COMMUNITY RESPONSE TO ROAD TRAFFIC NOISE IN LIVING ENVIRONMENTS

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ABSTRACT

This study aimed to clarify the community response to road traffic noise in living environments. Social surveys were carried out for the inhabitants along trunk roads in the Kanagawa prefecture, Japan. After the collection of the questionnaires, noise and vibration exposures were estimated. In this paper, the authors focused on individual differences caused by that inhabitants giving weight to different factors in living environments. Respondents were classified into four groups based on individual differences. Through the comparison of dose-response relationships and path analysis, it was verified that the structure of noise annoyance was different among these groups.

1. INTRODUCTION

Trunk roads have brought about much benefit of convenience. On the other hand, the resulting elevated noise and vibration levels have caused annoyance and have interfered with daily activities [1, 2]. Moreover the expansion of trunk gives rise to environmental problems in new areas. In Japan, noise regulation laws, vibration regulation laws and environmental quality standards for noise were established in order to preserve living environments and protect people's health. At the same time, there has been an increase in awareness and concern over the noise and vibration levels by inhabitants living along trunk roads because of a desire for comfortable living environments, and the diversification of life-styles and individualities. Noise and vibration problems are a reality despite monitoring values remaining below the standard values or the regulation values. Given this situation, it is important to assess the effects of noises and vibrations upon people's daily lives. This assessment is complicated by the fact that the effect of noises and vibrations on people is mainly a psychological one, an effect that differs greatly between individuals. In order to create and preserve a pleasant living environment, it is necessary to evaluate noises and vibrations in light of the inhabitants themselves.

Figure 1 shows a model that represents the structure of evaluation in living environments. In this study, we consider that differences among levels of importance in living environment factors lead to individual differences. The synthetic evaluation of living environments differs greatly between individuals because people give different weightings to each of the living environment factors [3]. Figure 2 shows a causal model that represents the structure of the evaluation in noise environments that is included in the living environment structure. We expect that these individual differences affect the dose-response relationship of noises.

In this paper, on the basis of these differences obtained by social surveys, the respondents were categorized into four groups. The purpose of this paper is to comprehend differences among community responses to road traffic noises in each group. Furthermore, path analysis is applied to the community responses in order to clarify factors affecting noise annoyance.

