inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 6.6

COMPARISON OF COMMUNITY RESPONSES TO ROAD TRAFFIC NOISE IN JAPAN AND SWEDEN, PART II: CAUSAL MODELING BY PATH ANALYSIS

T. Yano*, T. Sato, M. Bjorkman***, R. Rylander*****

* Kumamoto University, Kurokami 2-39-1, 860-8555, Kumamoto, Japan

** Hokkaigakuen University, Chuo Minami 26 Nishi 11-1-1, 064-0926, Sapporo, Japan

*** University of Gothenburg, Medicinaregatan 16, 413-90, Gothenburg, Sweden

Tel.: +81-96-342-3560 / Fax: +81-96-342-3569 / Email: yano@gpo.kumamoto-u.ac.jp

Keywords:
PATH ANALYSIS, ROAD TRAFFIC NOISE, ANNOYANCE, CROSS-CULTURAL

ABSTRACT
Path analysis was applied to data obtained in social surveys in Gothenburg, Sweden, Sapporo and Kumamoto, Japan, to cross-culturally compare the causal models that describe the multiple stratum relationships between road traffic noise annoyance, endogenous variables and exogenous variables. An *a priori* path model was constructed and the structure equations for the endogenous variables were formulated. The path coefficients were calculated, showing the strength of the linkage between variables. The characteristics of annoyance responses are as follows: 1) Annoyance caused by exhaust has the strongest effect on noise annoyance; 2) Structures of noise annoyance are different between Japan and Sweden and between housing types, due to differences in lifestyle.

1 - INTRODUCTION

Path analysis [1] is a method based on causality to investigate the structural linkage between many related factors and has been widely used in the field of the social sciences. Taylor [2] applied the method to a noise annoyance study around Toronto Airport. He proposed an exploratory causal model for aircraft noise annoyance in relation to several acoustical and non-acoustical factors. Izumi et al. [3] performed a path analysis on the data from social surveys on community response to road traffic noise in Hokkaido, Japan and showed the importance of noise exposure, hearing, and sleep disturbances on road traffic noise annoyance. Osada et al. also applied this method to social surveys on community response to aircraft noise around Narita Airport [4] and road traffic noise in Tokyo [5]. They confirmed that the main findings were consistent with those obtained by Taylor and Izumi et al. The present authors used this analysis in their own studies on the annoyance interaction of noise and vibration [6], the effects of noise barriers on road traffic noise annoyance [7], comparison of community responses to road traffic and railway noises [8], and so on. From these studies path analysis is found useful to compare the annoyance structures that show how various factors affect noise annoyance. This paper presents the results of path analysis applied to the data obtained in social surveys on community response to road traffic noise in Gothenburg, Sweden, and Sapporo and Kumamoto, Japan, following Part I [9]. Cross-cultural differences in road traffic noise annoyance are discussed based on the causal relationships between noise annoyance and acoustical and non-acoustical factors in the three cities.

2 - PATH ANALYSIS

Path analysis was performed to compare the causal models that describe the multiple-stratum relationships between road traffic noise annoyance, endogenous variables and exogenous variables. The path model can estimate not only the direct effect of a variable on annoyance but also the indirect effect of the variable via other variables. The exogenous variables, which are not dependent on other variables in the model, were selected from housing, personal and environmental factors and the endogenous variables

