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Comparison of dose–response relationships between railway and road traffic noises: the moderating effect of distance

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Abstract

It has been found in European studies that railway noise causes less annoyance than road traffic noise. However, recent Japanese studies have shown that there is no systematic difference in dose–response relationships between railway and road traffic noises. In general Japanese houses are situated closer to railways or roads than European houses. The purpose of the study was to investigate whether the distance from noise source to houses influences community responses to railway and road traffic noises. A re-analysis was made of data from social surveys on community responses to railway and road traffic noises, which have been obtained from 1994 to 2001 in Kyushu, a warmer area of Japan and Hokkaido, a colder area. The results showed that the annoyance in areas close to railways was greater than that in distant areas, while there was no difference in dose–response relationships for road traffic noise between both areas. Considering the situation of houses in Europe and Japan, it is expected that the annoyance caused by railway noise is more severe in Japan than in Europe. The distance from noise source to houses may be one of the causes of the difference in community responses between Europe and Japan.

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1. Introduction

It has been found in European studies that railway noise is less annoying than road traffic noise at the same L_{Aeq} levels [1–4]. This is reflected as a so-called ''railway bonus'' in noise regulations of some European countries. However, it has been found in recent Japanese studies that railway noise annoyance is almost the same as or even a little higher than road traffic noise annoyance [5,6]. Several hypotheses can be considered to explain the differences.

(1) It has been reported that railway noise causes greater listening disturbance than road traffic noise [3]. Double pane windows are generally found in central and northern European countries while single panes are common in Japan, except in colder areas like Hokkaido. The less-effective sound insulation of the Japanese house may thus cause greater listening disturbance and therefore greater annoyance from railway noise than from road traffic noise.

(2) Japanese houses are situated closer to railways or roads than European houses. The vibration level by train passages is usually higher than that from road traffic. Furthermore, since the mass of Japanese houses is less than that of European houses, Japanese houses are apt to be affected by vibration. For these reasons, Japanese people living close to railway may be more disturbed in their daily-life activities by vibration and then more annoyed than European people.

(3) European people enjoy outdoor activities in gardens or on balconies more than Japanese. Such a difference in lifestyle may affect community responses to both noises [7].

(4) Attitude to noise source is an important factor for annoyance response. Fields et al. [1] pointed out that romantic, nostalgic, safety and environmental considerations for trains moderated the annoyance. The attitudes may be different between Japanese and European people.

To elucidate hypothesis (1) the dose–response relationships for railway and road traffic noises were compared between Kyushu, a warmer area of Japan, and Hokkaido, a colder area. However, no difference was found between the areas [8]. There is not enough data to prove hypotheses (3) and (4). The purpose of the present study is to test hypothesis (2) and investigate how the distance from noise source to houses affects community response to both noises.

2. Methods

2.1. Social surveys

Social surveys on community responses to railway and road traffic noises were carried out in Hokkaido and Kyushu, Japan from 1994 to 2001. Table 1 shows the outline of the social surveys. The purpose of these surveys was to compare the influence of different noise sources and different climates on community responses to noise. Respondents, 20–80 years of age, were randomly selected on a one-person per family basis from detached houses facing railways or roads. The sample sizes were between 400 and 500 and the response rates were 64–80%.

Long-term noise measurements were made at reference points near the railways and roads and short-term noise measurements were also made at the reference points and other several points for the estimations of distance reduction. The amount of noise exposure ($L_{Aeq,24\,h}$) was determined from measurements and estimations. Road traffic noise was between 50 and 76 dB and railway noise was between 30 and 80 dB.

Table 1
Outline of surveys

Noise source	Railway noise	Road traffic noise
Area	Hokkaido	Hokkaido (Sapporo)
Housing type	Detached house	Detached house
Survey site	Residential area along four railway lines around Sapporo	11 sites in Sapporo
Method	Self-administered	Self-administered
Survey term	2001.8-9	1997.10-1998.1
Measurement term	2001.9-10	1998.7-10
Sample size	497	411
Response rate (%)	69.9	63.5
Traffic volume/day	87-344	2491-48219
$L_{\mathrm{Aeq,24\,h}}$(dB)	30-78	53-76
Area	Kyushu	Kyushu (Kumamoto)
Housing type	Detached house	Detached house
Survey site	Residential area along three railway lines from Kumamoto to Fukuoka	15 sites in Kumamoto
Method	Self-administered	Self-administered
Survey term	1994.5-6,9-10,1995.5	1996.5-7
Measurement term	1994,10	1996.9-11
Sample size	464	378
Response rate (%)	79.7	76
Traffic volume/day	72-414	3936-44787
$L_{\mathrm{Aeq,24\,h}}$(dB)	34-74	49-74

The percent highly annoyed was defined as the rate of the number of people who responded to the top category of 4-point annoyance scale to the total number of people exposed in a $L_{\mathrm{Aeq,24\,h}}$ range. The significance of difference in the rate between near and distant areas was tested by a chi-square test.

