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PATH ANALYSIS OF THE COMMUNITY RESPONSE TO ROAD TRAFFIC NOISE

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Path analysis was applied to data collected in a social survey on the community response to traffic noise along a trunk road in Tokyo. The data were collected from more than 390 female residents by means of a questionnaire. A path model was developed for the causal relation of the noise annoyance, dissatisfaction with living environment, and the wish of the respondents to move to the antecedent variables, including noise levels, personal factors, and noise effects. The strongest effect on annoyance was for the noise level, followed by interferences with daily activities. The model explains 43% of the variation in annoyance. The dissatisfaction with the living environment and wish of respondents to move depended strongly on noise annoyance, but other factors should also be considered, as only 33% and 19% of their variation, respectively, could be explained by the model.

1. INTRODUCTION

Health effects of noise relate to many factors having to do with both the noise and the individual, e.g., noise levels, distance from the noise source, age, sex, history of exposure, etc. [1]. Effects of noise include various impacts on mental and physical health and disturbance of daily activities, and lead to the perception of annoyance and development of behavioral responses [1]. Community reactions to environmental noise thus relate to various factors, including noise level and personal conditions, and complicated interrelations also exist among the residents' reactions. Many kinds of statistical methods have been applied to analyze the community reaction to noise [2–4]; among them the path analysis, which is helpful in clarifying the causal relationship between noise and people's responses. Path analysis has been widely used in social studies, but only a few studies have been published in which it has been used to examine community reactions to noise [5, 6]. In this study, path analysis and other multivariate analyses were applied to analyze the structure of community reactions to road traffic noise and to clarify the causal relation of noise annoyance and dissatisfaction with the environment to antecedent variables, including noise levels and personal factors. The data used in this study were obtained in a social survey performed along a trunk road in Tokyo.

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2. MATERIALS AND METHODS

The data used were collected in a social survey on the effect of road traffic noise performed along a trunk road in Tokyo in 1996. The area surveyed was 800 m long and 100 m wide on both sides of the road. Five hundred female residents, from 20–60 years old and residents of the area for more than three years, were selected from the resident register. The questionnaire was mailed to these females and collected by interviewers. The recovery rate was 393/500, about 80%. The noise level and distance from the road were estimated for each of the respondents. The questionnaire included the following: (1) age, occupation, house structure, length of residence, etc.; (2) evaluation of the surrounding environment: noisiness of and annoyance from the traffic, dissatisfaction with the environment, wish to move, etc.; (3) mental and physical health condition: headache, cough, fatigue, etc.; (4) sleep condition: difficulty in falling asleep, waking during the night, difficulty in waking in the morning, etc.; (5) disturbance of daily activities: interference with conversation, talking on the telephone, listening to TV, reading, thinking, etc.

TABLE 1

Factor analysis of the health conditions (1–11, 22–28) *and annoyance* (12–21) *reported by the respondents*; *primary factor method*.

