inter-noise 83

THE USE OF TIME-ABOVE MEASURES TO PREDICT SPEECH INTERFERENCE FROM AIRCRAFT AND ROAD TRAFFIC NOISE

Fred L. Hall, John E. Palmer and S. Martin Taylor

Department of Civil Engineering and Department of Geography, McMaster University, Hamilton, Ontario (L8S 4K1) Canada

INTRODUCTION

Several recent papers have shown that community response to the same noise level differs between different sources of transportation noise. Differences have been found between road traffic noise and aircraft noise [1], for road traffic and rail-line noise [2, 3], and between any two of road, rail, and aircraft noise [4, 5]. All of these differences arise when a long-term averaging metric is used to measure the noise (e.g. 24-hour L_{eq}, L_{dn}, NNI). A plausible working hypothesis for such differences is that they arise because of the different time patterns of the noise from the different sources, together with differences in maximum levels. One way to specify these higher noise levels is by time-above measures: how much time during a day the sound level is above a stated threshold. This paper tests this suggestion with three time-above variables -- the time above 65, 75, and 85 dBA (TA65, TA75, TA85) -- in conjunction with 24-hour L_{eq}.

The response variable is speech interference, as measured by the percentage of respondents at each site reporting it voluntarily. This variable has been selected for three reasons. First, it has a more direct link with the physical characteristics of noise than attitudinal measures such as annoyance. Second, it is a strong correlate of annoyance, which is often used as a summary measure of noise effects. Third, earlier analyses of our data showed the greatest difference in dose-response functions between road traffic and aircraft when speech interference was used as the response variable. Consequently, it should provide the best chance to identify the usefulness of noise measures additional to time averaging metrics such as L_{eq}. The time-above measure is used because above a certain threshold it seems to be a logical indicator of speech interference effects. In addition, it shows low correlations with average noise measures, and hence introduces additional information, which may be of value.

DATA

The data for this analysis were acquired in 1975, 1976 and 1978. The road traffic data used here are a subset of a larger data set collected during 1975 and 1976. Twenty-three sites have been selected, for which road noise was the only major non-residential noise, and at which no collective complaint activity had occurred. The aircraft data were acquired in a 1978 study, which is described in [1]. Brief descriptions of the response variable, and of the acquisition of the noise data for the two sources are given here.

The speech interference information was obtained in response to the open-ended question, "Are there any activities which (source) noise interrupts?" The variable used in the analysis is the percentage of respondents at each of the 53 aircraft sites and 23 road traffic sites who reported some form of speech interference. Percentages are based on 10-15 respondents per site for aircraft noise, and 25-30 respondents per site for road traffic noise.

For aircraft noise, the US FAA Integrated Noise Model was used to estimate both average levels (24-hour L_{eq}) and three time-above measures (TA65, TA75, and TA85). For road traffic noise, the levels have been obtained from field measurements. In this case, the time-above measures have been calculated from the $L_{\%}$ information recorded by the monitors. Both sets of sound level data represent outdoor levels for an average summer weekday.

ANALYSIS AND RESULTS

The principal question is whether a time-above measure adds sufficient information about the noise source to explain some of the differences in community response observed between aircraft and road traffic noise. That question is addressed through three steps in this analysis. First, for each source separately and for the combined data, is a time-above measure more highly correlated than L_{eq} with speech interference? Second, do L_{eq} and a time-above measure taken together improve explanation of speech interference over either alone, for each source separately? Finally, for the combined data from the two sources, is the importance of the source-specific term in a regression equation reduced when the time-above measure is added?

The first question receives an ambiguous answer. For aircraft noise, TA85 is almost as highly correlated as L_{eq} with speech interference (Table 1). For road traffic, TA65 is marginally better than L_{eq}. The problem is that a different threshold is obviously needed for the two sources, according to the correlation results. However, when the data for both sources are combined, any one of the time-above measures is found to be a better correlate of speech interference than is L_{eq}. Hence there is reason to expect that one of the time-above measures may help to explain the cross-source differences, but it is not at all clear which one.

