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PATH MODELLING OF AIRCRAFT NOISE ANNOYANCE

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INTRODUCTION

In the recent literature, the development of disaggregate models of noise annoyance has received far less attention than has the search for aggregate dose-response relationships. However, the most recent findings which point to source differences in dose-response functions raise questions which require a reconsideration of the antecedents of annoyance with the framework of a disaggregate model.

The purpose in this paper is to examine the antecedents of individual annoyance due to aircraft noise. This is accomplished in two stages. The first involves specifying a path model of annoyance to define the antecedent variables and the structural links among them. The second involves testing the model to determine statistically the strengths of the effects of each variable on annoyance.

A PATH MODEL OF AIRCRAFT NOISE ANNOYANCE

A path model describes the direct and indirect effects of a set of independent variables on one or more dependent variables. In this case, the independent variables are the antecedents of annoyance and the dependent variable is the annoyance itself. In the absence of a theory of noise annoyance, specification of the independent variables and of the structural links among them depends on the partial evidence available from previous empirical studies and on the researcher's ability to construct a plausible conceptual model. Borsky [1] has synthesized past results and suggests that fear of crashes, perceived misfeasance, perceived health effects, judged importance of aircraft operations and personal sensitivity are among the most significant factors affecting aircraft noise annoyance. He points out that inferences from previous studies are limited by a general failure to separate the direct and indirect effects of independent variables and to take account of the covariations among them. It is in overcoming these limitations that a path modelling approach is especially valuable.

The initial path model for this analysis postulates an individual's annoyance at aircraft noise to be a function of seventeen antecedent factors. Of these, twelve are exogenous, that is variables which within the model are not dependent on any other factors, and the remaining five (excluding annoyance) are endogenous and therefore hypothesized to be partially determined by specified exogenous variables. The twelve exogenous variables divide into three subsets: three noise exposure measures (aircraft $Leq_{(24)}$, location of the resident's home relative to the flight path, background $Leq_{(24)}$); seven personal background characteristics (sex, age, level of education, presence of children at home, personal sensitivity to noise, hours spent outside on a weekend and length of residence); and two measures of general attitudes toward aircraft operations. The five endogenous variables mediate the indirect effects on annoyance of various exogenous variables as well as exerting direct effects of their own. The endogenous factors are the individual's perception of the non-noise effects of aircraft (eg. air pollution), personal concern about aircraft accidents, whether or not windows are kept closed to avoid unwanted noise, speech interference and sleep disturbance. The last two function as the immediate antecedents of annoyance and depend upon many of the exogenous and endogenous variables previously mentioned.

PATH ANALYSIS

The data used to test the model were collected in our 1978 survey of community response to aircraft noise and road traffic noise around Toronto International Airport. Information was obtained from 673 residents, approximately 12-15 at each of 56 sites. The aircraft noise exposure was estimated using the U.S. Federal Aviation Administration Integrated Noise Model. The range from the quietest to the noisiest site was 55-72 dBA (Leq_{24}). The annoyance measure used in the analysis is the individual's overall annoyance at aircraft noise measured on an eleven point numeric scale ranging from 0 (not at all disturbed) to 10 (unbearably disturbed).

The path model was expressed as six structural equations, one for each of the endogenous variables (including annoyance). The path coefficients for each equation were calculated as standardized partial regression coefficients using the ordinary least squares method. The results showed that many of the paths specified in the initial model were not statistically signficant. This led to the development of a revised model including only those paths statistically supported in the first stage of the analysis.

The revised path model contains six of the original twelve exogenous variables: aircraft $Leq_{(24)}$, flight path location, age, sensitivity, and the two measures of attitude towards aircraft operations. Three of the five endogenous variables remain: perception of non-noise effects, speech interference and sleep disturbance. Path coefficients estimated for this model are the basis for calculating the direct and indirect effects for each of the antecedents of annoyance. The eight variables which have direct effects together account for 40.1 percent of the variation in annoyance. The summary of these effects (Table 1) shows the nine independent variables ordered by the strength of their total effect.

Table 1. Summary of effects on aircraft noise annoyance

DEPENDENT VARIABLE	INDEPENDENT VARIABLES	Direct Effect	Indirect Effect	Total Effect
Aircraft noise annoyance	Sensitivity	0.195	0.093	0.288
	Speech interference	0.286	-	0.286
	Aircraft $Leq_{(24)}$	0.115	0.119	0.234
	Attitude to a/c operations I	0.201	-	0.201
	Sleep Disturbance	0.188	-	0.188
	Flight path location	0.086	0.026	0.112
	Attitude to a/c operations II	0.078	-	0.078
	Non-noise effects of a/c	0.071	-	0.071
	Age	-	-0.016	-0.016

Personal sensitivity to noise emerges as having the strongest effect on annoyance. This finding reinforces the conclusion of previous studies [2] which have shown sensitivity as a major determinant of annoyance. The second strongest total effect is for speech interference. This result suggests that annoyance may be strongly affected by the maximum noise levels associated with flyover events since these are most likely to determine the degree of speech interference.

Aircraft noise, represented by 24 hour Leq, is the third ranking variable in order of total effect. In terms of direct effect, it ranks only fifth but it has stronger indirect effects than any other variable. The finding in previous studies [3] that noise exposure is not necessarily the primary determinant of annoyance, is supported by this analysis. However, this conclusion must be qualified by the choice of noise descriptor. The argument just mentioned to explain the importance of speech interference suggests that the use of a maximum level measure might have increased the total effect attributable to aircraft noise. The effect of the other aircraft noise exposure variable, flight path location, is significant but not strong, ranking seventh overall, which may in part be due to difficulties in precisely defining flight paths.

Other important influences on annoyance include general attitudes towards aircraft operations, particularly opinions on whether sufficient is done to reduce the adverse effects of aircraft, which ranks fourth in total effect. The effect of sleep disturbance is also significant, although weaker than that for speech interference. This may reflect the scheduling of operations at Toronto Airport which includes a nominal curfew after 2300 hours.

CONCLUSIONS

The results of this path analysis show that the following variables have the strongest effects on aircraft noise annoyance: sensitivity; speech interference; aircraft $Leq_{(24)}$; attitudes toward aircraft operations; and sleep disturbance. These findings lead to hypotheses about the factors which may underlie source differences in dose-response functions. In particular, the strong effect shown for speech interference implies the importance of the maximum levels of noise events. It follows that source differences (eg. aircraft vs. road traffic) in maximum levels for the same $Leq_{(24)}$ may explain the direction of the reported differences in dose-response relationships.

REFERENCES

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[3] W.K. Connor and H.P. Patterson, Community Reaction to Aircraft Noise around Smaller City Airports, NASA CR-2104, Washington, D.C., (1972).