How to characterize environmental noise closer to people's expectations

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ABSTRACT

The issue of resident's exposure to environmental noise is related to a minimum of two complementary approaches: acoustics, as regards of its physical characterization, and social sciences regarding exposure, perception and communication with the concerned public.

Acoucité and Bruitparif (two French organizations in charge of management and organization of urban noise observatories in France) have worked since 2011 on a proposal for a new index closer to the feeling of the population. This research is conducted within the framework of the Harmonica project funded by the European Commission (LIFE).

As a result, the data analysis of an extensive 800 person survey, complemented by 240 home interviews and 120 laboratory interviews with public, associations, politicians, technicians, and experts in acoustics, can suggest some paths to develop new indexes taking into account the continuous and eventful nature of noise while receiving a better understanding and acceptance of the general public.

This type of index could supplement the information produced by the conventional indexes and indicators (Lden, L 10 ...). This article aims to present the results obtained in the framework of these approaches developed from the urban, peri-urban and rural population in France.

Keywords: Environmental Noise, Survey, Acoustic Indexes

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1. INTRODUCTION

Acoucité, sound environment skill centre, is a non-profit organisation created in 1996 by Greater Lyon and five public research centres (IFSTTAR, CERTU, CETEs, ENTPE, and CSTB). It takes part in twelve French urban area noise policies. Bruitparif created in 2003 at the initiative of Paris-Ile de France Region, performs its missions on the territory of Ile de France region.

The two non-profit organisations joined forces to help developing other noise observatories. Their common goals have quickly led to highlight some limitations in regulatory noise indicators, particularly in communicating with general public. HARMONICA project was born from these general comments (HARMOnised Noise Information for Citizens and Authorities). This three year European project is funded by the LIFE+2010 program. Bruitparif is the project leader and Acoucité leads project actions oriented towards assessing public expectations.

This article provides an overview of the methodologies and first results of public consulting. The acoustic dimension of this project and the presentation of new indexes are discussed in a second paper presented simultaneously: INTERNOISE 2013 (At the heart of Harmonica project: the Common Noise Index (CNI) C. Ribeiro, C. Anselme, F. Mietlicki1, B. Vincent).

2. CONTEXT

The noise observatory activities carried out in close coordination with the community as well as city operational or policy services enabled to quickly identifying the limits of the regulatory acoustic indicators. Based on a principle of noise dose, they (LEQ, Lden ...) have a poor capacity to take into account parameters such as eventful and temporal fluctuations of urban soundscapes. Besides, interventions in the context of urban projects (highway projects, abatement of noise) often highlight the limits of the only-acoustic indicators to be consistent with residents' daily life.

One of the objectives of HARMONICA project is to develop an approach to propose new indexes, complementary to those existing in the regulations, but closer to people's expectations. These new index will integrate the continuous and eventful nature of noise, while remaining easy to understand. This research is based on engineering on the one hand, especially acoustics, and on the other hand on the humanities and social sciences through evaluation of social people's perceptions and expectations.

This article reviews the knowledge gained in this project through three protocols about the expectations of public information.

3. OBJECTIVES

As part of this project related to human and social sciences, four objectives are targeted:

- Assessing the current level of knowledge from the involved people (objective -1)
- Establishing a frame of reference for public expectations in terms of information (objective-2)
- Quantifying annoyance and link the values in the new index (objective-3)
- Comprehending the level of acceptance and understanding of new indexes (objective -4)

To meet these objectives, three approaches have been implemented. They focus on random representative samples of the urban, peri-urban and rural population of two areas, one located in the Paris region (about 15 million) and the other in the Lyon area (approximately 1.5 million inhabitants):

- A telephone survey by questionnaire, with 800 people (objectives 1 and 2)
- A on-site survey by questionnaire with 240 inhabitants or public space users, coupled with acoustic monitoring (objectives 3 and 4)
- An evaluation in experimental situation using binaural audio recording (objectives 3 and 4) from a panel of politicians and policy makers (40 interviews), experts in acoustics and urban planning (40 people) and general public (40 people).

4. METHODOLOGY

4.1 Telephone survey in two urban areas

This survey was conducted over two weeks in early 2012 on a sample selected by the method of quota (sex, age, socio-economic classification, and localisation) based on data provided by INSEE (National institute of statistical and economic information). 400 people were interviewed in both urban areas, 800 people in total.

