

PAPER

Annoyance caused by road traffic noise with and without horn sounds

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(*Received 11 June 2008, Accepted for publication 12 February 2009*)

Abstract: The road traffic noise in Hanoi is characterized by a large number of motorbikes emitting frequent horn sounds. In order to cross-culturally investigate the effects of horn sounds on annoyance caused by road traffic noise, psychoacoustic experiments were conducted in Hanoi, Vietnam and Kumamoto, Japan. The annoyance caused by 12 types of road traffic noise with and without horn sounds was evaluated using two noise annoyance scales: an 11-point numeric scale and a 5-point verbal scale. The conditions and procedures of the experiments were the same in Hanoi and Kumamoto. The main findings are as follows: (1) the Vietnamese subjects were less affected by horn sounds than were the Japanese subjects; (2) the Japanese subjects were more annoyed by road traffic noise with horn sounds than that without horn sounds; (3) the Japanese subjects were generally more annoyed by road traffic noise than the Vietnamese subjects; and (4) differences between the characteristics of road traffic noise in Japan and Vietnam affected the annoyance of the Japanese subjects.

Keywords: Horn sound, Road traffic noise, Annoyance, Cross-culture

PACS number: 43.50.Qp [doi:10.1250/ast.30.327]

1. INTRODUCTION

Although a number of social surveys on community responses to environmental noise and psychoacoustic experiments have been carried out in Europe, the United States, and Japan [1–6], few social surveys have been conducted in other Asian countries. In Southeast Asia, apart from the social surveys previously conducted by the present authors in Thailand and Vietnam [7–9], no other systematic socio-acoustic surveys have been carried out.

Vietnam is a developing country in Southeast Asia, whose environment is being seriously affected by urbanization and industrialization. Together with the deterioration of infrastructure in big cities such as Hanoi (the capital city, northern Vietnam) and Ho Chi Minh (southern Vietnam), road traffic has become chaotic, with an increasing number of motorbikes and excessive horn use throughout the day. However, despite the potential adverse effects of noise on the public, Vietnam still does not have a practical noise policy.

In order to investigate the characteristics of road traffic noise in Vietnam, a socio-acoustic survey on community responses to road traffic noise was conducted in Hanoi in September 2005. The results from the initial analysis showed that the average day-night sound level (L_{dn}) was high and ranged from 74 to 83 dB and that the road traffic noise in Hanoi was characterized by a large number of motorbikes emitting frequent horn sounds [8]. It was noted that it is important to carefully measure the effects of horn sounds in order to provide a reliable data source for the establishment of a practical noise policy in Vietnam.

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Therefore, this study aims to systematically examine the effect of road traffic noise with horn sounds on noise annoyance. Moreover, the reactions to road traffic noise were compared cross-culturally between Japanese and Vietnamese subjects.

2. PSYCHOACOUSTIC EXPERIMENT

2.1. Test Sounds

2.1.1. Sound types

Twelve types of test sounds at three noise levels and four horn sound frequencies were used.

- Horn sound frequency:
  – Road traffic noise in Japan without horn sounds (RTNJ)
  – Road traffic noise in Hanoi without horn sounds (RTN0)
  – Road traffic noise in Hanoi with 12 noticeable horn sounds (RTN12)
  – Road traffic noise in Hanoi with 51 noticeable horn sounds (RTN51)
- Sound level ($L_{\mathrm{Aeq,\,35s}}$): 55, 65, and 75 (dB)
- Duration: Each test sound was played for 35 s including 2.5 s of fade-in and 2.5 s of fade-out.

The road traffic noises in Japan (RTNJ) at 75 and 65 dB were obtained from a CD made for professional use [10] and were recorded at distances of 5 and 25 m from a road shoulder. In order to create RTNJ at 55 dB, the 75 dB noise was decreased by 20 dB through a "house filter" as shown in Fig. 1. The house filter is based on the differences between indoor and outdoor sound pressure levels produced by a typical Japanese house window in real-life conditions [11].

The road traffic noise in Hanoi was recorded in September 2005 at a distance of 12 m from a road shoulder. RTN0, RTN12, and RTN51 at 75 dB were taken from parts of the noise recording with no, few, and many horn sounds, respectively. In order to make the test sounds at 65 dB, the road traffic noise in Hanoi was decreased by 10 dB by adjusting the volume of an amplifier. The house filter was used again to reduce the noise level of the recorded sounds at 75 dB by 20 dB in order to create the test sounds at 55 dB.

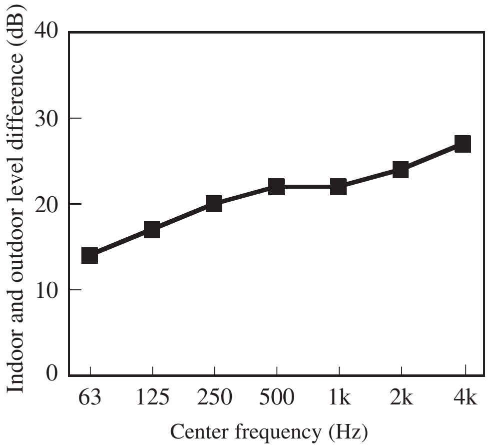
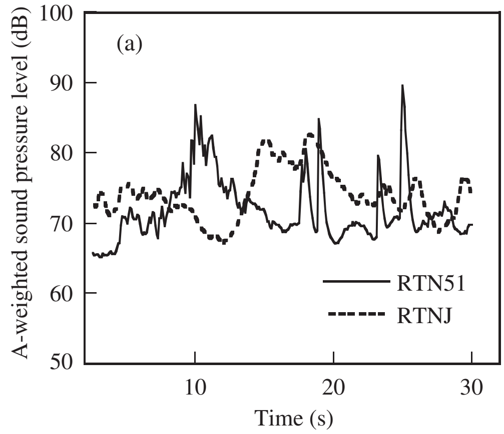
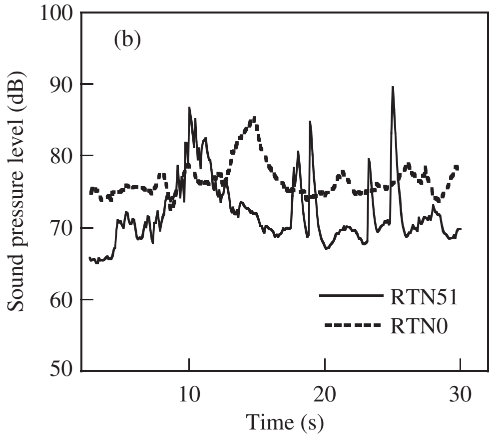


