underground	91,80	73,80	3,56	4,58	0,0312	0,0872	175,99	0,0011
Kid	78,70	34,00	3,25	2,61	0,0576	0,1210	69,57	0,0059
Ball	73,30	24,50	2,80	3,28	0,0398	0,0335	55,59	0,0060
Murmur	84,90	28,30	2,73	2,75	0,0331	0,0457	57,40	0,0094
Fast motorbike	85,10	50,30	3,62	3,85	0,0529	0,0608	118,10	0,0017
Show motorbike	79,00	31,10	3,19	3,29	0,0406	0,1320	69,71	0,0039
Motorbike near	89,10	63,10	4,33	4,20	0,0528	0,1130	164,05	0,0006
Underground stopping	88,40	61,20	3,76	4,20	0,0251	0,0627	147,71	0,0011
Underground starting	89,70	64,00	3,26	4,01	0,0399	0,0859	142,35	0,0022
Helicopter	83,80	26,30	2,17	2,89	0,0247	0,0505	53,68	0,0157
People	73,40	26,10	2,77	2,61	0,0358	0,0561	52,60	0,0100
Fast cars	93,80	84,10	4,67	5,34	0,0377	0,0282	241,36	0,0002
Adhesive tape	81,30	27,60	3,24	2,81	0,1180	0,0318	59,65	0,0052
Screaming Kid	95,20	70,40	3,90	4,57	0,0687	0,0701	176,26	0,0007
Bus for handicapped people	92,90	68,50	4,23	4,47	0,0198	0,0647	177,87	0,0006
Fast bus 1	88,90	54,20	3,52	3,92	0,1100	0,0328	126,07	0,0018
Fast bus 2	90,70	58,50	3,94	4,16	0,0497	0,0549	144,68	0,0009
Fast bus 3	88,10	51,70	3,56	3,77	0,0543	0,0847	119,34	0,0019
Ambulance near	101,30	90,40	4,70	4,00	0,0388	0,2160	245,26	0,0005
Ambulance far away	83,20	30,40	2,36	2,47	0,0733	0,1590	57,02	0,0171
Fast Ambulance	102,20	95,60	4,26	3,63	0,0652	0,2710	237,84	0,0010

CORRELATIONS

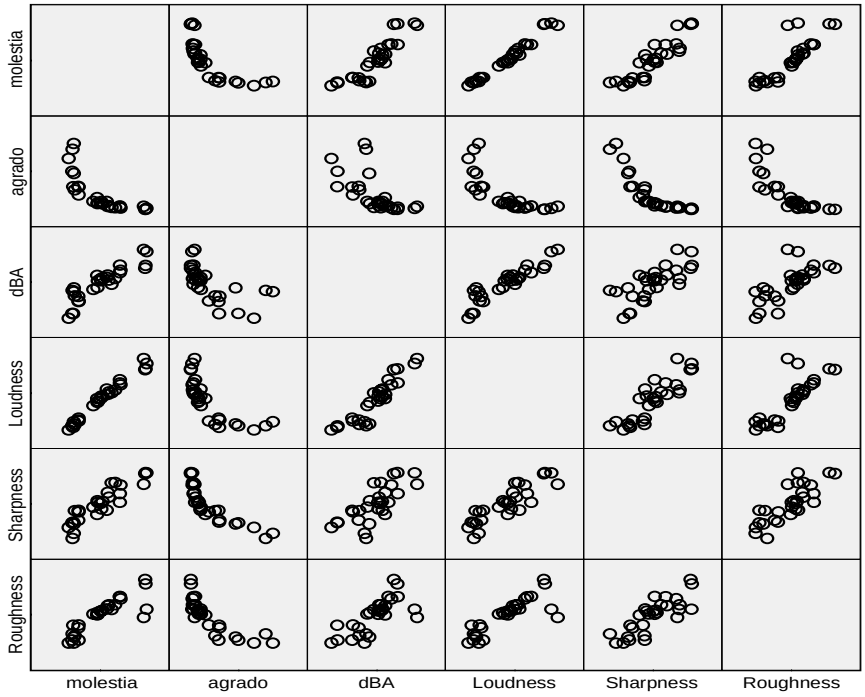
From the former results we have studied the correlations between the parameters. We have obtained the following results:

Correlaciones

		dBA	Loudness	Sharpness	Roughness	Fluctuation	Tonality	molestia	agrado
dBA	Correlación de Pearson	1	,924**	,746**	,723**	,033	,458*	,895**	-,639**
	Sig. (bilateral)		,000	,000	,000	,864	,012	,000	,000
	N	29	29	29	29	29	29	29	29
Loudness	Correlación de Pearson	,924**	1	,877**	,836**	-,060	,424*	,988**	-,757**
	Sig. (bilateral)	,000		,000	,000	,757	,022	,000	,000
	N	29	29	29	29	29	29	29	29
Sharpness	Correlación de Pearson	,746**	,877**	1	,816**	,040	,266	,915**	-,840**
	Sig. (bilateral)	,000	,000		,000	,838	,163	,000	,000
	N	29	29	29	29	29	29	29	29
Roughness	Correlación de Pearson	,723**	,836**	,816**	1	-,145	-,059	,855**	-,815**
	Sig. (bilateral)	,000	,000	,000		,453	,763	,000	,000
	N	29	29	29	29	29	29	29	29
Fluctuation	Correlación de Pearson	,033	-,060	,040	-,145	1	,034	-,082	-,079
	Sig. (bilateral)	,864	,757	,838	,453		,861	,671	,682
	N	29	29	29	29	29	29	29	29
Tonality	Correlación de Pearson	,458*	,424*	,266	-,059	,034	1	,380*	-,084
	Sig. (bilateral)	,012	,022	,163	,763	,861		,042	,664
	N	29	29	29	29	29	29	29	29
molestia	Correlación de Pearson	,895**	,988**	,915**	,855**	-,082	,380*	1	-,746**
	Sig. (bilateral)	,000	,000	,000	,000	,671	,042		,000
	N	29	29	29	29	29	29	29	29
agrado	Correlación de Pearson	-,639**	-,757**	-,840**	-,815**	-,079	-,084	-,746**	1
	Sig. (bilateral)	,000	,000	,000	,000	,682	,664	,000	
	N	29	29	29	29	29	29	29	29

**. La correlación es significativa al nivel 0,01 (bilateral).

*. La correlación es significante al nivel 0,05 (bilateral).



Sounds that are less annoying are murmur of people, the background sound and people speaking, as well as occurred with the pleasure. This is because, subjectively we are more used to ear them and they are not so disturbing as the traffic or a child crying. Concretely, the environment that is perceived in the Agora at the University is less annoying because it is an area which is closed to vehicle circulation and the perceived sound is just coming from people speaking, from bars (crockery) and from some moped passing through.

The sound of a child crying is more annoying than a bus or the traffic noise. The ambulances recorded at the “La Carrasca” Underground stop were passing nearer than the one

at the Av. De la Alameda, for this reason the annoyance is greater. This is a coherent result. The one at the La Paz Street is more intense because the street is narrower and the buildings have 4 or 5 levels, for this reason the equivalent level is greater than in a wider area as the Calatrava's bridge. This explains why the busses annoyance is greater in this area than in "La Carrasca". This is the same for mopeds and traffic sources.

The noise produced by a man with a adhesive tape, the kid with a ball and the woman with heels are classified as impact noise and they produced the same annoyance approximately. In the case of the underground stop at the Alameda, we have proved that the annoyance produced by the underground braking, stopped and starting is similar and quite high. This is because the station is placed in a closed area (although the ceiling is quite high), the indirect sound field is not negligible, enlarging the equivalent sound level received by the head.

CONCLUSIONS

First of all, this is a study about a quite new subject. For this reason, it is not possible to find extensive bibliography about studies similar to this. This fact have made little bit harder our work.

The sound quality is a subject which is being demanded by consumers, but it is still a subjective subject. It is not an exact science because it can occur that what a person causes annoyance for another does not or even could be pleasant. This factor could depend on the age of this person, the socio-cultural level or the origin.

The data analysis has been done taking into account the Zwicker's formulas for the pleasure and the annoyance. Studying the relation between annoyance and the other studied variables, we get that this relation is quite direct (lineal). This means that when L is higher (or dBA, or S, or R, or F), the annoyance is higher. To our knowledge, this means that the annoyance allows including all the (more or less) expected dependences within the parameters.

For us it is more interesting to prove that the pleasure does not behave in a lineal manner. In general, it is observed that a high level of dBA, or L, or S, or R implies a low pleasure. But when these values are not very high, we can see that the signal structure is important in the pleasure. This result shows that it is justified the use of the level as the main indicator in any field in acoustics. Even though, when levels are not very high, it is necessary to make a revision of the normative from the psycho-acoustic point of view.

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