4.2 On-site and laboratory survey organisation

The on-site and laboratory surveys are described below for the two territories (Lyon and Paris):

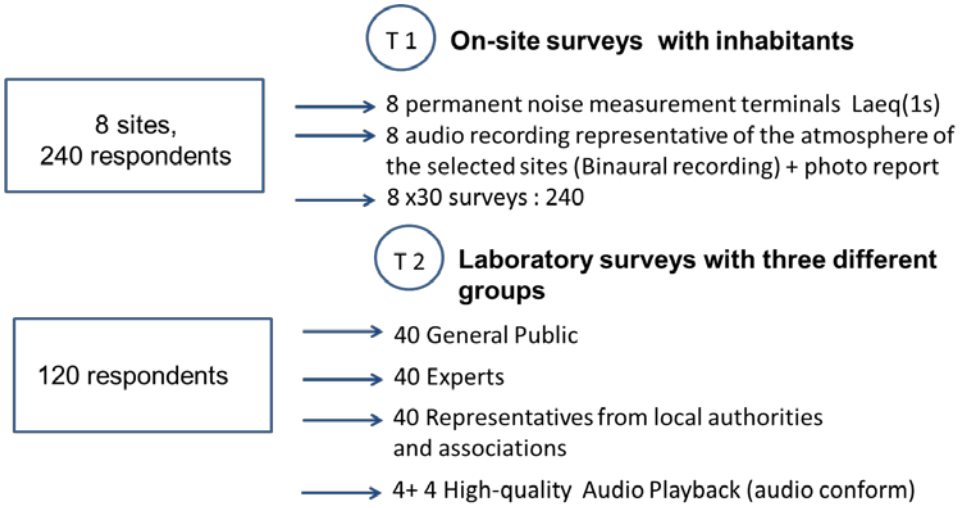

Figure 1–On-site and laboratory survey organisation

4.3 On-site survey

The interviews were conducted with residents or passers-by on four distinct sites of two areas (Lyon and Paris) (30 subjects * 2 * 4 sites territories = 240 subjects). A sex and age pseudo-Gaussian distribution was sought. The sites were selected next to continuous acoustic monitoring stations, so acoustic data can be analysed.

In the case of public spaces (parks, squares, pedestrian streets, etc.), interviews were carried out on the public domain and then the targets were passers-by. The acoustic indexes were calculated for periods when the site is usually used by pedestrians.

In other cases, the interviews were conducted in local residents' homes. The sampling was randomly done from inhabitants living close monitoring stations. The acoustic indexes were calculated for the hours when residents are home: 6 P.M-7 P.M or 7 P.M-8 P.M according to the site (Lyon and Paris agglomeration).

4.3.1 On-site survey protocol

At first, the person has to assess the perceived noisiness at home (or on the public space) and then the noise annoyance (scale from 0 to 10).

Secondly, four acoustic indexes are presented in a random order using fact sheets. For each index, there is a sound level graph, with a scale from 0 to 10 for the vertical axis. On fact sheets, the indexes are defined as simple and standardized as possible to limit the variability of judgment directly related to the definition. All those criteria were considered in fact sheets:

- The probability of using a specific word in French language
- The structures of definitions
- A review to ensure consistency
- An explaining graph
- An index value for two acoustic degraded situations (quiet / loud).

4.3.2 Description of the four indexes

For each site and during the reference periods (see 4.2), the four indexes are calculated from acoustic monitoring network data for a typical day (standard weather, representative traffic, etc.). These values were not presented in the interviews.

The correlation between noisiness and annoyance as expressed by respondents and the index values will be studied during the responses analysis[7].

The four indexes are characterized by:

- Index 1 : **background noise**, **variation of the amplitude** and **number of noise events** ;
- Index 2 : the **duration** when the noise levels do not exceed the thresholds (different for day, evening or night) ;
- Index 3 : **average noise level**, **background noise**, **number and duration of the quiet moments**, **noise level of the noisiest events** ;
- Index 4: **average noise level**, particularly taking into account the loudest noises.

4.3.3 Example of the description of one index

This example is based on index 3.