Factor loadings after varimax rotation

	Response	Factor 1	Factor 2	Factor 3	Factor 4	Communality
1	feel tired	*0·6513*	0·1078	0·0901	0·3412	0·5603
2	feel gloomy	*0·7329*	0·2559	0·1340	0·0866	0·6281
3	easily irritated	*0·6983*	0·1745	0·1242	0·1036	0·5442
4	feel spiritless	*0·7260*	0·1147	−0·0345	0·1137	0·5544
5	difficult to arrange ideas	*0·6620*	0·2077	0·0504	0·1565	0·5084
6	want to shout	*0·5577*	0·1054	−0·0338	−0·0621	0·3271
7	poor appetite	*0·5570*	0·1935	0·0269	0·3754	0·4893
8	difficult to fall asleep	*0·5870*	0·1985	0·1716	0·2195	0·4616
9	wake up at night	*0·5437*	0·2592	0·1117	0·2212	0·4242
10	difficult to wake up	*0·6079*	0·0771	0·0986	0·1382	0·4043
11	can't sleep well	*0·6816*	0·1780	0·1406	0·1526	0·5393
12	interfere with conversation	0·1125	*0·8235*	0·2107	0·0415	0·7370
13	windows vibrate	0·1341	*0·6939*	0·0475	0·1162	0·5152
14	hard to clean house	0·1836	*0·5710*	0·3038	0·2079	0·4953
15	hard to open windows	0·1191	*0·6404*	0·3577	0·1582	0·5773
16	interfere with thinking	0·2152	*0·7938*	0·0710	0·0093	0·6816
17	interfere with reading	0·1528	*0·8491*	0·1801	0·0646	0·7809
18	dissatisfied with environment	0·2266	0·2417	*0·5904*	0·0178	0·4587
19	noisiness of road traffic	0·0125	0·2615	*0·7903*	0·0356	0·6944
20	annoyance with traffic noise	0·1063	0·4678	*0·7043*	0·0908	0·7344
21	wish to move	0·1430	0·0543	*0·4370*	−0·0365	0·2157
22	have a headache	0·2870	0·1273	0·0618	*0·4096*	0·2702
23	cough in the morning	0·3240	0·1842	0·2006	*0·4917*	0·4209
24	catch cold often	0·4028	0·1774	0·1406	*0·5334*	0·4980
25	palpitation and short of breath	0·3031	0·2383	0·0066	*0·4705*	0·3701
26	stomach disorder	0·3121	0·0773	−0·0402	*0·4310*	0·2908
27	have a tinnitus	0·3153	0·0817	0·0700	*0·4084*	0·2778
28	feel unhealthy	0·5729	0·0687	0·0366	*0·4928*	0·5771
Contribution		5·7078	4·1079	2·1548	2·0661	14·0366
Contribution (%)		20·39	14·67	7·70	7·38	50·14

Results obtained in the social survey were analyzed by means of multivariate analytical methods: i.e., factor analysis, cluster analysis, and path analysis were applied, according to the computer program.

3. FACTOR ANALYSIS OF RESPONSES

The residents' responses were first treated by the primary factor method of factor analysis. The factor loadings of responses after the varimax rotation are shown in Table 1. The first to seventh items are responses to questions on emotional conditions and eighth to eleventh items concern sleep conditions. These have high loadings on the first factor. The twelfth to seventeenth items, with high loadings on the second factor, are the responses to questions on disturbances of daily activities. Items that have high loadings on the third factor are the eighteenth to twentieth responses and deal with the evaluation of the surrounding environment. The last group, with high loadings on the fourth factor, has to do with physical health conditions. The above results clearly shows that the responses can

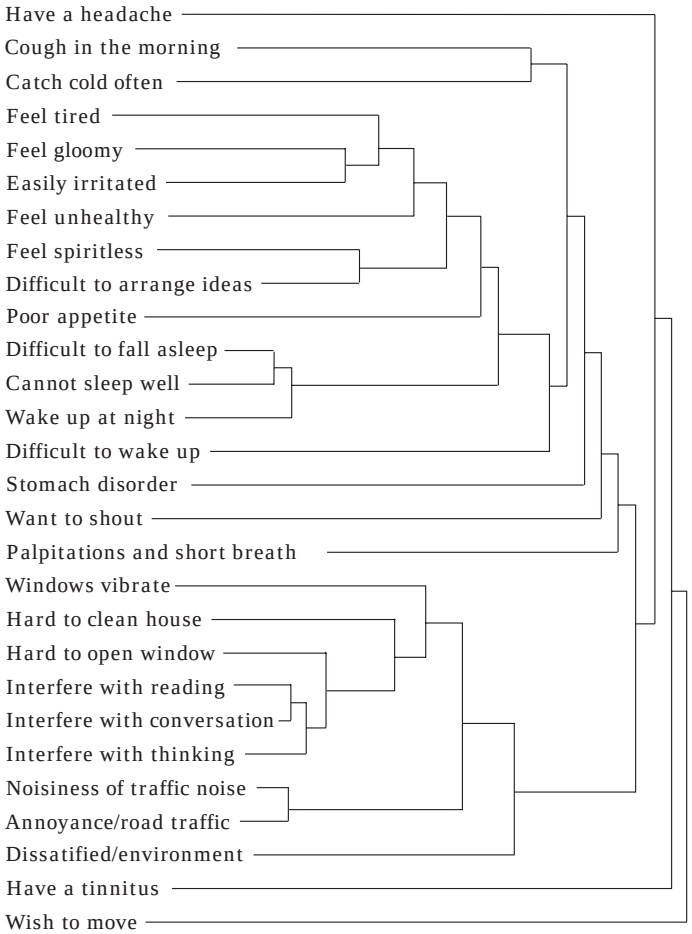

Figure 1. Dendrogram of the cluster analysis of responses to the questionnaire.

be classified into four or five groups and that, within each group, the items are closely related to each other.

