

## Comparison of annoyance response measured with ICBEN 5-point verbal and 11-point numerical scales in Japanese and Vietnamese

Thulan Nguyen<sup>1</sup>, Takashi Yano<sup>2</sup>, Takashi Morihara<sup>3</sup>, Shigenori Yokoshima<sup>4</sup>, Makoto Morinaga<sup>5</sup>

<sup>1</sup> Shimane University, Interdisciplinary Faculty of Science and Engineering, Shimane, Japan (corresponding author)

<sup>2</sup> Kumamoto University, Graduate School of Science and Technology, Kumamoto, Japan

<sup>3</sup> Ishikawa National College of Technology, Department of Architecture, Ishikawa, Japan

<sup>4</sup> Kanagawa Environmental Research Center, Kanagawa, Japan

<sup>5</sup> Defense Facilities Environment Improvement Association, Tokyo, Japan

Corresponding author's e-mail address: lan@riko.shimane-u.ac.jp

### ABSTRACT

This study examined the correspondence between the 5-point verbal and the 11-point numerical scales proposed by ICBEN (International Commission on Biological Effects of Noise) using the dataset of 15 social surveys on environmental noises conducted in Japan and Vietnam. In these surveys, the noise annoyance was measured using the both scales following ICBEN recommendation. In Japanese, the top category of the 5-point and the 11-point scales was found to correspond primarily to the top category of the 11-point and the 5-point scales, respectively. However, in Vietnamese, the top category of the 5-point and the 11-point scales corresponded to the top two categories of the 11-point and the 5-point scales, respectively. The logistic regression curves with the high annoyance defined by the top three categories of the 11-point numerical scale were found to have a good fit with the quadratic curves with the high annoyance defined by a cutoff point of 28% as recommended by Miedema and Vos, but separated from the logistic regression curves with the high annoyance defined by the top two categories of the 5-point verbal scale.

Keywords: ICBEN 5-point verbal annoyance scale, 11-point numerical annoyance scale, % highly annoyed, exposure-response relationships

### INTRODUCTION

Since firstly proposed by Schultz [1] in 1978, the percentage of the population who are “highly annoyed” has been the most widely accepted as an index of community response to noise. Schultz recommended to define the percentage of those who selected either of the top two categories of the 7-point annoyance scale (top 29%) and top three categories of the 11-point annoyance scale (top 27%) as % highly annoyed. However, noise surveys have been conducted using scales other than the 7-point and the 11-point scales as in Schultz’s study.

The use of various scales made the evaluation and comparison of community response to noise among different studies difficult. Miedema and Vos [2] addressed this problem and proposed a transformation of various scales to a 0 to 100 basis regardless of the number of points in the scale and the use of top 28% cut-off point as %highly annoyed.

In addition, Team 6 of the International Commission on Biological Effects of Noise (ICBEN) [3] developed a 5-point verbal and an 11-point numerical scales as well as a corresponding multi-linguistic question as international standardized measures of noise annoyance. Though Team 6 proposed to use both of these scales in socio-acoustic surveys, in general only either of these scales have been used. For example, only the 5-point scale was included in a fundamental questionnaire items for social survey on noise proposed by the Acoustical Society of Japan [4]. Meanwhile, only the 11-point numerical scale was used in noise surveys conducted in Korea [5]. Comparing the correspondence between ICBEN 5-point and 11-point scales and the annoyance response measured by the scales is necessary to accurately evaluate the exposure-response relationships obtained in various surveys serving the discussions of global noise policies

A recent study by Brink et al. [6] discussed the frequency distribution of responses measured by the ICBEN 11-point scale corresponding to the 5-point scale and vice versa. It was found that the frequency distributions of the upper two categories (very, extremely) of the 5-point scale on the highest categories "10" of the 11-point scale are almost the same. This study applied the analysis method of Brink et al. to the survey data in Japan and Vietnam and examined the correspondence between the ICBEN 5-point and 11-point scales. This study aims to investigate the relationship between the ICBEN scales in Japanese and Vietnamese surveys, to compare the exposure-response relationships corresponding to each scale, and to provide materials for the discussion of global noise policies

**DATASET FOR ANALYSIS**

We analyzed a total of 15 data sets including data obtained from seven socio-acoustic surveys in Japan and eight surveys in Vietnam (Table 1). The survey data in Japan includes data on aircraft, road traffic, conventional railway and shinkansen noise annoyance, and the Vietnamese survey data includes data on aircraft and road traffic noise annoyance. Since the railway operation and facility situation in Vietnam is greatly different from Japan and EU countries, railway noise data is not used for this study.