This index is made from four characteristics:

- *Average noise level*
- *Background noise, meaning the noise apart special events*
- *Number and duration of the quiet moments*
- *Noise level of the noisiest events, for example when a plane, a car or a train is passing by.*

Thus:

- *If the average noise level is low, that there are many quiet moments and the sound level of individual events is low, then the index is good (close to 0) ;*
- *If the average noise level is high, that there are few quiet moments and the sound level of individual events is high, then the index is bad (close to 10).*

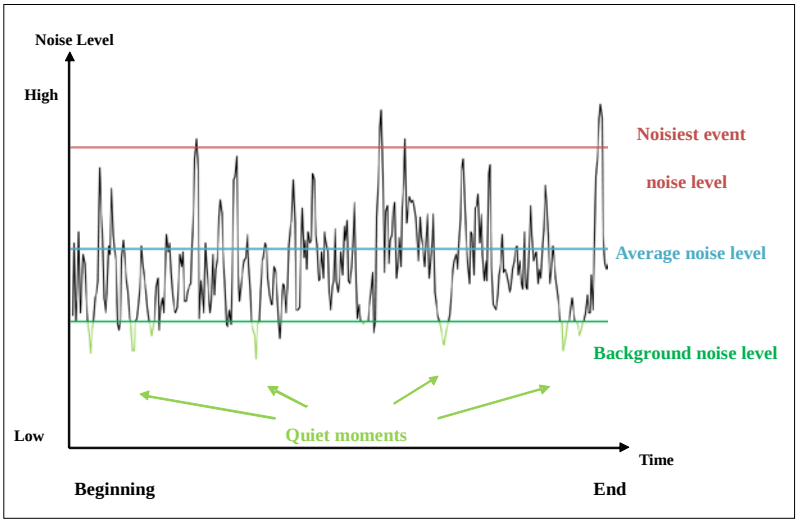

Figure 2 – Index explaining graph

For each site (Lyon and Paris urban areas), the acoustic indexes are calculated for their reference period (see 3.3) and a binaural recording has been done. These values were not presented during the interviews.

[7] Internoise 2013 At the heart of Harmonica project: the Common Noise Index (CNI)
C. Ribeiro, C. Anselme, F. Mietlicki1, B. Vincent.

4.4 Experimental approach, interviews in laboratory

The interviews were conducted face to face with 60 people for each of the two areas (120 people):

- 20 experts: acousticians, researchers, operating engineers (urban planning, architects, landscape architects, urban ecology ...)
- 20 elected representatives of the community of citizens, members of neighbourhood committees, heads of associations ...
- 20 members of the general public, randomly sampled, regardless of their exposure to noise.

The individual interviews were indifferently conducted either in volunteers' home or any other place that can guarantee:

- An absence of external disturbance during the survey;
- The presence of only one respondent with the operator;
- The furniture settings in coherence with the experimental requirements (silence, comfort)

The indexes will be calculated according the period of sound recording.

4.4.1 Experimental protocol

The term "experimental" is used since people are not surveyed on their own space and they will not have to give an answer based on their own experience, but according to an engineered soundscape (binaural listening with headphones).

This method is easily reproducible in situations where it is necessary to bring people to a job of listening (for example a local authority for a meeting with local residents as part of an urban project...).

Regarding the sound recording protocol, each team (Acoucité and Bruitparif) made four sound recordings from its territory. Restitution was audio-compliant and binaural. 60 people listened to the four recordings on both territories. These people were asked to make a judgment on four acoustic indexes (3 new indexes + 1 reference), thus generating a total of 1,800 responses.

4.4.2 Conduct of the experimental protocol

First of all, a sound montage is presented to the participants to illustrate the diversity of eight selected sound environments and familiarize them with the headphones. The sound montage is made of short recordings played in random order.

The experiment itself has four recordings entirely played in a random order. They have duration from 2 to 5 minutes depending on the variability of situations and specificities of the acoustic soundscapes. There are at least two sound events by audio for discontinuous environments (rail and air).

Photographs of sound recording places were taken and associated to the presentation of the played samples. The photos are the most neutral possible (light cloud cover, neutral passers action ...). A brief description of acoustic and urban context was displayed.