Fig. 1 Frequency characteristics of house filter.



(a) Road traffic noise in Japan without horn sounds (RTNJ) and road traffic noise in Hanoi with 51 horn sounds (RTN51) at 75 dB $L_{\mathrm{Aeq,\,35s}}$.



(b) Road traffic noise in Hanoi without horn sounds (RTN0) and road traffic noise in Hanoi with 51 horn sounds (RTN51) at 75dB $L_{\mathrm{Aeq,\,35s}}$.

Fig. 2 Fluctuation patterns of sound level.

2.1.2. Characteristics of test sounds

The sound level fluctuations of RTN51 compared with RTNJ and RTN0 at 75 dB $L_{\mathrm{Aeq,\,35s}}$ are presented in Figs. 2(a) and 2(b), respectively. In both figures, the sharp peaks in the solid curves correspond to the horn sounds. The relative cumulative frequency curves of noise level for RTNJ, RTN0, and RTN51 can be seen in Fig. 3. RTN51 exhibits a wide distribution, ranging from 42 to 92 dB, while RTNJ and RTN0 have narrower distributions, ranging approximately from 45 to 85 dB.

The result of a 1/3-octave-band frequency analysis of RTN51 at 75 dB $L_{\mathrm{Aeq,\,35s}}$ is presented in Fig. 4. The thicker line with filled symbols denotes the result reproduced in an anechoic room at Kumamoto University, and the thin line with open symbols indicates the result obtained from a

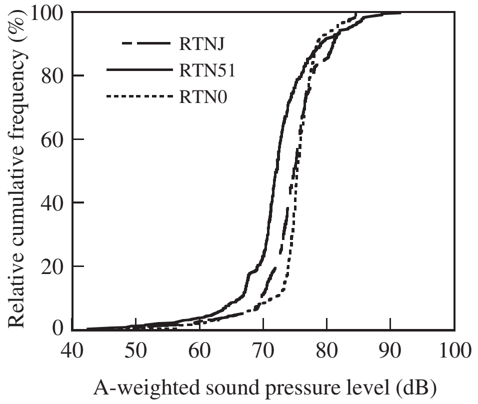


Fig. 3 Relative cumulative frequency curves of noise level of RTNJ, RTN0, and RTN51 at 75 dB $L_{\mathrm{Aeq,\,35s}}$.

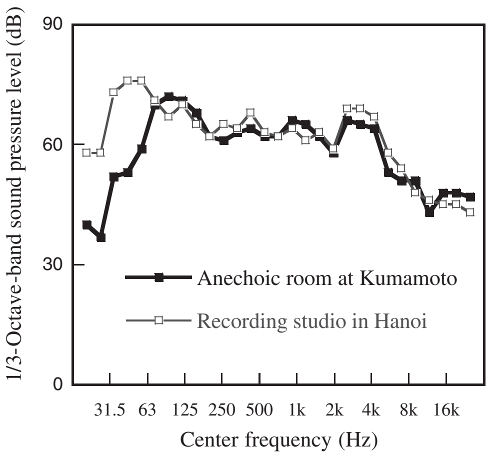


Fig. 4 Frequency analysis of test sound RTN51 at 75 dB $L_{\mathrm{Aeq,\,35s}}$.

(1) English	(2) Japanese	(3) Vietnamese
Not at all	Mattaku...nai	Hoan toan khong
Slightly	Sorehodo...nai	Mot phan nao
Moderately	Tasho	Khong qua
Very	Daibu	On nhieu
Extremely	Hijoni	Cuc on

Fig. 5 5-point verbal scale in English, Japanese, and Vietnamese.

Not at all										Extremely
0	1	2	3	4	5	6	7	8	9	10

Fig. 6 11-point numeric scale.

recording studio in Hanoi. The main components of the horn sounds can be seen clearly in the frequency range of 2–4 kHz. Even though these results correspond well in the middle- and high-frequency ranges, in the low-frequency range, the result of RTN51 reproduced in the recording studio in Hanoi is higher due to resonance.

2.2. Setting of Facilities

An anechoic room was used for the experiment at Kumamoto University. The dimensions of the room were 4.8 m × 5.4 m × 4.5 m. In Hanoi, a recording studio with dimensions of 3.98 m × 3.86 m × 2.83 m was used. The resonance frequency of the first axial mode is from 43 to 60 Hz. The test sounds were reproduced using a CD player, amplified, and then played back from a loudspeaker. The loudspeaker was set up adjacent to a wall, and the subjects sat 3 m away from the loudspeaker.