In these surveys, community responses to various noise sources were evaluated by using both the 5-point verbal and the 11-point numerical scales constructed by ICBEN Team 6. Table 2 shows the 5-point verbal scales in English, German, Japanese and Vietnamese and the intensity scores of each category. The question wordings are shown as follows:

A. Verbal annoyance question:  
Thinking about the last 12 months or so, when you are here at home, how much does road traffic noise bother, disturb, or annoy you?

	1	2	3	4	5
	Not at all	Slightly	Moderately	Very	Extremely
Road traffic noise	( )	( )	( )	( )	( )

B. Numeric annoyance question:

Thinking about the last 12 months or so, what number from 0 to 10 best shows how much you are bothered, disturbed, or annoyed by road traffic noise?

0	1	2	3	4	5	6	7	8	9	10
Not at all					Extremely					
Vietnamese: Hoan toan khong					Vietnamese: Cuc ky					
Japanese: Mattaku...nai					Japanese: Hijoni					

**Table 1:** Dataset used for analysis in this study

Noise source	Survey region	Year	No. of responses
<b>Japan</b>			
Aircraft	Kumamoto	2006	412
Road traffic	Ishikawa	2007	580
Railway	Hokkaido	2001	462
	Kyushu	2002	388
	Kyushu	2007	802
Shinkansen	Hokkaido	2003	715
	Nagano	2013	293
<b>Vietnam</b>			
Aircraft	Ho Chi Minh	2008	876
	Hanoi	2009	815
	Da Nang	2011	527
Road traffic	Hanoi	2006	1495
	Ho Chi Minh	2007	1467
	Da Nang	2011	489
	Hue	2012	687
	Thai Nguyen	2013	793

**Table 2:** The 5-point verbal scale in English, German, Japanese and Vietnamese

No.	Language	Intensity score	No.	Language	Intensity score
<b>English</b>			<b>Japanese</b>		
1	Not at all	0.6	1	Mattaku...nai	1.0
2	Slightly	16.3	2	Sorehodo...nai	21.0
3	Moderately	48.1	3	Taisho	44.5
4	Very	78.4	4	Daibu	75.2
5	Extremely	96.9	5	Hijoni	93.8
<b>German</b>			<b>Vietnamese</b>		
1	iiberhaupt nicht	0.48	1	Hoan toan khong	2.9
2	Etwas	18.61	2	Mot phan nao	25.3
3	Mittelmassig	47.84	3	Khong qua muc	55.1
4	Stark	76.20	4	Nhieu	84.2
5	Ausserst	90.74	5	Cuc ky	96.7