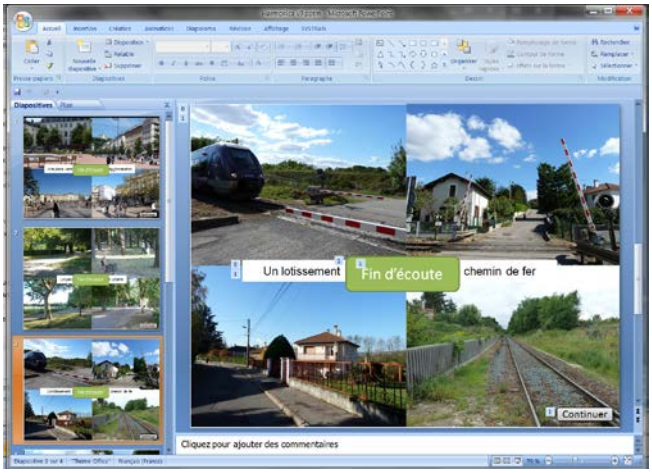

Figure 3 – binaural listening site presentation

At the end of each sequence, the perceived noisiness and potential annoyance are graded on a scale of 0 to 10. Once the 4 sequences of listening are done, 4 acoustic indexes are presented with their fact sheet in random order (a LAeq rescaled on 10 levels + 3 new indexes). After reading the explanation of an index card, people are invited to comment on their understanding of the index and its ability as an index to report their perception of the sound environment.

5. MAIN RESULTS

5.1 Results of the telephone survey on 800 persons.

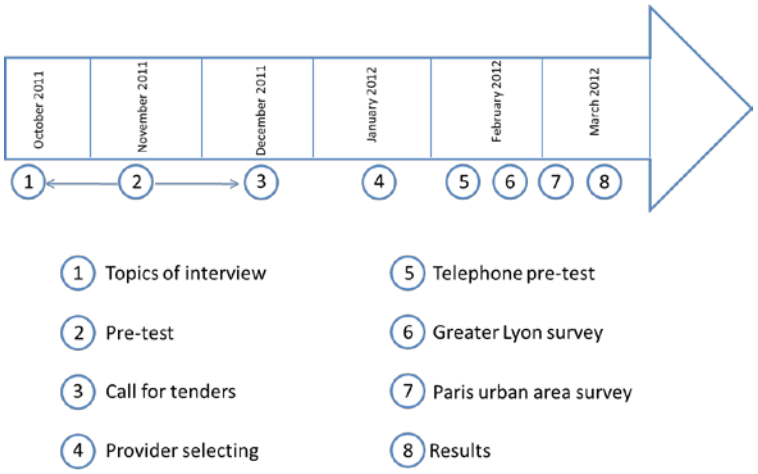

Figure 4 – Survey Chronology

The average duration of the general questionnaire was 12 minutes. It includes 25 questions mostly "closed". The sample was made according to the method of quotas in terms of sex, age and socio-professional category after stratifying by sectors according to population densities (Hyper-centre, first and second rings). The main results of the telephone survey are presented for all respondents (n = 800).

1) Knowledge about Decibel

Table 1- What unit is used for the intensity of the sound?

Others	2,4
Decibel	56,3
Do not know	40,7
Watt	0,6
Total	100,0

More than half of respondents spontaneously mentioned the decibel as a unit for the intensity of sound.

2) Knowledge of methods for assessing noise

Table 2 - In your opinion, what are the methods used by experts to evaluate the noise?

Measurement or recording	70,7
Surveys (questionnaires, interviews, statistical analysis)	3,0
Calculation (topographic data, traffic data)	1,1

Only the acoustic measurement is known to the general public. This result illustrates the need for complementarity between the values provided by the 2002/49/EC noise maps and the values provided by an acoustic monitoring network or measurement campaigns.

3) Public expectations by type of indexes (distribution of responses on three proposals)

Table 3 - For measuring noise exposure of a home, should we rather...

(Do not know)	8,7
Measure the average noise level?	36,3
Measure the number of noise peaks?	23,6
Measure the exposure time to a certain level of noise?	31,3

Over a third of respondents associate a measure of noise exposure at a "dose" (average noise level, average exposure time).

However, 55% of respondents are pending for indexes based on "peaks" or time of exposure exceeding a certain level. The logic of indexes based on a consideration of sound events will therefore complement and not replace the one based on the quantification of dose over a period (LAeq logic).

4) The effects of noise perceived by respondents ("open" question, multiple answers possible)

Table 4 – In your opinion, what are the adverse effects of noise exposure (% / multiple answers)?

Effects on hearing (tinnitus, deafness)	52,4
Effects in terms of discomfort, deterioration in the quality of life, inconvenience	12,0
Effects on sleep (fatigue)	32,6
Effects on behaviour (stress, nervousness, irritability)	65,5
Effects on communication and understanding (discussion television)	1,6
Effects on general health (heart reference)	25,0
Others	0,4

On spontaneous quotes, two-thirds of respondents associate the effects of noise on the behaviour to stress, for one-third to the effects on sleep, and a quarter to overall health. The effects associated by respondents are more behavioural, physiological and somatic.