4. CLUSTER ANALYSIS OF RESPONSES

The second method applied was cluster analysis by the nearest linkage method, and the resulting dendrogram is shown in Figure 1. Here again, responses on emotional conditions, sleep disturbances, and interference with daily activities are closely related to others in each group. Noisiness and annoyance from noise relate very closely. Dissatisfaction with the environment is related to both annoyance and disturbances of daily activities. Finally, the figure shows that the wish of the residents to move from the area is the last result of all of the responses.

5. PATH ANALYSIS OF RESPONSES

Path analysis was applied to clarify the causal relations between noise annoyance and other responses to various antecedent variables, such as noise levels and the respondents' personal factors. The primary scheme of the ordering of causality is shown in Figure 2. In path analysis, variables should be selected from those closely related to avoid the confusion of multicollinearity. Among the independent, exogenous variables, L_{Aeq24h} was selected as the physical antecedent from noise indices and distance from the road, because of their high intercorrelation. With reference to the results of factor analysis and cluster analysis described above, "catch cold often", "cannot sleep well", and "feel gloomy" were selected from the responses on health, sleep, and emotional conditions, respectively. From

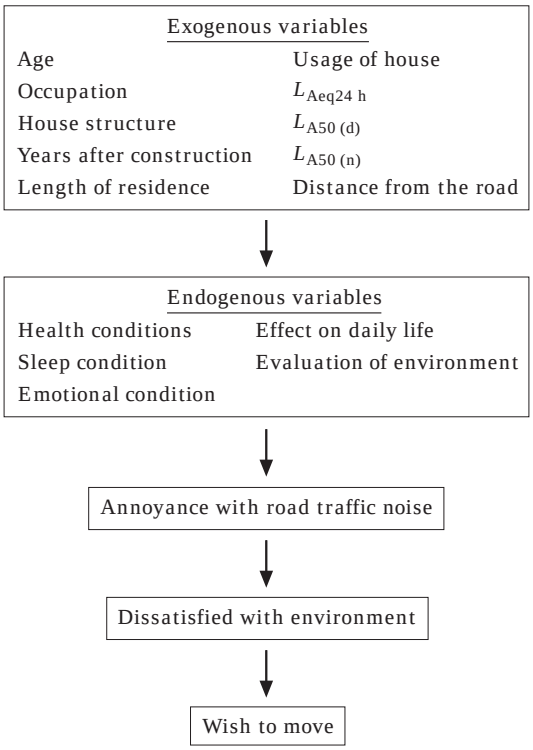

Figure 2. Primary scheme of the ordering of causality in the path model.

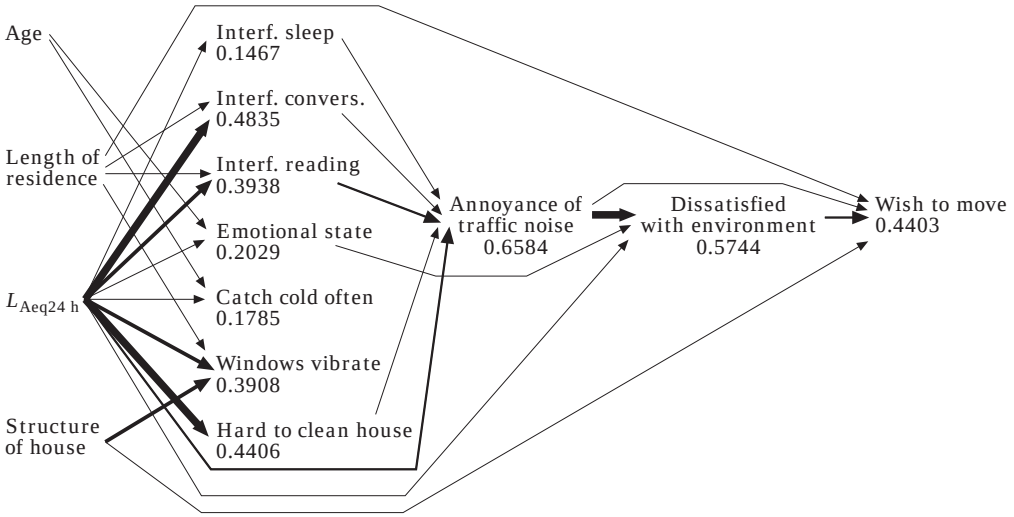

Figure 3. Path diagram of the community response to traffic noise. Paths with statistical significances were illustrated.