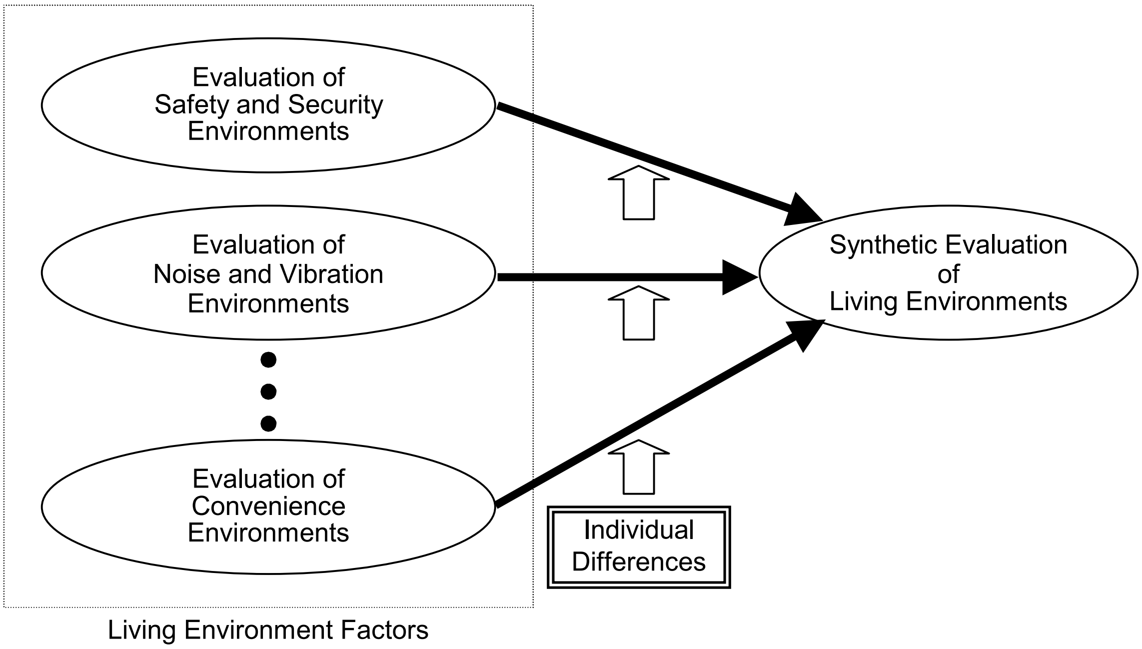


Figure 1. Structure of evaluation in living environments

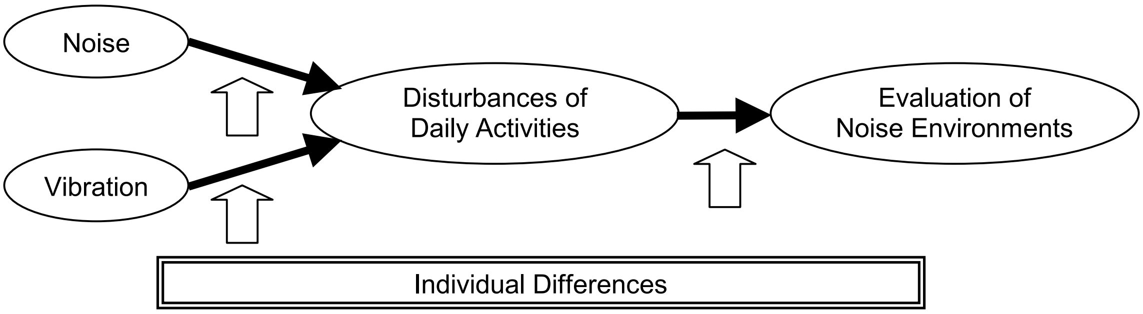


Figure 2. Structure of evaluation in noise environments

2. SOCIAL SURVEY

In 1999 and 2000, social surveys on community response were carried out in 58 residential areas in the Kanagawa Prefecture, Japan. This area was categorized into two: 43 areas within 40 meters off trunk roads (road areas) which were constantly exposed to road traffic noise, and 15 areas in the vicinity of noise areas (control areas) but free from road traffic noise. The selected houses were all detached houses. Questionnaires were distributed to an inhabitant living in each detached house and collected by mail. The title of our questionnaire was “Social Survey for Living Environments”. Table 1 shows the outline of the questionnaire. The questionnaire contained evaluations of present and past living environments, disturbances of daily activities, environmental technical terms and demographic factors. In this paper, noise annoyance was evaluated by Road traffic noise dissatisfaction included in Q1. The category scale of the noise dissatisfaction was a 5-point scale; 1) satisfied, 2) fairly satisfied, 3) neither satisfied nor dissatisfied, 4) fairly dissatisfied, 5) dissatisfied. There were 661 respondents over the two-year period. The recovery rate was 66%. Table 2 shows rates of primary demographic factors and house properties.

3. NOISE AND VIBRATION MEASUREMENTS

In order to estimate the noise and vibration exposures of each house after the collection of the questionnaires, noise and vibration levels were measured at the same points in each of road areas simultaneously.

Noise levels were measured using a sound level meter with both the A-weighted frequency response and the Fast dynamic response. The $L_{Aeq,10min}$ was measured for more than one hour at a reference point located along the shoulder of the road and for 10 minutes at response points simultaneously. $L_{Aeq,24h}$ was measured simultaneously at a fixed point which was close to the reference point. The noise exposures at each house were calculated from the $L_{Aeq,24h}$ at the reference point and from distance reductions. The $L_{Aeq,24h}$ at the reference point was estimated from the $L_{Aeq,24h}$ at the fixed point and the $L_{Aeq,10min}$ at the reference points. The distance reductions were estimated from the $L_{Aeq,10min}$ at the reference and response points. In this paper L_{Aeq} represents noise exposures.

Vibration levels were measured at the ground in the vertical direction using a vibration level meter and with the VL-weighted frequency response (JIS C 1510). In Japan, the vibration level is defined as $20log_{10}\ (a/a_0)$, where a_0 is equal to 10^{-5} m/s^2. The 10% percentile vibration levels (VL_{10}) at 10-minute intervals were measured for more than one hour at the reference point and for 10 minutes at the response points simultaneously. Vibration exposures at each house were calculated from the maximum VL_{10} at the reference point and from distance reductions. The distance reductions were estimated from the VL_{10} values at the reference and response points. In this paper, VL_{10} represents vibration exposures.