2.2. Distance data

As there was almost no difference in dose–response relationships for both noises between Hokkaido and Kyushu, the data for both noises, obtained from the community surveys in Hokkaido and Kyushu, were combined. Table 2 shows the distance from railways or roads to houses in our surveys and distance data from surveys in which Griefahn et al. [9] investigated the effects of railway and road traffic noises in Germany. In the Japanese data, the average distance from the railways to the houses was 43 m in the present railway noise survey and 90% of the houses were situated within 94 m from the railways. The average distance from the roads to the houses was 10 m and 90% of the houses were situated within 18 m from the roads. In the German data, the average distance from the railways to the houses was 106 m in the present railway noise survey and 90% of the houses were situated within 188 m from the railways. The average distance from the roads to the houses was 41 m and 90% of the houses were situated within 90 m from the roads. The houses were situated farther from the railways than from the

Table 2
Outline of distance data (m)

		Japanese data		German data	
		Railway	Road traffic	Railway	Road traffic
Average		43	10	106	41
Standard deviation		56	12	56	36
Mode		10	5	33	10
Percentile (%)	100	414	84	374	208
	90	94	18	188	90
	50	23	7	98	27
	10	8	3	38	8
	0	1	1	23	4
Sample size		958	783	616	635

roads in both countries. German houses were situated farther from the noise sources than the Japanese.

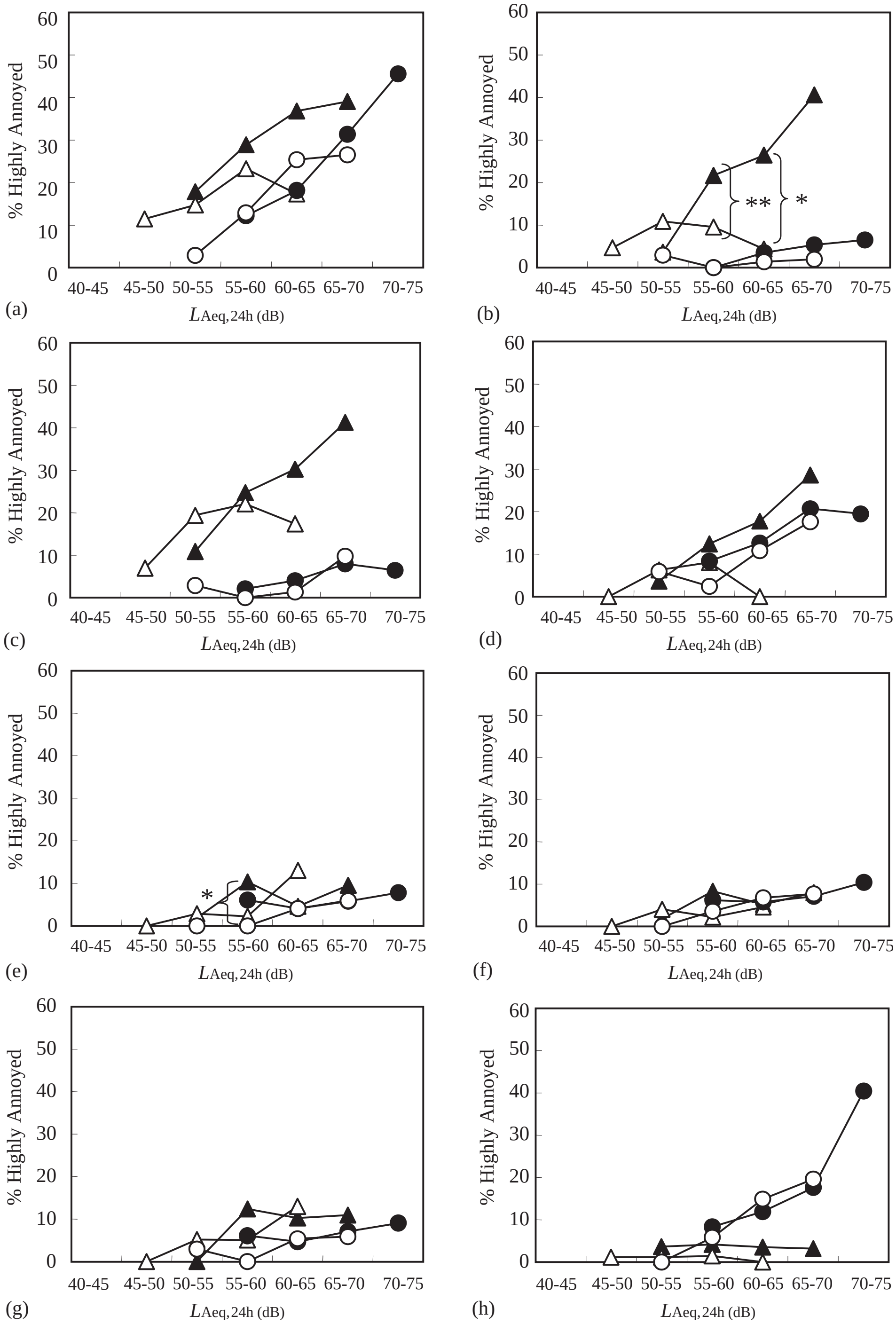
3. Comparison of community responses to railway and road traffic noises between near and distant areas