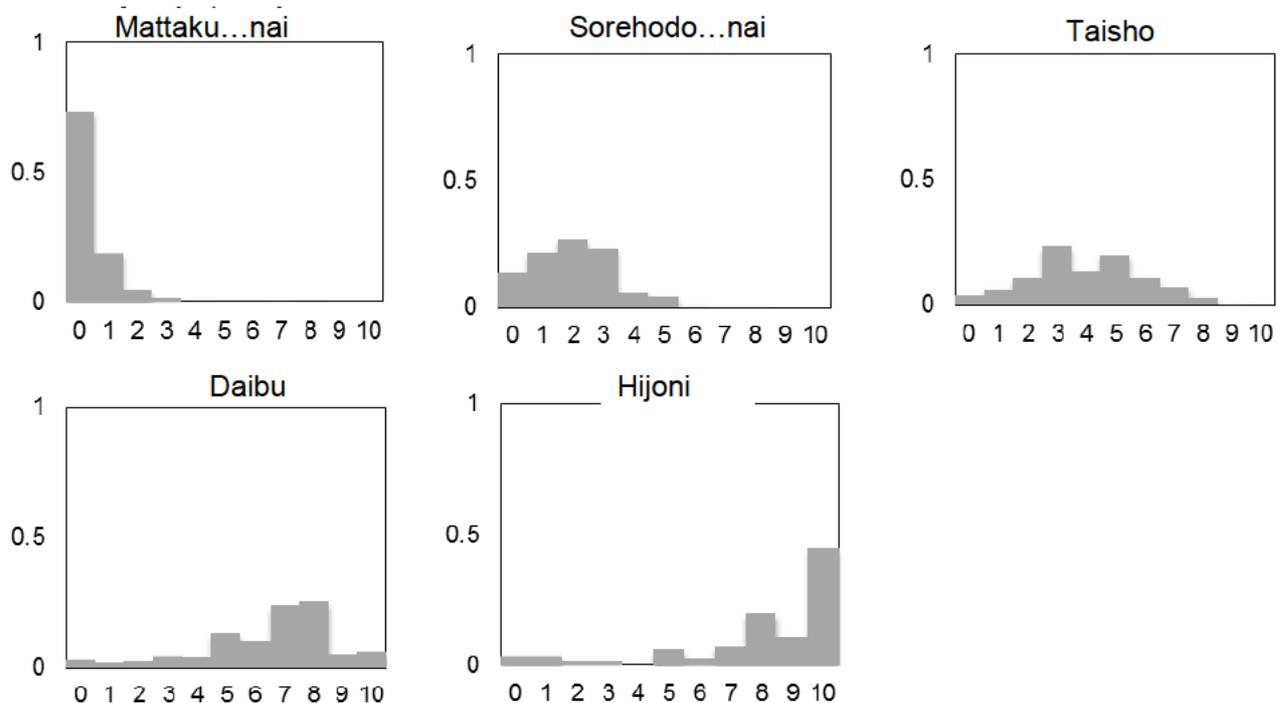
## RESULTS

### The correspondence between ICBEN 5-point verbal and 11-point numerical scales

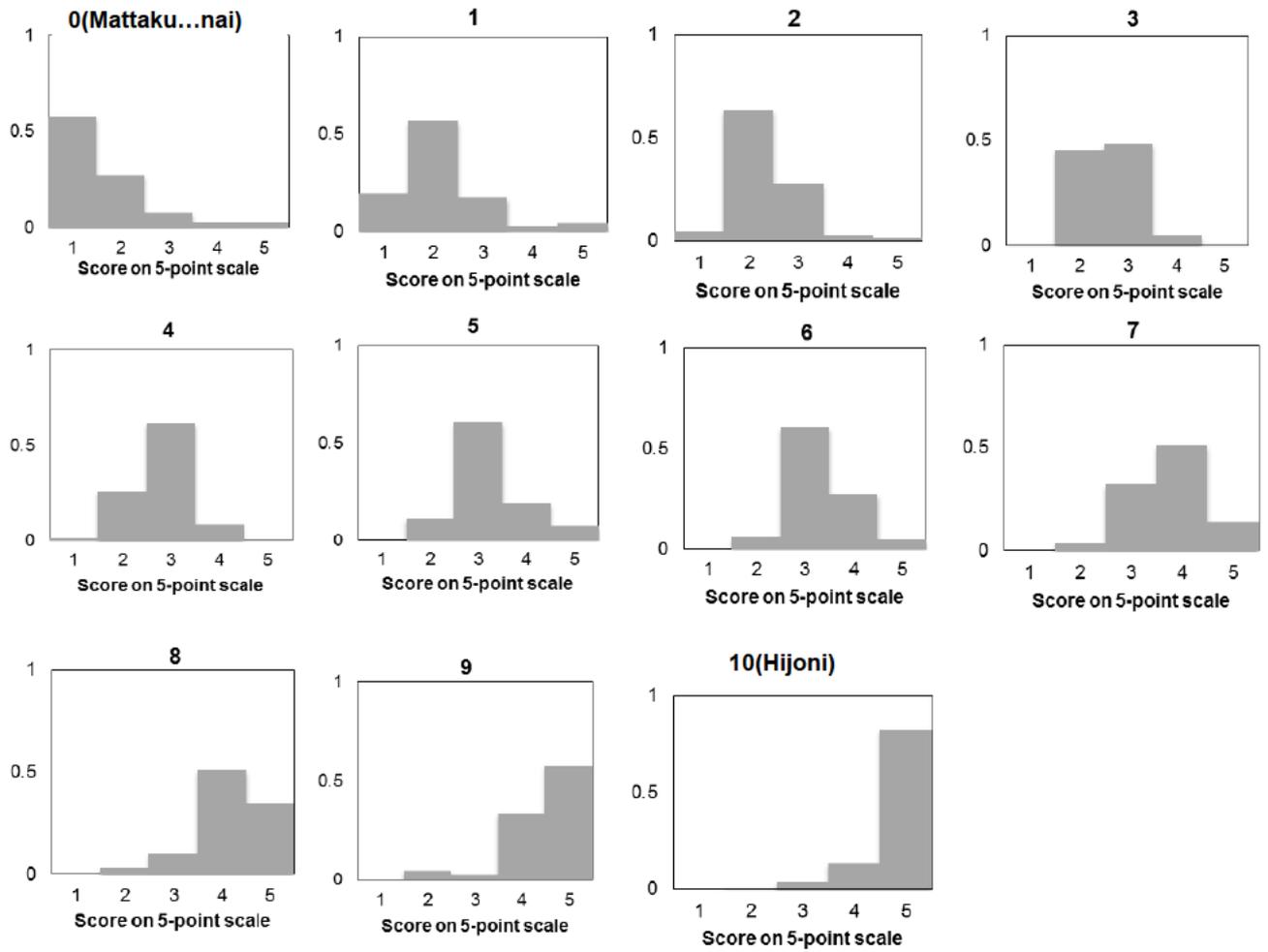
Figures 1 and 2 show the frequencies of responses corresponding to each category of the 11-point scale allocated to each category of the five-point scale and vice versa in Japanese, respectively. Figures 3 and 4 show those in Vietnamese. In the Japanese survey, the scale point 4 is assigned to categories 7 and 8 on the 11-point scale most frequently. However, in Vietnamese survey data, the scale point 4 is assigned to categories 5, 6, 7, 8, 9 on the 11-point scale frequently. In other word, the intensity of Category 4 of the Vietnamese verbal scale ranges widely.