the effects on daily activities, interference with conversation and reading, vibration of windows, and difficulty in cleaning house were selected for the representative effects of noise, vibration, and air pollution caused by road traffic. Responses on noisiness and annoyance from road traffic showed a very high correlation, and the latter was used.

After the multiple regression analysis of exogenous and endogenous variables thus selected, a path diagram was obtained, as shown in Figure 3. In this diagram, only the paths having statistically significant path coefficients (standard partial regression coefficients) are illustrated. The thickness of the paths corresponds to the amounts of each path coefficients: the thin paths are of coefficients less than 0·2, and the thickest one is of greater than 0·4. The figures beneath the variables are multiple correlation coefficients. The strength of the effects of exogenous and endogenous variables on explained variables, i.e., noise annoyance, dissatisfaction with the environment, and wish to move, was calculated and is given in Table 2. In terms of noise annoyance, noise level exerts the strongest direct and indirect effects, followed by interference with activities. For dissatisfaction with the environment, annoyance from road traffic has the strongest effect followed by the noise level. Finally, among the effects on the wish to move away from the area, noise annoyance, dissatisfaction with the environment, and structure of the house have greater effects than the noise level. According to the multiple correlation coefficient of the annoyance, the model explaining 43% of the variation in the annoyance, and a rate almost equal to that of previous studies [5, 6]. However, the strengths of explanation of the model for dissatisfaction with the environment and wish to move are 33% and 19%, respectively, meaning that there are many other factors than those expected that relate to such responses.

6. CONCLUSION

Data from a social survey on the effects of road traffic noise were analyzed by means of path analysis to estimate the effects of relevant factors on noise annoyance, evaluation of the environment, and wish of the residents to move. While noise level had the strongest effect on annoyance, other variables were also influential. The result of this study confirms

TABLE 2

Summary of the effects of variables on the noise annoyance, dissatisfaction with environment, and wish of respondents to move

Variables	Direct effect	Indirect effect	Total effect
1. Effect on annoyance with road traffic noise†			
L_{Aeq24h}	0·2681	0·2431	0·5112
Interference reading	0·2476	–	0·2476
Interference conversation	0·1635	–	0·1635
Interference sleep	0·1309	–	0·1309
Hard to clean house	0·1174	–	0·1174
Length of residence	–	0·0463	0·0463
2. Effect on dissatisfaction with environment‡			
Annoyance with noise	0·4245	–	0·4245
L_{Aeq24h}	0·1401	0·1228	0·2629
Emotional condition	0·1616	–	0·1616
Interference reading	–	0·1051	0·1051
Interference conversation	–	0·0694	0·0694
Interference sleep	–	0·0556	0·0556
Hard to clean house	–	0·0498	0·0498
Length of residence	–	0·0197	0·0197
Age	–	−0·0237	−0·0237
3. Effect on wish to move§			
Annoyance of noice	0·1783	0·1053	0·2836
Dissatisf. environment	0·2480	–	0·2480
Structure of house	0·1776	–	0·1776
L_{Aeq24h}	–	0·1564	0·1564
Interference reading	–	0·0702	0·0702
Interference conversation	–	0·0464	0·0464
Interference sleep	–	0·0371	0·0371
Hard to clean house	–	0·0333	0·0333
Age	–	−0·0059	−0·0059
Length of residence	–	−0·1543	−0·1543

Coefficient of multiple correlation adjusted by deg. freedom: † 0·6584; ‡ 0·5692; § 0·4562.

the scheme proposed previously [1], in which annoyance and behavioral responses develop as the integrated and composite effects of the direct and indirect effects of noise.

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