2.3. Subjects

In Kumamoto, the subjects were 30 Japanese students (15 males and 15 females) aged 18–24 years. In Hanoi, the subjects were 30 Vietnamese students (15 males and 15 females) aged 20–24 years. Both subject groups had self-reported normal thresholds of hearing.

An error was identified in the results of one Japanese subject and another of one Vietnamese subject. Therefore, the analysis is based on only the results of 29 Japanese and 29 Vietnamese subjects.

2.4. Experimental Procedure

In both locations, the experiment was conducted with three subjects entering the test room at the same time. Each subject was given a set of instructions outlining the purpose and procedures of the experiment. The subjects were seated at the assigned spots, and they were told to take their time and imagine that they were relaxing at horn after school or work.

The experiment included three sessions: annoyance evaluation using an 11-point numeric scale or a 5-point verbal scale (session 1), annoyance evaluation using the other scale to that used in session 1 (session 2), and semantic differential (SD) evaluation using 13 pairs of antonymous adjectives (session 3). There was a 5 min pause between sessions 2 and 3. However, the results from the SD evaluation will only be mentioned in Sect. 3.2 to explain the difference in the annoyance scores between the numeric and verbal scales. The 5-point verbal scale and 11-point numeric scale were constructed in Japanese and Vietnamese in accordance with the ICBEN method [12–14]. Figure 5 shows the 5-point verbal scale in English, Japanese, and Vietnamese, and Fig. 6 shows the 11-point numeric scale.

In sessions 1 and 2, the subjects were asked to evaluate the noise annoyance twice for each of the 12 types of test sounds by using the 5-point verbal scale and 11-point numeric scale. The test sounds were presented randomly. The order of the numeric scale and verbal scale was switched for every three subjects, whereby the order effect was cancelled.

When the experiment was completed, the subjects were asked to provide their age and gender and to answer the following questions:

- Are you annoyed by road traffic noise at home at present?
- Have you ever been annoyed by road traffic noise at home?
- Are you sensitive to noise?
- Do you frequently use a motorbike or car?
- Do you think motorbikes and cars are safe?
- Do you frequently use the horn while driving a vehicle?
- Are horn sounds necessary for safety?
- Do you have any comments on the road traffic situation and/or road traffic noise and on this experiment?

The total duration of the experiment was 45 min.

3. RESULTS

3.1. Mean Annoyance Scores Evaluated by Two Scales for Japanese and Vietnamese Subjects

The mean values of the noise annoyance scores evaluated using the numeric scale by the Japanese and Vietnamese subjects are displayed in Figs. 7 and 8, respectively. The Wilcoxon signed-rank test was applied to test the difference in annoyance scores between every pair of sounds at each noise level as shown in Tables 1(a) and 1(b).

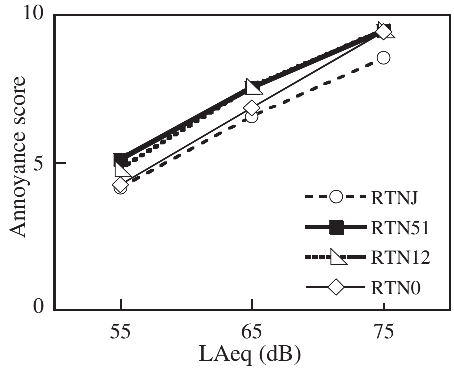


Fig. 7 Noise annoyance evaluated by Japanese subjects using the numeric scale.

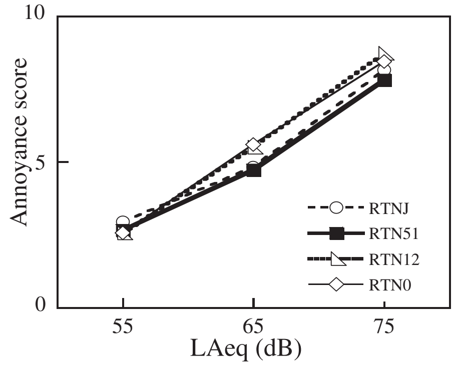


Fig. 8 Noise annoyance evaluated by Vietnamese subjects using the numeric scale.

In Fig. 7, it is shown that the noise annoyance scores of Japanese subjects for RTN12 and RTN51 were almost the same in that they remained as the most annoying sounds among all the test sounds at all noise levels. The Wilcoxon signed-rank test also showed no significant difference between RTN12 and RTN51 at any noise level. No significant difference was observed between RTNJ and RTN0, from the Wilcoxon signed-rank test at 55 and 65 dB. However, at 75 dB, RTN0 was evaluated to be as annoying as RTN12 and RTN51, while RTNJ continued to be the least annoying sound. There were no significant differences between RTN0 and RTN51 or between RTN0 and RTN12 at 75 dB, but there were significant differences between RTNJ and RTN0 ($p < 0.01$), between RTNJ and RTN12 ($p < 0.01$), and between RTNJ and RTN51 ($p < 0.001$) at 75 dB. The Japanese subjects were more annoyed by the Vietnamese noises than by the Japanese ones.