There is also the possibility that time-above plus L_{eq} explain more of the variation in speech interference effects than either alone, for a single noise source. This was investigated by comparing the R^2 values for step-wise regression analyses. Again, the results are ambiguous. On the one hand, some improvement did occur: a 20% increase in R^2 (from 0.64 to 0.77) for road traffic, using TA75: and a 30% increase (from 0.24 to 0.31) for aircraft noise, using TA65. (These were the best equations for each source.) On the other hand, a different time-above measure provides the improvement in each case, and the overall explanation is not increased as much as one would expect in light of the low correlation between time-above and L_{eq}. Further, there is still a considerable difference between the two noise sources -- this time with respect to the overall level of explanation.

The final question, then, is whether a time-above measure and L_{eq} jointly explain variations in speech interference across the two sources, even though they do not do so for one source alone. A forced regression approach has been used, entering L_{eq} first, then the time-above measures, and finally a dummy variable (0 for aircraft, 1 for road traffic). The results show that none of the time-above measures solve the problem of the cross-source differences. The dummy, or source-specific, variable remains highly significant for all three time-above measures, more than doubling the R^2 achieved with L_{eq} and time-above (Table 2). Further, in the equations without the dummy variable, L_{eq} does not enter significantly, suggesting that L_{eq} and time-above measures do not combine additively to explain speech interference. Finally, with the dummy variable, none of the three time-above measures provide results that warrant much confidence: the sign on TA65 is counter-intuitive; the coefficient for TA75 is not significant; and TA85 is non-zero for only 3 road traffic sites (although certainly the equation for this variable is sensible).

Hence it appears that the time-above measures are not sufficient to explain the difference in response to road traffic noise and aircraft noise. Alone, they are better cross-source predictors than 24-hour L_{eq}, but are the same as L_{eq} for predicting the speech interference effects of either source considered separately. Even in combination with L_{eq}, the time-above measures are not as significant in an equation as a dummy variable for the source. Other accoustical variables will need to be considered to explain the difference in the effects of the two noise sources.

REFERENCES

[1] Hall, F.L., S.E. Birnie, S.M. Taylor, and J.E. Palmer, "Direct comparison of community response to road traffic noise and to aircraft noise", J. Acoust. Soc. Am. 70, 1690-1698 (1981).

[2] Knall, V., The differing annoyance levels of rail and road traffic noise. Presented at the Third International Workshop on Railway

and Tracked Transit System Noise, Monument, Colorado, 8-10 April, (1981).

[3] De Jong, R.G., Some developments in community response research since the second international workshop on railway and tracked transit system noise. Presented at the Third International Workshop on Railway and Tracked Transit Noise, Monument, Colorado, 8-10 April, (1981).

[4] Fields, J.M. and J.G. Walker, Comparing the relationships between noise level and annoyance in different surveys: a railway noise vs aircraft and road traffic comparison. J. Sound Vib 81, 51-80, (1982).

[5] Ahrlin, U. and R. Rylander, Annoyance caused by different environmental noises. J. Sound Vib 66, 459-462 (1979).

TABLE 1

Correlations with speech interference, by source

	L_{eq}	TA65	TA75	TA85
Aircraft noise	$.49^a$	$-.03^n$	$.27^n$	$.46^a$
Road traffic noise	$.79^a$	$.83^a$	$.58^b$	$.67^{a*}$
Combined sources	$.06^n$	$.31^b$	$.55^a$	$.44^a$

Notes: [a] coefficient significant at .001 level
[b] coefficient significant at .01 level
[c] coefficient significant at .05 level
[n] not significant at .05 level
[*] only 3 of 23 sites have TA85 > 0

TABLE 2

Step-wise regression results using L_{eq}, time-above, and a dummy variable, for combined data (Notes as in Table 1)

Variable added	Equation	R^2 Original (L_{eq} only)	R^2 with extra variable	improvement
TA	$\%SI=32.2^n-0.171^nL+0.248^bTA65$	.004	.096	.092
	$\%SI=67.9^c-0.748^nL+1.139^aTA75$	.004	.224	.220
	$\%SI=78.4^c-0.800^nL+7.756^aTA85$	.004	.214	.210
D	$\%SI=-137.1^a+3.21^aL-0.196^cTA65-55.3^aD$		.542	.446
	$\%SI=-95.0^c+2.301^aL+0.051^nTA75-44.7^aD$		.507	.283
	$\%SI=-59.5^n+1.676^bL+3.315^cTA85-40.3^aD$		.539	.325