Regarding the correspondence between the categories of the 5-point verbal scales and the top category "10" of the 11-point scale, the frequency distribution of the top category of the 5-point scale "hijoni" are significantly higher than the second upper categories "daibu" in Japanese. In Vietnamese, the frequency of the second category is slightly less than the top. In other words, the distribution pattern of the categories of the 5-point scale in Vietnamese is located in between the German and Japanese scales.

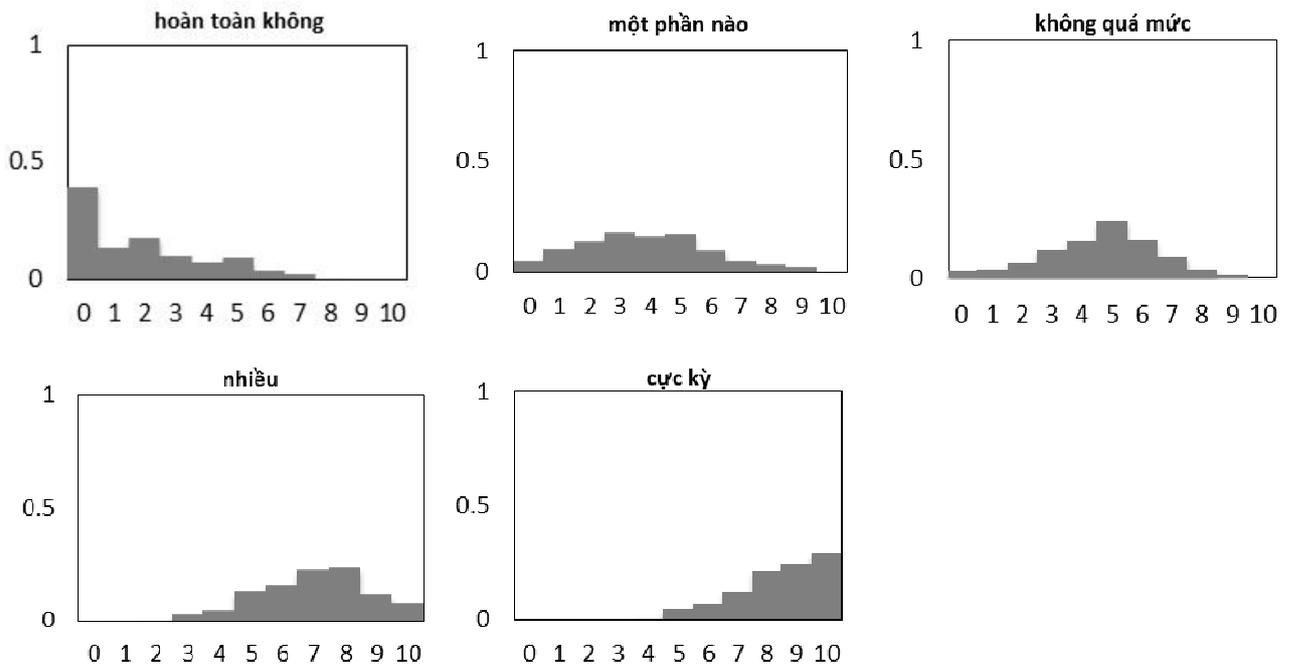
This result seems to be influenced by the intensity score of the top and second categories of the 5-point verbal scale of the three languages. The intensity score of the top category of German scale is 90.74, which is smaller than other languages (English: 94.85, Japanese: 93.84, Vietnamese: 96.69) and may be probably perceived equivalent to the second category. The intensity score of the second category of Vietnamese scale is 85.21, higher than that in other languages (English: 75.62, Japanese: 75.26, German: 76.20), therefore corresponded to the highest score "10" of the 11-point scale and also assigned to the other categories at high frequencies (Figure 4).