In many works, the term discomfort is often used to evaluate the overall impact of noise although the term discomfort is very rarely mentioned spontaneously. When the concept of discomfort is proposed and evaluated on a scale, respondents are most likely to rate their discomfort taking account of the overall effects (behavioural, somatic ...) they associate with noise.

5) Expectations in terms of information

To the question "*would you like more information about the acoustic environment of your home*" 26% of respondents expressed an expectation in terms of information.

6) Organisations that could communicate over the noise

Table 5 – Who do you trust the most to inform you about the sound environment?

The State	3,1
Administrative areas or departments	3,2
Local council, local authorities	**11,4**
Private organisations specialized on noise	5,7
Public organizations (associations) specialized on noise	**13,5**

Concerning providing of information on noise exposure, local authorities and associations are the two sources of information most frequently mentioned.

7) The personal involvement in measures for noise reduction.

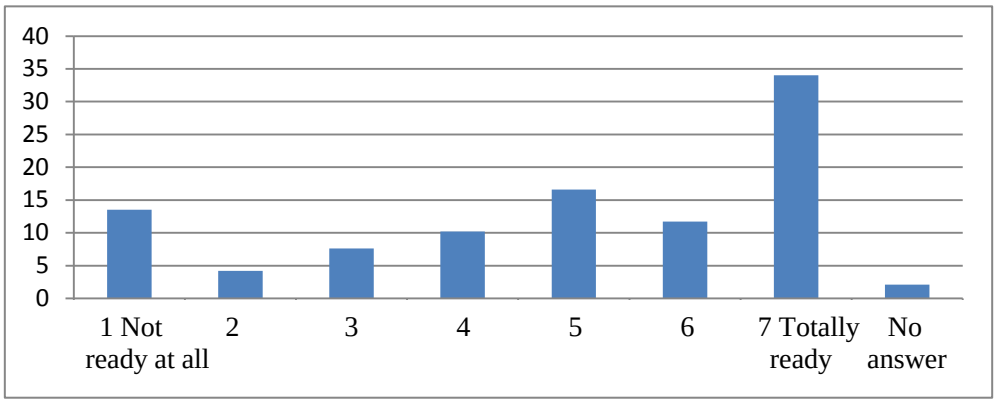

Figure 5 – Are you ready for banning individual vehicles from city centres (with adjustments such as relay parks, transportation networks reinforced)?

To reduce their exposure to noise, a very strong support in principle to measures usually considered difficult to implement is observed in this survey.

8) Summary of main results of the telephone survey

This telephone survey highlights the following key points:

- The road noise is the main noise source for about one third of the inhabitants ;
- Knowledge in acoustics (measurement methods, noise levels, regulation ...) of respondents are very fragmented ;
- Information on noise level index based on emergence would provide a good complement to those based on a dose ;
- The effects of noise spontaneously reported by respondents are stress, hearing, sleep and general health ;
- A quarter of the population (mostly people declaring themselves as impacted by noise) expect information spread primarily by specialized associations or by local authorities ;
- Finally, it is interesting to note that almost three quarters of respondents are not opposed to efforts to implement traffic restrictions or changes in travel behaviours ;

Within HARMONICA project, a website will present the implementation of new indexes on ten urban sites in late 2013 (news on http://www.harmonica-project.eu/en). A survey will be available in early 2014 to people who would visit the website in order to compare the results with those obtained in 2012.

5.2 Results of the on-site survey on 8 sites, 240 interviews

Table 6 - Dominant noise sources identified within different urban configurations

	Nothing	Air	Road	Rail	Other	Total
Total	89	**58**	**56**	**36**	7	246

The results show diversity in the perception of soundscapes for the eight different urban configurations. This diversity will allow exploring the relevance of new indexes according to the variety of soundscapes.

Tableau 8 – Understanding of the indexes (n=246)

	No answer	Not at all	Not really	Quite yes	Absolutely Yes
Understanding IND-1	0,8	2,8	8,9	43,9	43,5
Understanding IND-2		5,3	8,9	31,3	54,5
Understanding IND-3	0,4	1,6	13,4	35,8	48,8
Understanding IND-4 (LAeq)		1,6	6,9	31,7	59,8

After presenting the four indexes, the rate of understanding varies from 85% to 92.5%. Although the LEQ (index4) has the best score of understanding, no index can be excluded because of its non-understanding to the public.