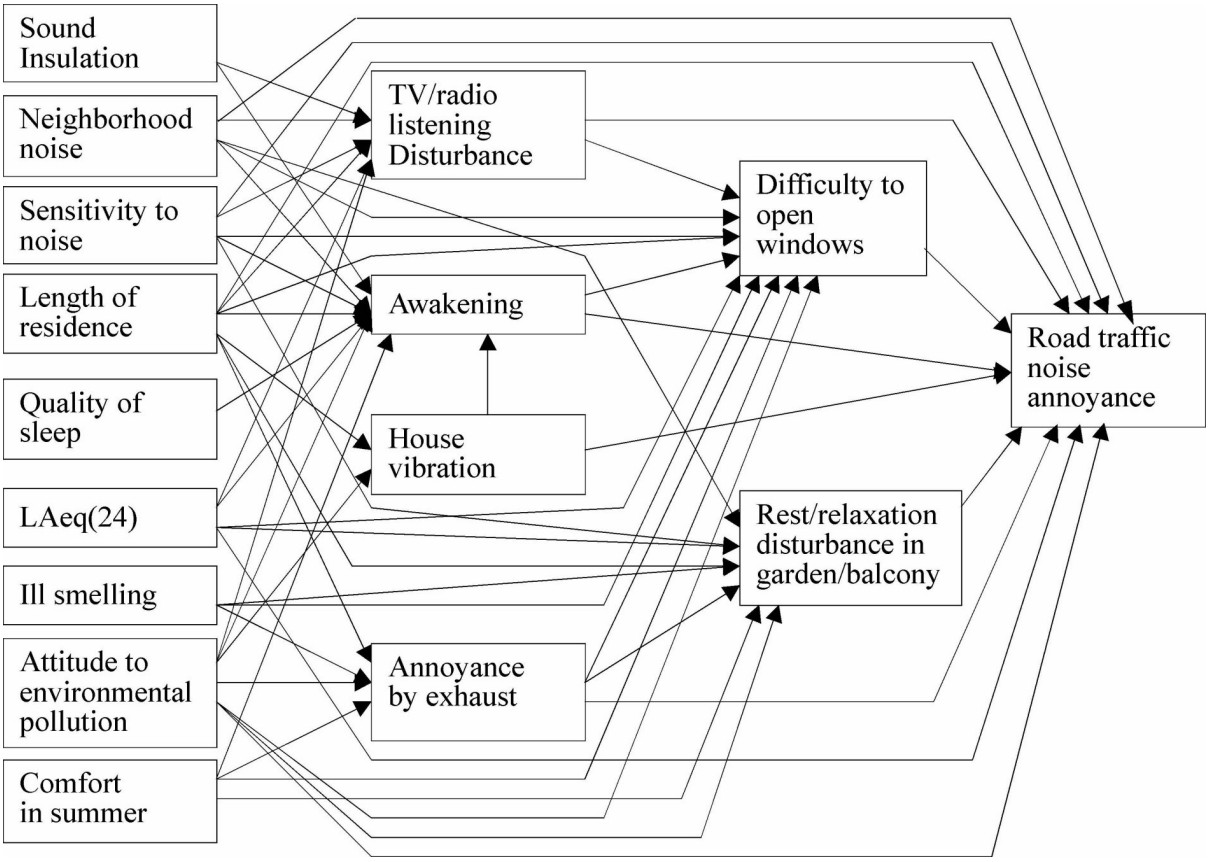

Figure 1: A priori path model of road traffic noise annoyance.

were selected from various activity disturbances and related effects, on the basis of the results of correlation between variables and discrimination by factor analysis. The endogenous variables are partially dependent on some of the exogenous and the endogenous variables and have direct effects on road traffic noise annoyance.

Noting the causal relations and the previous research findings, an *a priori* path model was constructed using nine exogenous variables and seven endogenous variables, as shown in Fig. 1. The arrows show the causal relations between the variables. For example, this model shows that $L_{\mathrm{Aeq(24)}}$ affects "road traffic noise annoyance" both directly and indirectly via "TV/radio listening disturbance." The linkage between the non-acoustical factors "house vibration" and "exhaust" and noise annoyance can be interpreted as the result of the subjective attitude toward the noise sources of a respondent who is annoyed by vibration or exhaust.

According to the normal solution of the path analysis, a series of structural equations were formulated to correspond with this *a priori* model. Most of the variables here are actually of the ordinal scale, but they are commonly treated as those of interval scale. The equations are the same as the multiple linear regression equations, and they are solved by the least square technique. The standardized partial regression coefficients are called path coefficients and show the strength of the linkage between variables. Among the paths in this model, some were not statistically significant. Deleting the insignificant paths above the 1% level, six revised path models were constructed for each housing type in the three cities. Fig. 2 summarizes the effects of significant variables on road traffic noise annoyance for the revised models.

3 - RESULTS

Observing the profiles of the effects of various factors on traffic noise annoyance that are shown in Fig. 2, the following findings were obtained:

- In almost all cases, it was found that annoyance caused by exhaust had the strongest effect on noise annoyance. This can be interpreted as an indication that annoyance caused by exhaust tends to strengthen negative attitudes towards the noise source.

- The profiles of the effects of various factors on annoyance for the same house types were similar in Sapporo and Kumamoto. However, the profiles in Gothenburg were quite different from those in the two Japanese cities. This suggests the presence of cross-cultural differences in community response to road traffic noise.

- Rest disturbance in gardens or on balconies had a strong effect on noise annoyance for people living in detached houses and a weaker, but still significant effect for those living in apartment houses in Gothenburg. However, there was no significant effect in Sapporo or Kumamoto. This is related to the Swedish customs of enjoying activities in the gardens or on balconies.