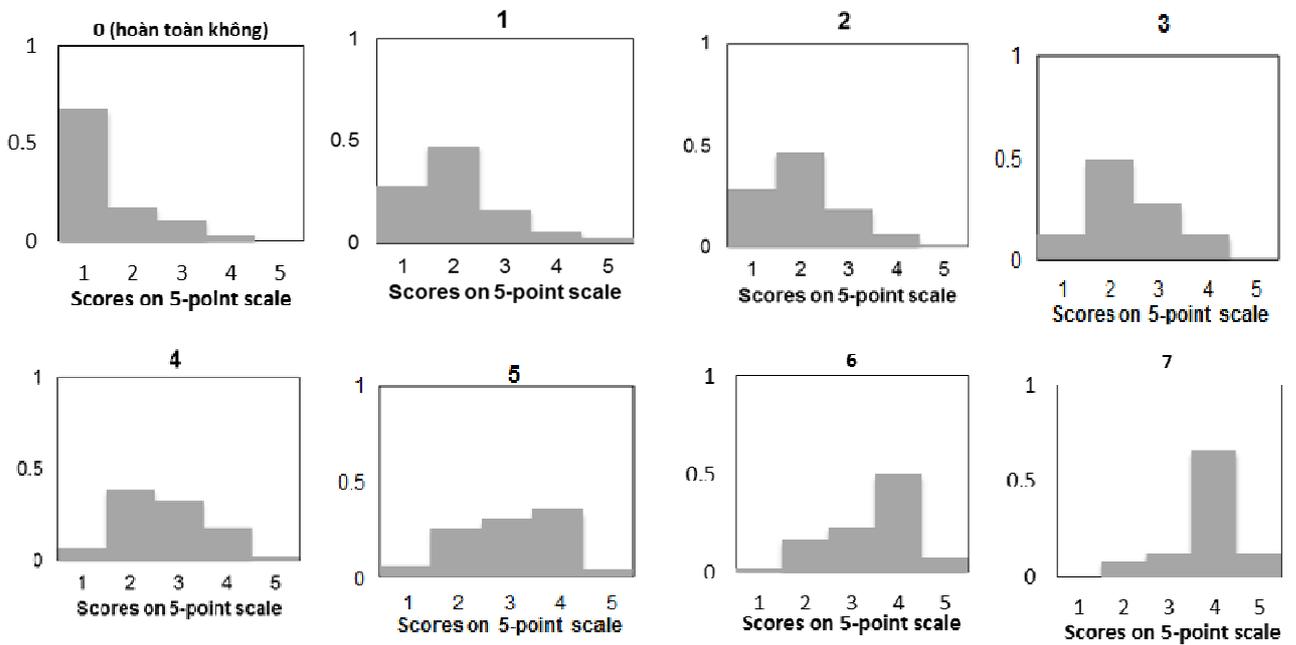
**Figure 1:** The frequency distributions of the chosen alternatives corresponding to each category of the 5-point scale on the 11-point scale using data of the surveys in Japan

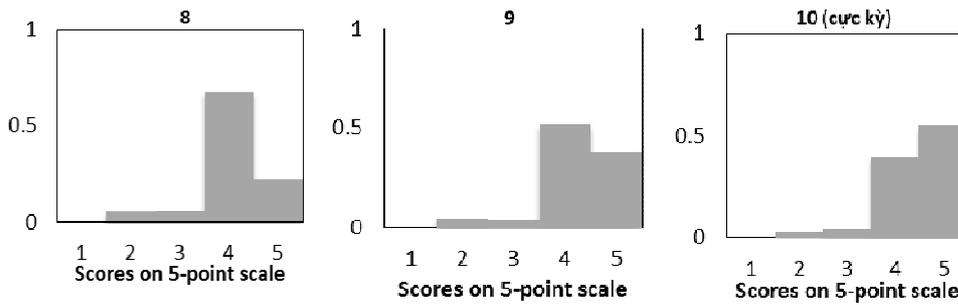


**Figure 2:** The frequency distributions of the chosen alternatives corresponding to each category of the 11-point scale on the 5-point scale using data of the surveys in Japan



**Figure 3:** The frequency distributions of the chosen alternatives corresponding to each category of the 5-point scale on the 11-point scale using data of the surveys in Vietnam





**Figure 4:** The frequency distributions of the chosen alternatives corresponding to each category of the 11-point scale on the 5-point scale using data of the surveys in Vietnam

### Comparisons of exposure-response relationships

Using the above ICBEN 5-point verbal scale and the 11-point numerical scale, the exposure-response relationship was formulated in the following two ways:

#### (1) Quadratic function

Miedema and Vos [2] calculate the percentage of highly annoyed using a cutoff point of 28% by counting the frequency to the top two categories (very, extremely) of the 5-point scale but weighing 0.4 to "very". According to the method of Miedema and Vos, % HA defined by ICBEN's 5-point verbal scale is expressed by the following quadratic equations:

Exposure-response relationship for each noise source in Japan:

Aircraft:

$$y = 0.016(L_{den}-30) + 0.067(L_{den}-30)^2 \quad (1)$$

Road traffic:

$$y = -0.186(L_{den}-40) + 0.046(L_{den}-40)^2 \quad (2)$$

Railway:

$$y = 0.071(L_{den}-30) + 0.035(L_{den}-30)^2 \quad (3)$$

Shinkansen:

$$y = 0.254(L_{den}-40) + 0.239(L_{den}-40)^2 \quad (4)$$

Exposure-response relationship for each noise source in Vietnam:

Aircraft:

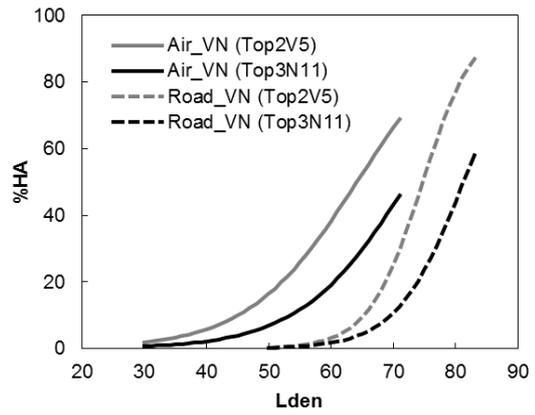
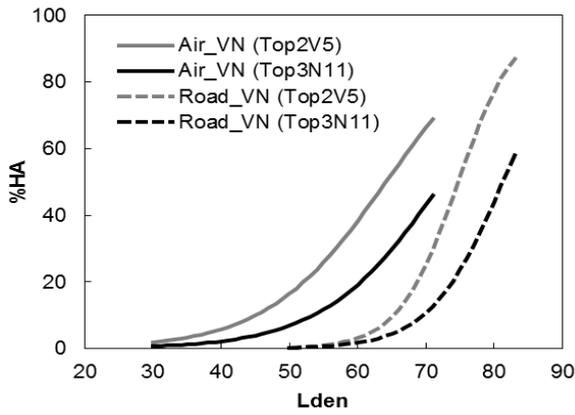
$$y = -0.044(L_{den}-30) + 0.023(L_{den}-30)^2 \quad (5)$$

Road traffic

$$y = 0.762(L_{den}-60) + 0.068(L_{den}-60)^2 \quad (6)$$

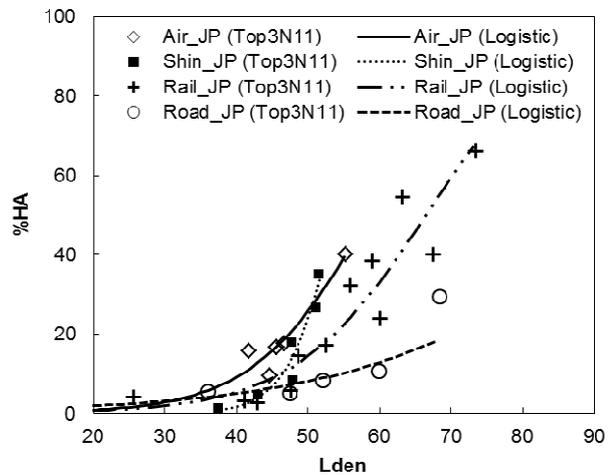
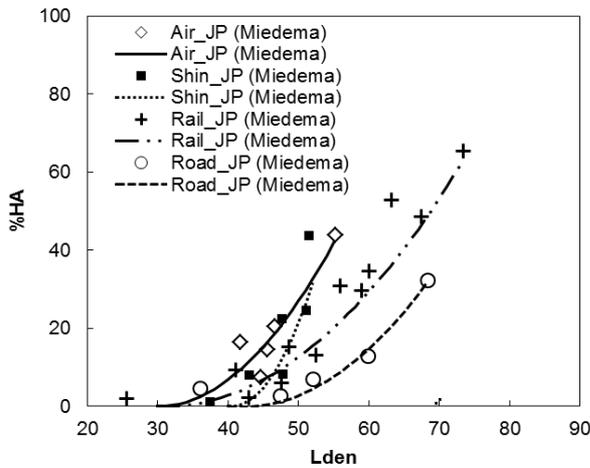
#### (2) Logistic function:

The top three categories (top 27%) of the 11-point numerical scale proposed by ICBEN as % highly annoyed.