In Fig. 8, it is indicated that the trend of annoyance exhibited by the Vietnamese subjects was slightly different from that of the Japanese subjects. At 55 dB, the noise annoyance scores for all test sounds were almost the same. The results obtained from the Wilcoxon signed-rank test also indicated that there was no significant difference among any of the test sounds. At 65 dB, the annoyance scores for RTNJ was almost the same as that for RTN51; however, it was lower than those for RTN12 and RTN0. The Wilcoxon signed-rank test showed that the annoyance scores were not significantly different between RTNJ and RTN51. However, significant differences were found between RTNJ and RTN0 ($p < 0.01$), between RTNJ and RTN12 ($p < 0.01$), between RTN0 and RTN51 ($p < 0.001$), and between RTN12 and RTN51 ($p < 0.001$). At 75 dB, the annoyance caused by RTNJ was almost the same as that by RTN51, and both of these were less annoying than RTN12 and RTN0. According to the Wilcoxon signed-rank test, no significant difference was found between RTNJ and RTN51. However, significant differences were found between RTNJ and RTN12 ($p < 0.05$), between RTN0 and RTN51 ($p < 0.001$), and between RTN12 and RTN51 ($p < 0.001$).

The mean noise annoyance scores of the Japanese and Vietnamese subjects evaluated by the verbal scale are shown in Figs. 9 and 10, respectively. The Wilcoxon signed-rank test was also applied to test the difference in annoyance response between every pair of test sounds at each noise level as shown in Tables 2(a) and 2(b).

As shown in Fig. 9, the Japanese subjects evaluated, using the verbal scale, RTN12 and RTN51 to be the most

Table 1 (a) Result of Wilcoxon signed-rank test using the numeric scale for Japanese subjects. (b) Result of Wilcoxon signed-rank test using the numeric scale for Vietnamese subjects.

(a)

	RTNJ × RTN0	RTNJ × RTN12	RTNJ × RTN51	RTN0 × RTN12	RTN0 × RTN51	RTN12 × RTN51
55 dB	—	**	**	*	*	—
65 dB	—	**	*	**	*	—
75 dB	**	**	***	—	—	—

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

(b)

	RTNJ × RTN0	RTNJ × RTN12	RTNJ × RTN51	RTN0 × RTN12	RTN0 × RTN51	RTN12 × RTN51
55 dB	—	—	—	—	—	—
65 dB	**	**	—	—	***	***
75 dB	—	*	—	—	***	***

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

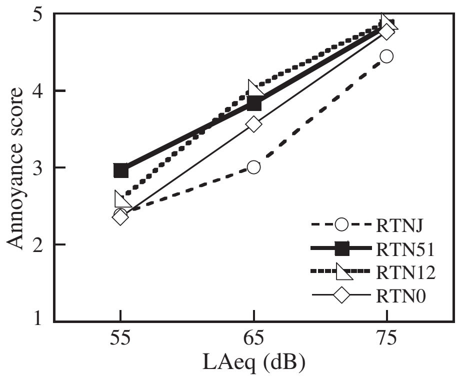


Fig. 9 Noise annoyance evaluated by Japanese subjects using the verbal scale.

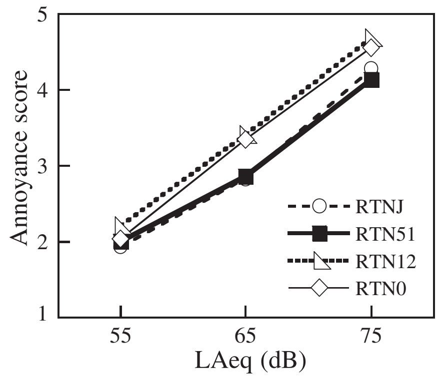


Fig. 10 Noise annoyance evaluated by Vietnamese subjects using the verbal scale.

annoying sounds and RTNJ to be the least annoying sound. Thus, the trend obtained was similar to that shown in Fig. 7. However, the annoyance was not significantly different between RTNJ and RTN12 at 55 dB, which is indicated in Table 2(a) but not in Table 1(a). Moreover, while RTN0 was evaluated to be as annoying as RTNJ at 55 and 65 dB as shown in Fig. 7, RTN0 was more annoying than RTNJ at 65 dB in Fig. 9. Table 2(a) indicates that the annoyance scores were significantly different between RTNJ and RTN0 at 65 dB. In Fig. 10, a trend similar to that in Fig. 8 can be seen.

3.2. Difference in Annoyance Evaluated by Numeric and Verbal Scales

The differences found in the annoyance evaluations of the Japanese subjects using the numeric and verbal scales can be observed more clearly in Fig. 11. Here, the annoyance values of the Japanese subjects for RTNJ, RTN0, and RTN12 at 55 dB, and for RTNJ at 65 dB differed between the two scales and were distributed above the equivalence line. On the other hand, the annoyance values of the Vietnamese subjects presented in Fig. 12 were generally distributed closer to the equivalence line. The possible reasons for such differences found among the Japanese subjects are the large dispersion of the annoyance scores at lower noise levels and the large standard deviation of the intensity score for the middle-category modifiers.

The standard deviations of the annoyance scores of the Japanese subjects based on the numeric and verbal scales are shown in Tables 3(a) and 3(b), respectively. In both tables, it is indicated that the dispersion of annoyance scores based on both scales was large at 55 and 65 dB. However, the standard deviations of the annoyance scores of the Vietnamese subjects based on the two scales displayed in Tables 4(a) and 4(b) are smaller than those of the Japanese subjects, particularly at 55 and 65 dB.

The standard deviations of the intensity score for the modifiers in Japanese and Vietnamese languages are also presented in Tables 5(a) and 5(b), respectively. In general, the intensity score for the middle-category modifiers as above of the verbal scale shows large deviations. In

Table 2 (a) Result of Wilcoxon signed-rank test using the verbal scale for Japanese subjects. (b) Result of Wilcoxon signed-rank test using the verbal scale for Vietnamese subjects.