- TV/radio disturbance had quite a strong effect on noise annoyance in Sapporo and Kumamoto. In particular, the disturbances for people living in apartment houses were stronger than those for people living in detached houses. The disturbances in Kumamoto were greater than those in Sapporo. This may be due to the fact that apartment houses are apt to be more exposed to noise than detached houses and that the sound insulation of windows in Sapporo is greater than that in Kumamoto. Noise exposure is dependent on the positional relation between the road and houses. The higher the floors of houses are, the more directly they are exposed to noise and the less they are exposed to exhaust. Also double pane windows are usually used in Sapporo while single panes are usually used in Kumamoto.

- The effect of awakening is stronger in Kumamoto than Sapporo and Gothenburg. This was more remarkable for apartment houses. This trend may be due to the difference in sound insulation and noise exposure as mentioned above.

- The effect of vibration was more significant for people living in detached houses than apartments and larger in Kumamoto and Sapporo than Gothenburg. The mass of apartment houses is greater than that of detached houses. That of detached houses in Gothenburg is greater than that in Kumamoto and Sapporo. Generally speaking, the ground consists of rock in Gothenburg and soil or clay in Kumamoto and Sapporo. Thus, vibration is less easily transmitted in Gothenburg than in Kumamoto and Sapporo.

- The effects of sensitivity to noise and $L_{\mathrm{Aeq}(24)}$ are larger for apartment houses than detached houses in the three cities. This may also be due to the fact that apartment houses are apt to be more affected by noise than detached houses.

4 - DISCUSSION

There appear to be consistent rationales for the difference in annoyance profile between cities and between housing types. In Kumamoto and Sapporo, activity disturbance indoors, such as disturbance in listening to TV/radio, significantly affects noise annoyance, especially in apartment houses, while activity or rest disturbances in gardens or on balconies have a stronger effect in detached houses in Gothenburg. This may owe to the different customs in Japan and Sweden, such as spending a great deal of time in well air-conditioned rooms in the hot climate of Kumamoto, while the outdoors is enjoyed in gardens or on balconies in Gothenburg. Auditory effects like TV/radio disturbance and awakening are greater for people living in apartment houses than detached houses, probably due to the difference in balance of noise and exhaust exposure depending on the floor level.

The above differences in path models suggest that cultural differences and housing types must be considered when proposing effective noise counter-measures. For example, sound insulation measures such as airtight structures and double or more pane window are more effective for apartment houses than detached houses and more useful in Kumamoto than Gothenburg. An effective noise counter-measure for detached houses in Gothenburg, where people enjoy activities in gardens or balconies, may require not only noise abatement by sound insulation but also noise reduction from sources and measures against other pollutants like exhaust. Outdoor activities are not affected by sound insulation of houses but by pollutants emitted from road traffic. Consideration of such cultural factors may facilitate the prediction of community response to noise when the lifestyle changes over time with the social or economical conditions.

5 - SUMMARY

The characteristics of annoyance responses obtained by path analysis are as follows:

- Noise annoyance is most strongly affected by exhaust fumes.

- In Sapporo and particularly in Kumamoto, activity disturbance indoors, such as TV/radio listening disturbance, significantly affects noise annoyance, while activity or rest disturbances in gardens or on balconies have a strong effect in Gothenburg, owing to the difference in customs between Japan and western Sweden.
- The auditory effects of noise such as TV/radio listening disturbance and awakening are more remarkable for people living in apartment houses than those living in detached houses, since apartments at higher floors are more exposed to noise.
- Noise level presented by $L_{\mathrm{Aeq(24)}}$ does not have a very strong direct effect on noise annoyance.

From the two kinds of analyses in Part I and Part II, it is concluded that non-acoustical factors, particularly exhaust from road traffic and the different customs of the people living in the two different countries and in the different types of housing, are important for the evaluation of annoyance from road traffic noise. Further research is necessary to verify the findings obtained here.

ACKNOWLEDGEMENTS
Grateful ackowledgement is given here to the late President Kiyoto Izumi of Muroran Institute of Technology for giving us the opportunity to conduct the international joint study.

REFERENCES

1. **H.B. Asher**, *Causal Modeling*, 1976
2. **S.M. Taylor**, A path model of aircraft noise annoyance, *J. Sound Vib.*, Vol. 96, pp. 243-260, 1984
3. **K.Izumi et al.**, Community responses to road traffic noise: social surveys in three cities in Hokkaido, *J. Sound Vib.*, Vol. 151, pp. 505-512, 1991
4. **Y. Osada et al.**, Path analysis of aircraft noise annoyance in a community response survey, *J. Acoust. Soc. Jpn.*, Vol. 53, pp. 599-604, 1997
5. **Y. Osada et al.**, Path analysis of the community response to road traffic noise, *J. Sound Vib.*, Vol. 205, pp. 493-498, 1997
6. **T. Sato**, Path analyses of the effects of vibration on road traffic and railway noise annoyance, In *The 1994 International Congress on Noise Control Engineering*, pp. 923-928, 1994
7. **T. Yano et al.**, Effects of noise barriers on annoyance caused by road traffic noise from Kyushu highway, In *The 1997 International Congress on Noise Control Engineering*, pp. 1253-1256, 1997
8. **T. Yano et al.**, Comparison of responses to road traffic and railway noises, In *7th International Congress on Noise as a Public Health Problem*, pp. 582-585, 1998
9. **T. Sato et al.**, Comparison of community responses to road traffic noise in Japan and Sweden: outline of surveys and dose-response relationships, In *The 2000 International Congress on Noise Control Engineering*, 2000