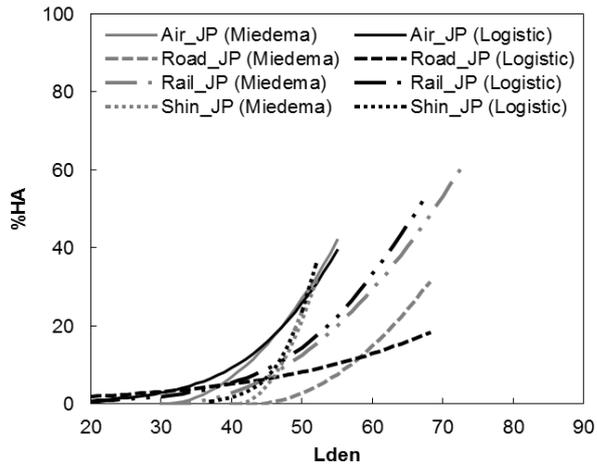
Figures 5 and 6 show the exposure-response relationships for environmental noises in Japan as a function of quadratic and logistic regression functions, respectively. Figure 7 compares the relationships obtained by the two functions. Figures 8 and 9 show the exposure response relationship for aircraft and road traffic noises in Vietnam by quadratic and logistic functions, respectively. Figure 10 compares the relationships by the two functions in Vietnam. In all cases, the logistic curves are almost coincident to the quadratic curves. This result indicates practically no difference in the models.

Figures 11 and 12 compare the logistic regression curves with % HA defined by the top 27% of the 11-point numerical scale as described above and top two categories (top 40%) of the 5-point scale as proposed by Fields et al [3]. The result indicates that the curves with % Highly annoyed defined by the top two categories of the 5-point scale (top 40%) are located much higher than those with % highly annoy defined by top 27-29% of the annoyance scale..

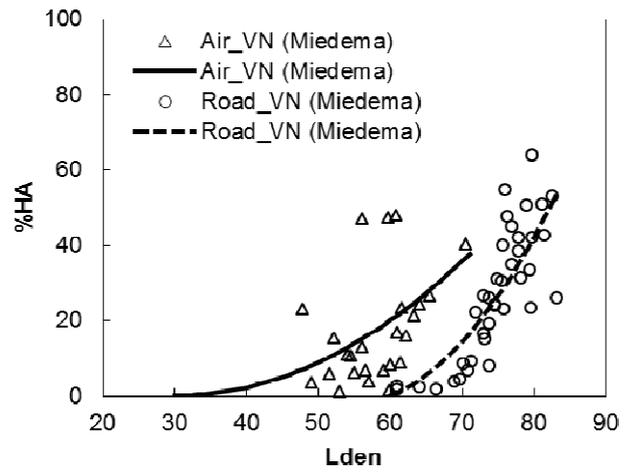


**Figure 5:** The exposure-response relationships obtained by a quadratic function with %HA defined by top 28% of the 5-point verbal scale for Japanese surveys

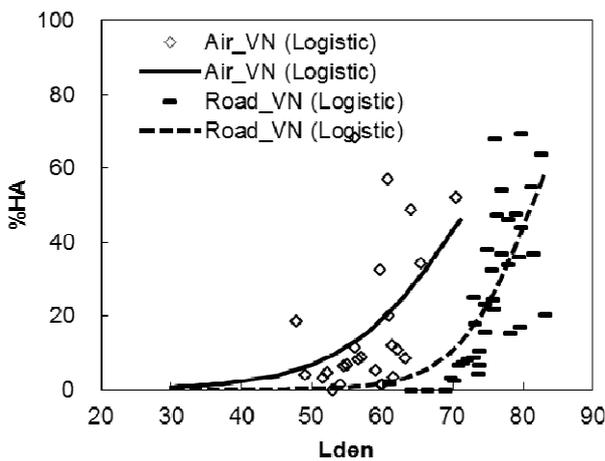
**Figure 6:** The exposure-response relationships obtained by a logistic regression function with %HA defined by top three categories of the 11-point numerical scale for Japanese surveys



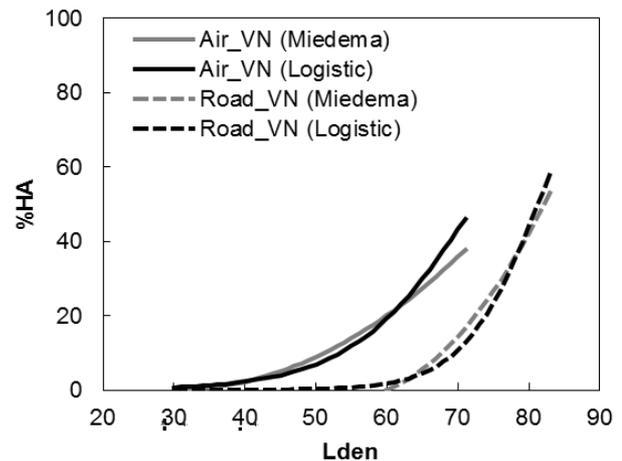
**Figure 7:** Comparison of the exposure-response relationships obtained by quadratic and logistics regression functions for Japanese surveys