Table 9 – Feeling (n=246)

	No answer	Not at all	Not really	Quite yes	Yes absolutely
Close to feeling IND-1	0,8	4,5	15,0	38,6	41,1
Close to feeling IND-2		13,4	17,5	34,6	34,6
Close to feeling IND-3	0,4	6,1	12,6	34,1	46,7
Close to feeling IND-4 (LAeq)	0,4	13,0	24,4	32,1	30,1

Similarly, the differences between the indexes (ability to reflect the respondents feeling) were insignificant.

- Only LAeq (Index 4) collects less than 63% of favourable responses.
- Index 2 collects 70% positive reviews.
- Indexes 1 and 3 collect more than 80% positive reviews.

Tableau 10 – Favourite index, only one answer possible (n=246)

	Frequency
No answer	9,8%
Index 1	25,2%
Index 2	17,9%
Index 3	35,8%
Index 4	11,4%

Indexes 1 and 3 have collected the highest rates of preference.

Considering these results, for their understanding, for their ability to reflect the individual feeling, and for the preference of respondents, indexes 1 and 3 appear to be the two most appropriate indexes to meet the objectives (easy to understand and good ability to take into account noise index perception).

5.3 Results of the experimental approach, 131 binaural hearings in laboratory

Table 11 – Interview durations

Less than ¾ hour	70 %
From 3/4 hour to an hour	27%
More than an hour	3 %

The duration of the survey varies from 30 minutes to an hour and fifteen minutes.

Tableau 12 – Index perception (N= 13)

	IND-1		IND-2		IND-3		IND-4	
	Understanding	Close to feeling	Understanding	Close to feeling	Understanding	Close to feeling	Understanding	Close to feeling
No answer	0,8%	0,8%	0,8%	0,8%	0,8%	0,8%	0,8%	1,5%
Not at all		1,5%		10,8%	0,8%	2,3%	1,5%	33,8%
Not really	10,0%	15,4%	5,4%	33,1%	12,3%	17,7%	6,9%	46,2%
Quite yes	37,7%	37,7%	37,7%	43,1%	42,3%	42,3%	19,2%	16,2%
Yes absolutely	51,5%	44,6%	56,2%	12,3%	43,8%	36,9%	71,5%	2,3%

We observe, in consistence with the results obtained for the on-site survey:

- A very good understanding of the LAeq (IND-4) but a low ability to account for the acoustic feeling ;
- A very good understanding of the three other indexes, including the index 2 ;
- A better ability of the indexes 1 and 3 to account for the acoustic feeling.

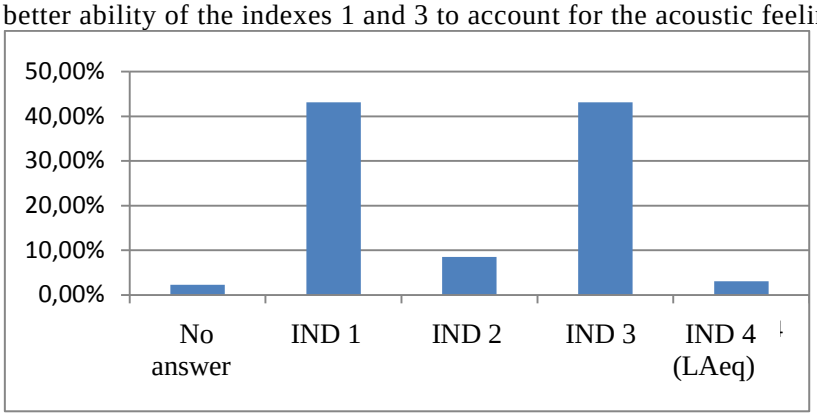

Figure 6 – Favourite index.

At the end of the protocol, it was proposed to respondents to take all fact sheets and designate their preferred index. Indexes 1 and 3 obtained the best rates.

6. CONCLUSIONS

The results of the three methods (telephone survey, on-site survey and experimental approach) provide complementary and coherent knowledgeable elements.

It is clear that the public's expectations in terms of information is high (it affects about 50% of people sensitive to noise in their homes, or about 15% of the total population).

These results also show that local authorities and independent organisations have an important role to play.

In addition, it is important to note a very high expectation for indexes that would better reflect temporal variations in noise levels, in addition to conventional indicators based on “dose”.

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