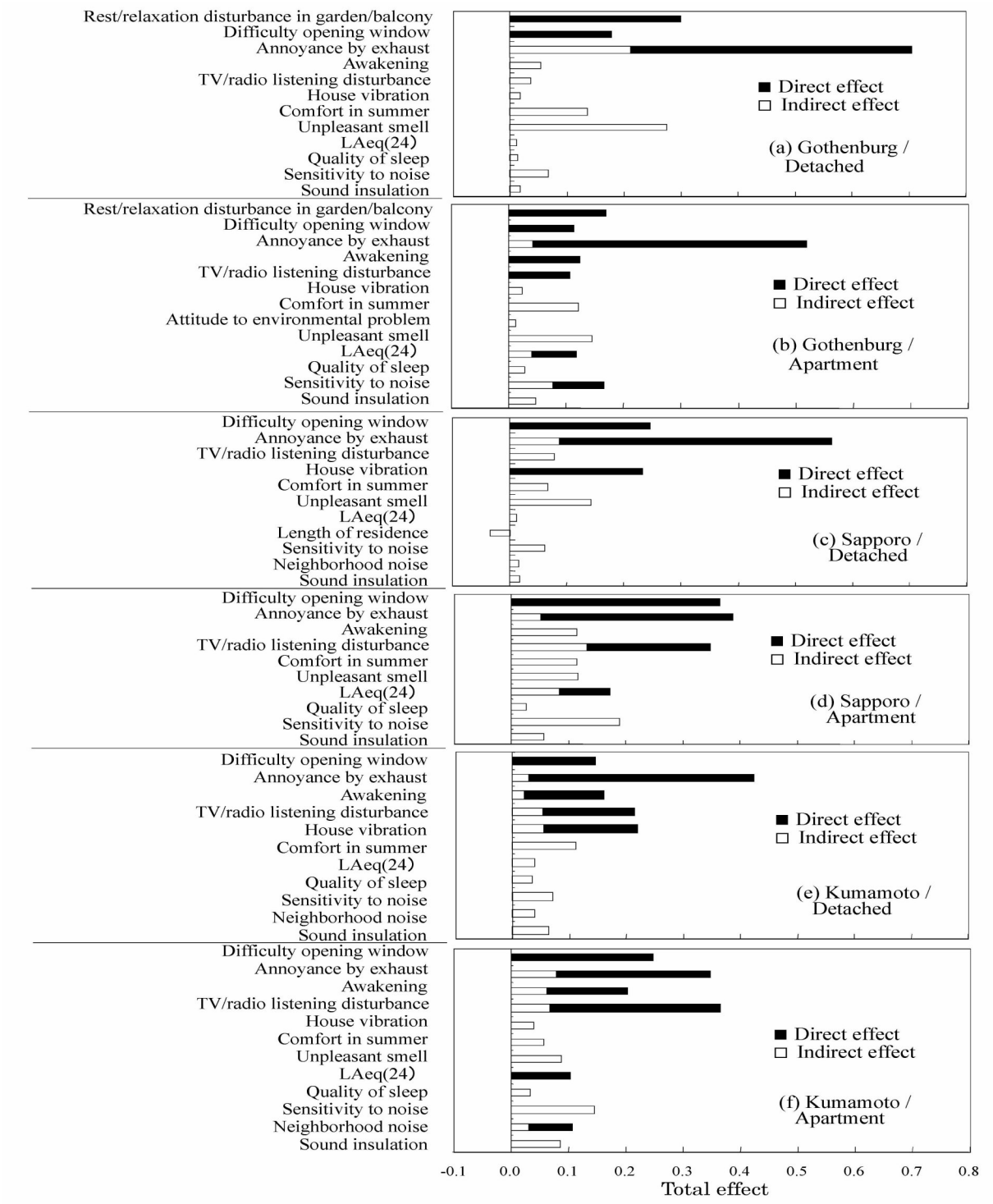

Figure 2: Effect on road traffic noise annoyance for revised model.