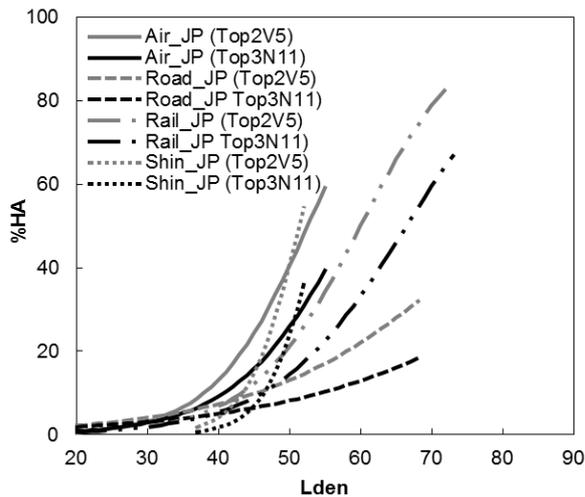
**Figure 8:** The exposure-response relationships obtained by a quadratic function with %HA defined by top 28% of the 5-point numerical scale for Vietnamese surveys



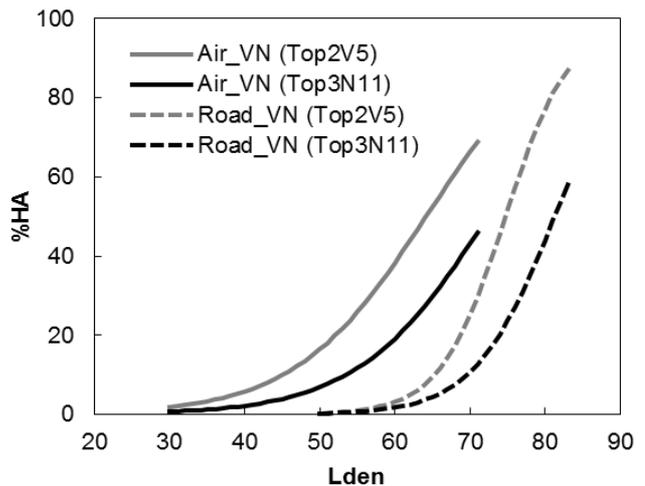
**Figure 9:** The exposure-response relationships obtained by a logistic regression function with %HA defined by top three categories of the 11-point numerical scale for Vietnamese surveys



**Figure 10:** Comparison of the exposure-response relationships obtained by quadratic and logistics regression functions for Vietnamese surveys



**Figure 11:** Comparison of exposure-response relationships obtained by a logistic regression function with %HA defined by top three categories of the 11-point numerical scale and top two categories of the 5-point verbal scale for Japanese surveys



**Figure 12:** Comparison of exposure-response relationships obtained by a logistic regression function with %HA defined by top three categories of the 11-point numerical scale and top two categories of the 5-point verbal scale for Vietnamese surveys

## CONCLUSION

The correspondence between each category of the 5-point verbal and the 11-point numerical scales proposed by ICBEN was examined using the data of 15 social surveys on transportation noises in Japan and Vietnam. In Japanese, the top category of the 11-point and the 5-point scales was found to correspond primarily to the top category of the 5-point scale and the 11-point scale, respectively. However, in Vietnamese, the top category of the 5-point and the 11-point scales corresponded to the top two categories of the 11-point and the 5-point scales, respectively. The exposure-response relationships obtained by the logistic regression function with the high annoyance defined by the top three categories of the 11-point scale fit well to the quadratic curves proposed by Miedema and Vos, but located separately lower than the logistic regression relationships with high annoyance defined by the top two categories of the 5-point scale.

## Acknowledgements

This study was financially supported by Grant-in-Aid for Scientific Research (C) by Japan Society for Promotion of Science (No. 26420585). The authors appreciate the contributions to the surveys and field measurement of all lecturers and students of the universities in Hanoi, Ho Chi Minh City, Da Nang, Hue and Thai Nguyen.

## REFERENCES

- [1] T.J.Schultz, "Synthesis of social surveys on noise annoyance," *J.Acoust. Soc. Am.*, 64(2), 377-405 (1978).
- [2] H.M.E. Miedema and H.Vos, Exposure-response relationship for transportation noise, *J. Acoust. Soc. Am.*, 104 (6), 3432-344 (1998).
- [3] J.M. Fields et al., Standardized general-purpose noise response questions for community noise surveys: Research and a recommendation, *J. Sound Vib.*, 242(4), 641-679 (2001).

- [4] S.Namba et al., Proposal of fundamental items for social survey on noise problems, Report from research committee, *Acoust. Sci&Tech.* 31, 2 (2010).
- [5] C. Lim et al., Effect of background noise levels on community annoyance from aircraft noise, *J. Acoust. Soc. Am.*, 123(2), 766-771 (2008)
- [6] M. Brink et al., Effects of Scale, Question Location, Order of Response Alternatives, and Season on Self-Reported Noise Annoyance Using ICBEN Scales: A Field Experiment, *Int. J. Environ. Res. Public Health* 2016, 13.