Table 1 Outline of our questionnaire

Q1	Satisfaction of Living Environments	30 items	single answer (5-point scale)
Q2	Importance of Living Environments	30 items	multiple answer
Q3	Much Importance of Living Environments	30 items	limited answer (5 items)
Q4	Synthetic Evaluations of Living Environments	4 items	single answer (5-point scale)
Q5	Wishes for Life	10 items	multiple answer
Q6	Disturbances of Daily activities	15 items	multiple answer
Q7	Past Living Environments	9 items	single answer (3-point scale)
Q8	Knowledge of Environmental Terms	6 items	single answer (3-point scale)
Q9	Demographic Factors	10 items	
Q10	Free Opinions		

Table 2 Demographic factors and house attitudes

Gender	Female (55%), Male (45%)
Age	Fifties (28%), Sixties (26%)
Occupation	Employment income earner (30%), Housewife (27%)
Number of family members	Two persons (27%), Four persons (25%)
Structure of house	Wooden house (85%), Steel framed house (11%)
House age	10-19 years (34%), 20-29 years (27%)

4. RESULTS

4.1 Community Responses to Living Environments

Table 3 shows the percentage of dissatisfied respondents for the living environment factors involved in Q1. A total of 28 items were common questions used in the surveys for both years. In road areas, Road traffic noise and Road traffic vibration rank 1st and 2nd, respectively; the rates of % dissatisfied in Road traffic noise and Road traffic vibration are above 50%. In control areas, the rates of % dissatisfied in the living environment factors involved in Road traffic noise and Road traffic vibration are below 20%. These results indicate that road traffic noises and vibrations have annoyed inhabitants along trunk roads.

Table 3 also shows each average of importance scores in the living environment factors. The average of the importance scores is defined here as the rate of the sum of people who responded to “important” in Q2 and “very important” in Q3. In road areas, the averages of importance scores in Medical care facilities and Clean air are above the 1-point mark. Road traffic noise and Road traffic vibration rank 4th and 8th, respectively. In control areas, the averages of Road traffic noise and Road traffic vibration rank 14th and 23rd, respectively. Thus, inhabitants along trunk roads have weighted highly the importance of road environment factors such as air pollutions, noises and vibrations. From these results, data obtained by people in road areas are analyzed.

Table 3 Rates of dissatisfaction and importance scores in living environment factors

Living Environment Factors	% dissatisfied		Importance scores	
	Road areas	Control areas	Road areas	Control areas
1. Familiarity with waterside	18%	19%	0.37	0.40
2. Contact with green	8%	4%	0.71	0.87
3. Convenience of transportation	9%	9%	0.82	1.11
4. Convenience of shopping	6%	4%	0.62	0.85
5. Parks and open spaces	14%	6%	0.50	0.40
6. Public facilities	17%	13%	0.49	0.47
7. Medical care facilities	11%	11%	1.04	1.19
8. Road traffic vibration	51%	12%	0.65	0.34
9. Construction vibration	32%	8%	0.26	0.17
10. Road traffic noise	60%	12%	0.87	0.53
11. Aircraft noise	16%	13%	0.30	0.37
12. Construction noise	23%	6%	0.23	0.13
13. Accumulation of garbage	4%	2%	0.58	0.74
14. Surrounding cleanliness	7%	2%	0.55	0.55
15. Tap water	8%	6%	0.66	0.80
16. Indoor sunlight	8%	7%	0.63	0.78
17. Indoor ventilation	6%	5%	0.34	0.39
18. Size of dwelling	6%	6%	0.20	0.23
19. Layout of dwelling	8%	5%	0.15	0.15
20. Surroundings in stroll	8%	5%	0.36	0.36
21. Comfortableness in town	11%	7%	0.40	0.43
22. Surrounding landscape	14%	7%	0.24	0.27
23. Clean air	33%	9%	1.04	0.99
24. Smell of air	27%	10%	0.50	0.54
25. Neighborly companionship	6%	2%	0.38	0.46
26. Surrounding disaster measures	7%	5%	0.59	0.77
27. Surrounding public morals	6%	4%	0.60	0.72
28. Surrounding road safety	21%	10%	0.88	0.86

4.2 Grouping Based on Individual Differences

Using the importance scores obtained form Q2 and Q3, the respondents were grouped. To start with, factor analysis was applied to the importance scores. This revealed the following eight factors: (1) amenity, (2) noise and vibration, (3) convenience, (4) dwelling, (5) health, (6) safety, (7) air quality, and (8) road traffic noise and vibration. The cluster method was then applied to the factor analysis scores for individuals to categorize people into four groups. Finally, discussing the averages of factor analysis scores, we named the groups the following: convenience environments (Group1), safety environments (Group2), noise and vibration environments (Group3,), and dwelling environments (Group4), separately. The number of people in each group is 193(Group1), 271(Group2), 96(Group3), and 101(Group4). No significant relationships between the demographic factors and the groups were here observed.