(a)

	RTNJ × RTN0	RTNJ × RTN12	RTNJ × RTN51	RTN0 × RTN12	RTN0 × RTN51	RTN12 × RTN51
55 dB	—	—	**	—	***	—
65 dB	**	***	***	**	*	—
75 dB	**	**	**	—	—	—

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

(b)

	RTNJ × RTN0	RTNJ × RTN12	RTNJ × RTN51	RTN0 × RTN12	RTN0 × RTN51	RTN12 × RTN51
55 dB	—	—	—	—	—	—
65 dB	**	**	—	—	***	***
75 dB	*	**	—	—	**	***

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

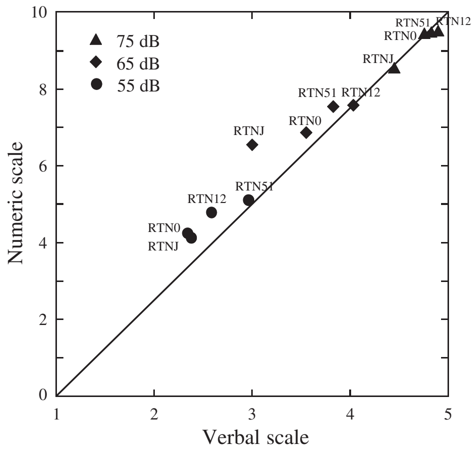


Fig. 11 Correlation between annoyance values obtained from the verbal and numeric scales for Japanese subjects.

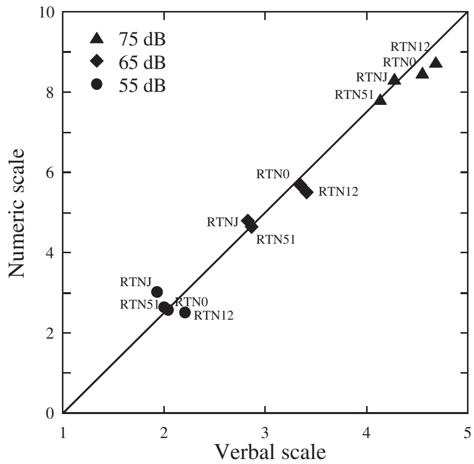


Fig. 12 Correlation between annoyance values obtained from the verbal and numeric scales for Vietnamese subjects.

particular, the modifier "Tasho" (representing category "3" in the ICBEN standardized Japanese language verbal scale [15]) has the largest standard deviation, which possibly the evaluation of annoyance at a medium noise level.

At a high noise level, the noise evaluation is mainly affected by the noise level regardless of the scale used. On the other hand, at low and medium noise levels, the Japanese subjects tend to be more tolerant in their annoyance evaluation of noises with no or few horn sounds when the Japanese verbal scale is used. This may be due to the Japanese subjects' familiarity with such noise because they generally live in a sound environment with no or few horn sounds. In addition, the linguistic characteristics of the Japanese modifiers in terms of their ambiguity in meaning, particularly for the middle-category modifiers as below may have also caused the difference. Considering these two factors, the large dispersion of the annoyance scores at lower levels and the large deviation of the intensity score for middle-category modifiers resulted in a tendency that the Japanese subjects were more tolerant to the noises at lower levels. Nevertheless, such as an effect of being used to the noises that were taken from a familiar environment was not found among the Vietnamese subjects. On the basis of the current data, because no further explanation can be given to clarify the cause of such cultural differences, more scientific theories are needed from future research.

3.3. Comparison of Annoyance Scores of Test Sounds With and Without Horn Sounds between Japanese and Vietnamese Subjects

In this section, the noise annoyance scores for two pairs of test sounds, RTN51 and RTN0 together with RTNJ and RTN51, are compared between the Japanese and Vietnamese subjects. The annoyance scores for RTN51 and RTN0

Table 3 (a) Mean and standard deviation of annoyance scores based on the numeric scale for Japanese subjects ($n = 29$). (b) Mean and standard deviation of annoyance scores based on the verbal scale for Japanese subjects ($n = 29$).

(a)

	55 dB		65 dB		75 dB	
	Mean score	Standard deviation	Mean score	Standard deviation	Mean score	Standard deviation
RTNJ	4.13	1.88	6.55	2.12	8.55	1.47
RTN0	4.24	1.90	6.86	1.99	9.44	0.96
RTN12	4.79	1.68	7.58	1.73	9.51	0.85
RTN51	5.10	1.66	7.55	1.40	9.48	0.72

(b)

	55 dB		65 dB		75 dB	
	Mean score	Standard deviation	Mean score	Standard deviation	Mean score	Standard deviation
RTNJ	2.37	0.76	3.00	1.11	4.44	0.67
RTN0	2.34	0.76	3.55	0.77	4.75	0.30
RTN12	2.58	1.03	4.03	0.76	4.89	0.30
RTN51	2.96	0.67	3.82	0.83	4.82	0.38

Table 4 (a) Mean and standard deviation of annoyance scores based on the numeric scale for Vietnamese subjects ($n = 29$). (b) Mean and standard deviation of annoyance scores based on the verbal scale for Vietnamese subjects ($n = 29$).