To investigate whether the distance from noise source to houses influences the community response to noise, respondents were divided into two groups according to distance, and the dose–response relationships were compared. The borders were 10 m from roads and 20 m from railways. The border of 10 m for road traffic noise survey was based on a finding that a severe reaction of residents to road traffic noise is restricted to distances of 10 m from roads [10]. However, since a similar finding appeared not to be obtained for any railway noise survey, the samples were divided into almost two equal sample sizes. The sample size in the area within 10 m from roads was 532, and that in the area more than 10 m away from roads was 251. The sample size in the area within 20 m from railways was 402, and that in the area farther than 20 m from railways was 556.

Fig. 1 shows the relationships between $L_{\mathrm{Aeq,24\,h}}$ and percent highly annoyed.

No significant differences in general annoyance or in any disturbances were found between near and distant areas in the road traffic noise survey. The annoyance caused by exhaust in the near area was not greater than that in distant area, although that was expected (Fig. 1h).

Fig. 1. Comparison of dose–response relationships between distance area and near area. $^{**}p<0.01$, $^{*}p<0.05$. (a) General annoyance, (b) telephone listening disturbance, (c) TV/radio listening disturbance, (d) annoyance caused by vibration, (e) falling asleep disturbance, (f) awkening, (g) rest disturbance, (h) annoyance caused by exhaust. –▲– railway (<20 m), –△– railway (⩾20 m), –●– road (<10 m), –○– road (⩾10 m).


% Highly Annoyed
0
10
20
30
40
50
60
40-45
45-50
50-55
55-60
60-65
65-70
70-75
LAeq,24h (dB)
**
*
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)

In the railway noise survey, there was no significant difference in general annoyance, but the annoyance in the near area was systematically greater than in the distant area. Telephone listening disturbance in the near area was significantly greater than in the distant area, at a 5% level in the 60–65 dB range and at a 1% level in the 55–60 dB range. Though no significant difference in TV/radio listening disturbance and annoyance caused by vibration were found, the disturbance in the near area was systematically greater than in the distant area at the 55 dB or more range. Although the falling-asleep disturbance in the near area was significantly greater than in the distant area at a 5% level in the 55–60 dB range, these differences were not systematic. No significant differences in awakening and rest disturbance were found between near and distant areas.

4. Conclusions

It was shown that the annoyance and activity disturbances caused by railway noise in the areas close to railways were greater than those in more distant areas. Particularly, the differences were significantly greater for listening disturbances. There was no difference in dose–response relationships for road traffic noise between the areas. Considering that the houses in Europe are farther apart from the noise source than in Japan, it is expected that the annoyance caused by railway noise will be more in Japan than in Europe. Therefore, it is concluded that the distance may be one of the causes of the difference in dose–response relationships for railway and road traffic noises between Europe and Japan.

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