4.3 Comparison of Dose-response Relationships

Figure 3 shows the relationships between noise exposures and disturbances of daily activities sorted by groups. The disturbances of daily activities are defined here as the sum of responses to the following disturbances; rattle due to passing automobiles, interference with listening to the telephone or TV, hard to open windows, and being woken up at night or in the morning. These were included in Q6. This figure shows that the disturbances of daily activities simply rise as L_{Aeq} increases. There is no significant difference in the disturbances of daily activities among Group1, Group2, and Group4 in every range. However, the disturbances of daily activities in Group3 are significantly higher than those in other groups in the –55dB range.

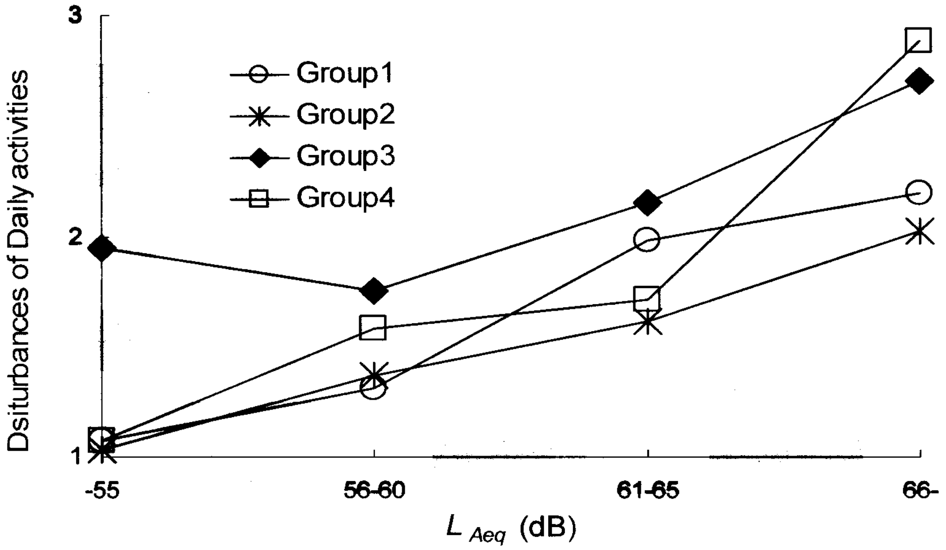
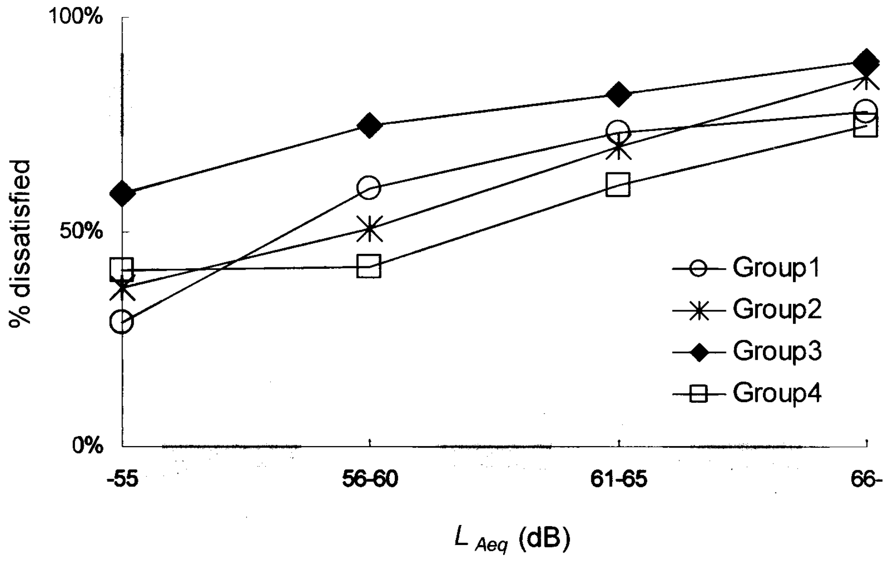


Figure 3. Relationships between LAeq and Disturbances of daily activities

Figure 4 shows the relationships between noise exposures and rates of dissatisfaction. A similar trend is observed in Figure 4 as in Figure 3. For example, Group3 indicates significantly higher rates than Group1 in the –55 dB range and than both Group2 and Goup4 in the 56-60dB range separately. These results make it clear that people in Group3 have harsher responses to road traffic noises than those in other groups, especially at low levels.