(a)

	55 dB		65 dB		75 dB	
	Mean score	Standard deviation	Mean score	Standard deviation	Mean score	Standard deviation
RTNJ	3.03	1.56	4.79	1.70	8.34	1.12
RTN0	2.58	1.27	5.68	1.72	8.48	1.00
RTN12	2.51	1.16	5.51	1.56	8.75	0.77
RTN51	2.65	1.53	4.65	1.64	7.82	1.39

(b)

	55 dB		65 dB		75 dB	
	Mean score	Standard deviation	Mean score	Standard deviation	Mean score	Standard deviation
RTNJ	1.93	0.83	2.83	0.75	4.28	0.69
RTN0	2.03	0.81	3.34	0.54	4.55	0.50
RTN12	2.21	0.66	3.41	0.72	4.69	0.46
RTN51	2.00	0.53	2.86	0.68	4.14	0.68

are compared in order to identify the difference in the annoyance caused by road traffic noise with and without horn sounds in Hanoi between the Japanese and Vietnamese subjects. In other words, annoyance scores for RTN51 and RTN0 are compared in order to investigate the effects of horn sounds on the annoyance. The comparison of annoyance scores for RTNJ and RTN51 was performed in order to measure the differences between Japanese road traffic noise and current Vietnamese road traffic noise and to measure the differences in the annoyance response. With the process of development, the traffic situation in Vietnam is gradually changing, and the traffic is expected to change from being dominated by motorbikes to being dominated by car in the future. Therefore, this comparison was designed to identify the possible changes in noise annoyance for Vietnamese citizens. The Wilcoxon rank-sum test was applied to test the difference between the Japanese and Vietnamese subjects in their annoyance response to the three sounds at each noise level, as shown in Tables 6(a) and 6(b).

Table 5 (a) Mean and standard deviation of intensity score for modifiers in Japanese language ($n = 1{,}102$). (b) Mean and standard deviation of intensity score for modifiers in Vietnamese language ($n = 200$).

(a)

Modifier	Mattaku. . .nai	Sorehodo. . .nai	Tasho	Daibu	Hijoni
Mean score	1.0	21.0	44.5	75.2	93.8
Standard deviation	2.6	13.0	17.8	13.2	9.4

(b)

Modifier	Hoan toan khong (HT)	Mot phan nao (PN)	Khong qua (KQ)	On nhieu (ON)	Cuc on (CO)
Mean score	2.9	24.6	44.8	85.2	96.6
Standard deviation	9.4	12.1	16.0	10.8	11.6

Table 6 (a) Result of Wilcoxon rank-sum test using the numeric scale to evaluate difference between Japanese and Vietnamese. (b) Result of Wilcoxon rank-sum test using the verbal scale to evaluate difference between Japanese and Vietnamese.

(a)

	RTNJ	RTN0	RTN12	RTN51
55 dB	*	**	***	***
65 dB	***	*	***	***
75 dB	—	***	***	***

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

(b)

	RTNJ	RTN0	RTN12	RTN51
55 dB	*	—	—	***
65 dB	—	—	*	***
75 dB	—	—	—	***

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

3.3.1. Vietnamese road traffic noise with many horn sounds (RTN51) and Vietnamese road traffic noise without horn sounds (RTN0)

Figure 13 compares the mean annoyance score assigned by the Japanese (solid lines with filled symbols) and Vietnamese subjects (dotted lines with open symbols) for RTN51 and RTN0 using the numeric scale. It is shown that at 55 and 65 dB, the Japanese subjects evaluated RTN51 as being more annoying than RTN0, but at 75 dB both test sounds appeared to be equally annoying. On the other hand, for the Vietnamese subjects, RTN0 was more annoying than RTN51 at 65 and 75 dB, but the annoyance caused by both test sounds was the same at 55 dB. The results of the Wilcoxon rank-sum test are shown in Table 6(a), which indicated that there were significant differences in the annoyance response ($p < 0.01$) between the Japanese and Vietnamese subjects for RTN51 and RTN0 at all noise levels. In general, the Vietnamese subjects were less annoyed by both test sounds than the Japanese subjects.

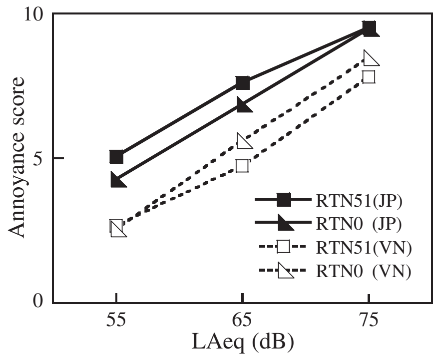


Fig. 13 Comparison of annoyance scores between Japanese and Vietnamese subjects for RTN51 and RTN0 evaluated using the numeric scale.

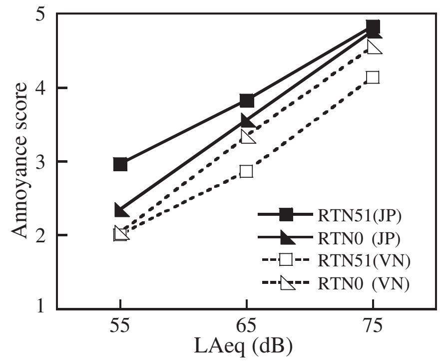


Fig. 14 Comparison of annoyance scores between Japanese and Vietnamese subjects for RTN51 and RTN0 evaluated using the verbal scale.

Figure 14 compares the mean annoyance scores assigned by the Japanese and Vietnamese subjects for RTN51 and RTN0 based on the verbal scale. The results shown in this figure exhibited almost the same trend for both Japanese and Vietnamese subjects as that described in Fig. 13. However, for the Japanese subjects, RTN51 was only slightly more annoying than RNT0 at 65 dB. The Japanese subjects also evaluated RTN0 to be only slightly more annoying than the Vietnamese subjects. Table 6(b) indicates that there were significant differences between the Japanese and Vietnamese subjects in the annoyance response for RTN51 at all noise levels ($p < 0.001$). However, there was no significant difference in their annoyance for RTN0. The trend obtained in Fig. 14 is consistent with that obtained in Fig. 13. As pointed out in Sect. 3.2, certain phenomena appear to cause less annoyance when Japanese subjects evaluate annoyance using the verbal scale rather than the numeric scale.

The results from Figs. 13 and 14 show that the annoyance response to road traffic noise with and without horn sounds in Hanoi was different between the Japanese and Vietnamese subjects. The Japanese subjects were more annoyed by road traffic noise with horn sounds, while the Vietnamese subjects were more annoyed by road traffic noise without horn sounds. Horn sounds, therefore, appeared to have an effect on the annoyance evaluation of the Japanese subjects. For the Vietnamese subjects, horn sounds appeared to have the opposite effect, probably because the Vietnamese subjects frequently use the horn when riding a motorbike, as discussed in the next paragraph.

At the end of the experiment, responses to the following two questions were obtained: “Do you frequently use the horn while driving a vehicle?” and “Are horn sounds necessary for safety?” Seventeen out of 25 Vietnamese subjects used the horn when driving a motorbike, and 24 out of 29 people considered using the horn to be necessary for safety. On the other hand, only 1 out of 14 Japanese subjects used the horn when driving a car, and 22 out of 29 people considered using the horn to be necessary for safety. The results of the chi-square test showed that there was a significant difference between the Japanese and Vietnamese subjects in their response to the answer “Do you frequently use the horn while driving a vehicle?” However, there was no significant difference between the two subject groups their opinion of whether using the horn is necessary for safety. This may be a reason why the Vietnamese subjects considered RTN51 as the least annoying sound.

3.3.2. Japanese road traffic noise (RTNJ) and Vietnamese road traffic noise with many horn sounds (RTN51)

Two different trends in the results were observed from Figs. 15 and 16. For the Japanese subjects, there was a clear difference between the Japanese road traffic noise and the Vietnamese road traffic noise. The Vietnamese road traffic noise caused more annoyance for the Japanese subjects. In contrast, there was almost no difference in annoyance scores between the two types of road traffic noise for the Vietnamese subjects.

Figure 15 shows a comparison of the mean annoyance scores between the Japanese and Vietnamese subjects for RTNJ and RTN51 measured using the numeric scale. At all noise levels, the Japanese subjects appeared to be more annoyed by RTN51 than by RTNJ. However, the Vietnamese subjects evaluated RTN51 and RTNJ as causing almost the same annoyance. The Japanese subjects showed greater annoyance toward both the test sounds, particularly RTN51, than the Vietnamese subjects. The result of the Wilcoxon rank-sum test is shown in Table 6(a), in which there were significant differences in the annoyance reactions between the Japanese and Vietnamese subjects for RTNJ with $p < 0.05$ at 55 dB and with $p < 0.001$ at 65 dB, and for RTN51 with $p < 0.001$ at all noise levels. At 75 dB, a significant difference with $p < 0.001$ was found between the Japanese and Vietnamese subjects for RTN51, but no such difference was found for RNTJ.

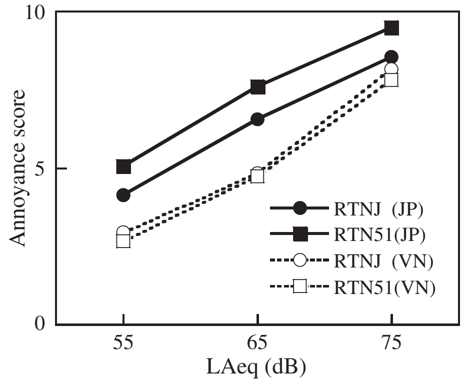


Fig. 15 Comparison of annoyance scores between Japanese and Vietnamese subjects for RTN51 and RTNJ evaluated using the numeric scale.

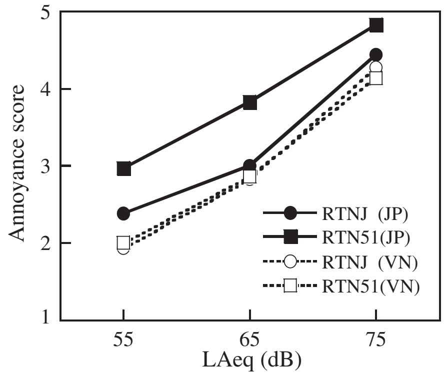


Fig. 16 Comparison of annoyance scores between Japanese and Vietnamese subjects for RTN51 and RTNJ evaluated using the verbal scale.

Figure 16 shows a comparison of the mean annoyance scores between the Japanese and Vietnamese subjects for RTNJ and RTN51 assigned using the verbal scale. The trend in the annoyance response of the Vietnamese subjects based on the verbal scale displayed in this figure is consistent with the result for the numeric scale in Fig. 15. However, the Japanese subjects exhibited a slightly different trend compared with the results of the response based on the numeric scale. Although the Japanese subjects were more annoyed by RTN51 than RTNJ at all noise levels, the annoyance caused by RTNJ for the Japanese subjects was nearly the same as that caused by both RTNJ and RTN51 for the Vietnamese subjects at 65 and 75 dB. The Wilcoxon rank-sum tests summarized in Table 6(b) also support these results, in which significant differences were found between the Japanese and Vietnamese subjects for RTN51 at all noise levels with $p < 0.001$ and for RTNJ with $p < 0.05$ at 55 dB, and no significant difference was found between the Japanese and Vietnamese subjects for RTNJ at 65 and 75 dB. The cause of the lower annoyance values of the Japanese subjects for RTNJ at 65 dB was previously explained in Sect. 3.2.