4.4. Path Analvsis

Figure 4. Relationships between LAeq and road traffic noise dissatisfaction

and noise annoyance, has been widely used in social studies. A causal model contains multiple stratum relationships between exogenous variables, endogenous variables, and dependent variables. The model can estimate not only the direct effects of exogenous variables but also the indirect effects of exogenous variables via endogenous variables.

Our causal model, based on experience and previous findings, is constituted in Figure 3. The exogenous variables were picked up from the noise and vibration exposures. The endogenous variables were selected from the disturbances of daily activities related to road traffic noises and vibrations. The dependent variable was the road traffic noise dissatisfaction. The standardized partial regression coefficients, called path coefficients, show the strength of linkage between the variables. Figures 5 and 6 show path coefficients in Group3 and other groups, respectively. The path coefficients between the groups are now compared. The path coefficients from VL_{10} to disturbances of daily activities, from VL_{10} to road traffic noise dissatisfaction, and from L_{Aeq} to disturbances of daily activities, were found to be different between the groups. In Group3, in addition to the direct effect of noise exposures, the direct and indirect effects of vibration exposures also affected road traffic noise dissatisfaction. In contrast, in other groups, the direct and indirect effects of noise exposures alone cause road traffic noise dissatisfaction.

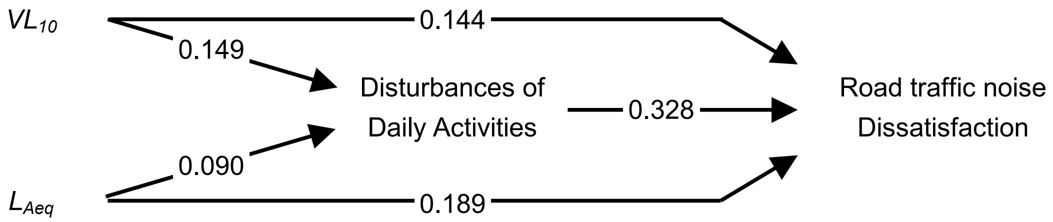


Figure 5. Causal model of road traffic dissatisfaction in Group3

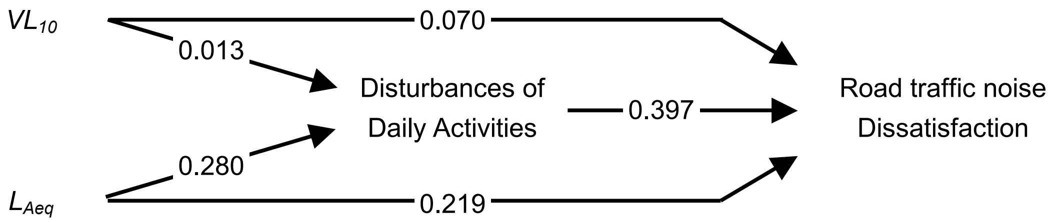


Figure 6. Causal model of road traffic dissatisfaction in other groups (Group1, Group2, and Group4)

5. CONCLUSIONS

(1) Road traffic noises and vibrations have annoyed inhabitants along trunk roads.

(2) On the basis of the differences among levels of importance in living environment factors, respondents were categorized into four groups. People in each group weighed to convenience environments (Group1), safety environments (Group2), noise and vibration environments (Group3), and dwelling environments (Group4).

(3) No differences were observed in the disturbances of daily activities among Group1, Group2, and Group4 in every range. However, the disturbances of daily activities in Group3 were found to be significantly higher than those in other groups in the range of less than 55 dB.

(4) People in Group3 are more annoyed by road traffic noises than those in other groups, especially at low noise levels.

(5) In Group3, in addition to noise exposures, vibration exposures affect road traffic noise annoyance. In contrast, in other groups, noise exposures alone affect the annoyance.

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