4. DISCUSSION

The annoyance caused by traffic noise was found to be different between the Japanese and Vietnamese subjects. Road traffic noise with few horn sounds (RTN12) and road traffic noise without horn sounds (RTN0) were seen as having certain effects on the noise annoyance evaluation of the Vietnamese subjects. From the results of the social survey on community responses to road traffic noise in Hanoi in 2005, Phan *et al.* [8] found that road traffic noise in Hanoi was characterized by a large number of motorbikes emitting frequent horn sounds. Moreover, the results of the survey at the end of the experiment showed that all Vietnamese subjects used motorbikes as their usual means of transportation and frequently used the horn for safety. It can be said that Vietnamese subjects considered RTN51 as the least annoying sound because the sound may have been interpreted positively.

On the other hand, the noise annoyance scores obtained from the Japanese subjects were most strongly affected by the presence of horn sounds at 55 and 65 dB. At 75 dB, the Japanese subjects were annoyed not only by road traffic noise with horn sounds, but also by road traffic noise without horn sounds recorded in Hanoi. It can be concluded that at low and medium noise levels, horn sounds affect the noise annoyance evaluation of the Japanese subjects, but at a higher level of noise exposure, the evaluation is also affected by the difference in road traffic noise characteristics between Japan and Vietnam. In general, the annoyance scores for by the Japanese subjects were greater than those for the Vietnamese subjects. This difference may be accounted for by various differences in culture between Japan and Vietnam, in terms of the social conditions and people's habituation to the road traffic noise in each country.

In a psychoacoustics experiment on railway bonus with two subject groups, namely, German and Japanese subjects, Fastl *et al.* [3] indicated that no systematic difference in the evaluation of loudness was found between the German and Japanese subjects. In another psychoacoustics experiment on railway bonus with two groups of Chinese and Japanese subjects, Ma and Yano [16] found no systematic differences in the evaluation of disturbance between the Chinese and Japanese subjects, even though the Japanese subjects tended to be more severely disturbed by transportation noises than the Chinese subjects. Ma and Yano also emphasized the need to investigate the effects of other factors such as subjective attitudes to transportation noises. The present experiment supports the importance of subjective attitudes and illustrates systematic differences between the Japanese and Vietnamese subjects. The difference in the findings among the three studies may be due to the attributes based on which the evaluation was made. It may be easier to speculate on the findings for loudness and disturbance than those for annoyance, which may be more affected by cultural factors.

In an intensive questionnaire-based survey on soundscapes across Europe, Yang and Kang [17] found that differences in evaluation of sound might have been influenced by the environment with which the subjects were familiar. Moreover, they found a significant difference among different age groups in terms of acoustic comfort, i.e., younger subjects exhibited less comfort than older subjects. Considering these results, it can be inferred from the present experiment that the familiarity with an environment affects the annoyance caused by a sound from that environment. Further investigations should be conducted on the affects of age, environmental adaptation, and social and cultural factors on noise annoyance.

Japan used to have a problem of excessive horn-use. In the 1930s, because of a large number of complaints from foreign visitors to Japan on the use of the horn, restrictions on horn use were first imposed in 1932 in Osaka. Two years later, Tokyo imposed the same restrictions. Although there were concerns about the possibility of increased traffic accidents due to the restrictions on horn use, the number of traffic accidents did not increase. In 1938, the restrictions on horn usage were applied all over Japan [18]. Under the current circumstances, the results of the psychoacoustics experiments suggest that the prohibition of horn use may be unnecessary in Vietnam; however, to promote international integration and recognition and to ensure a better environment for its citizens, Vietnam appears to be in a more urgent need of a practical noise policy.

5. SUMMARY

Cross-cultural psychoacoustic experiments were conducted in Kumamoto and Hanoi to investigate the effects of horn sounds on the annoyance of Japanese and Vietnamese subjects to traffic noise. The results suggested that the annoyance response to road traffic noise recorded in Hanoi with and without horn sounds was different between the Japanese and Vietnamese subjects. The Japanese subjects were more annoyed by the Vietnamese road traffic noise with horn sounds, while the Vietnamese subjects were more annoyed by the Vietnamese road traffic noise without horn sounds. The effect of horn sounds was confirmed by evaluating the annoyance of the Japanese subjects at low and medium noise exposure levels. The horn sounds appeared to have the opposite effect on the annoyance evaluation of the Vietnamese subjects than on the Japanese subjects, probably because of the Vietnamese subjects' frequent horn use.

The results also indicated that the annoyance of the Japanese subjects was more intense than that of the Vietnamese subjects, and the differences between the Japanese road traffic noise and the Vietnamese road traffic noise affected the annoyance of the Japanese subjects but not the Vietnamese subjects. These results emphasized the need to further investigate the cultural factors that may affect the annoyance caused by noise.

ACKNOWLEDGEMENTS

This study was financially supported by the Core University Program of the Japan Society for the Promotion of Science (JSPS) and the National Center for Science and Technology (NCST) and by a Grant-in-Aid for Scientific Research (Project No. 17560533). The authors highly appreciate the kind support provided by Professor Pham Ngoc Dang, Professor Pham Duc Nguyen, Dr. Nguyen Thu Hoa, and the students of the Hanoi University of Civil Engineering during the planning and performance of experiments in Hanoi. The authors are grateful for the useful academic materials provided by Dr. Koji Nagahata at Fukushima University.

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