# 41. COMMUNITY REACTIONS TO AIRCRAFT NOISE

## PUBLIC REACTIONS

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## SUMMARY

In summary, the greater the noise exposure, the greater is the annoyance in a direct linear ratio for only about half the population survey. Aircraft noise exposure culminated in complaint behavior for a small but statistically significant proportion of this group. For the other half of the sample, the evidence is that annoyance does not have a simple monotonic relationship to noise exposure. Mediating factors operate so that as exposure increases beyond about 90 PNdB, there is not a corresponding increase in annoyance. Six primary and seven secondary mediating factors are identified. Further examination of these and other influences will be determined in future research.

## INTRODUCTION

A question which can properly be asked of the finding that a given composite noise exposure and annoyance are correlated can be put this way: Does aircraft noise exposure really lead to profound and direct annoyance, or are there factors other than exposure itself that "trigger" annoyance reactions? The presence of social and psychological influences has been known, in a general sense, since the first pilot studies of community reactions to aircraft noise, but their precise definition and the extent of their explanatory power is at present unknown. A central part of the study for NASA (under Contract NASw-1549) was devoted to answering the question, "What conditions, if any, exist to make the connection between aircraft noise exposure and annoyance more or less pronounced?"

## SCOPE OF RESEARCH

To answer this question, it was decided to conduct interviews with persons living near seven of our nation's largest international airports. In the first phase of the research, hour-long interviews were obtained in 4212 households within a 12-mile radius of four major cities: two in the Midwest, one in the Southwest, and one on the West Coast. The interviews and noise measurements by acoustical scientists were obtained in the late summer of 1967. In the second phase, not yet underway, the research is scheduled to be carried out in three Eastern cities.

The total research program encompasses an active data gathering and data reduction period of 2 years, in which two types of data are taken in the field. A noise measuring team obtains physical measurements of noise in sectors of the community where social scientists are also working. These noise measurements are presented in reference 1.

## SAMPLING PLAN

The general location of the data gathering near the airports is indicated in figure 1. In all social surveys, careful consideration must be given to the selection of persons to be interviewed who are representative of a total population or universe of well-defined characteristics. The concern in this study was to ensure that interviewees were representative of the total population of persons exposed to relatively high levels of aircraft noise near major airports.

The modified probability sampling plan shown in figure 1 is technically what is called a "three-stage-judgment, stratified probability sample," but for convenience it is labeled "Thunderbird", since the noise measurement data and interviews were collected in scattered areas roughly circumscribed by the boundaries of an Indian "thunderbird" design emanating from the ends of the most often used runways at the various airports, supplementary data being gathered in all areas immediately adjacent to the airport sites. The sampling plan ensured that data would be gathered under flight paths up to 12 miles from the end of the runways, and that representative areas overflown by approach and landing patterns would be included.

The blocks in which noise measurements were made coincided with areas where interviewers were working, whenever possible. These scattered sampling points were selected so that the widest possible range of income classes was represented in the different noise exposure areas. Blocks were numbered within these areas, and interviewing was conducted in the chosen blocks by a rotation procedure. Interviewers were given addresses to call upon, the number depending upon the quota of interviews needed within each block or census tract. The choice of the homes in which data were gathered was not left to the interviewer to determine; the selection was prearranged according to the sampling plan. In order to study the relationship between noise exposure and psychological or social reactions, it was necessary to assign to each household a noise exposure number. Therefore, noise measurements were made in each census tract during a 2- to 3-week period concurrent with interviewing.

## DEFINITION OF ANNOYANCE

The first index of reactions to aircraft noise was a replication of a measure developed by the National Opinion Research Center for their studies of reactions to noise from

U.S. Air Force Bases in 1952 and 1955 to 1957. This index was the first of six ways of measuring annoyances that were explored before it was decided to settle on a composite index based primarily on attitudinal reactions to disturbance of daily activities. The initial disturbance measure was constructed in this manner: Respondents that were bothered by aircraft noise and who freely volunteered, first without prompting and later with prompting, were asked to identify the kinds of daily activities that were disturbed by the noise and to indicate how bothered they were. Answers were scored according to the scale in a little device called an "opinion thermometer." (See fig. 2.)

A person who answered "not at all" to disturbance of sleep, for example, chose a score of one; if he was "extremely disturbed," he chose a score of 5. Intermediate points on the scale, of course, referred to intermediate degrees of sleep disturbance, according to the respondent's own estimation. Responses from the 4212 persons interviewed were approximately normally distributed, with a modal position of three-on the scale. A total of 4153 persons - 98.6 percent of the total sample - reported one or more disturbances of daily activities by aircraft noise and, correspondingly, at least some degree of bother. A total of 76 percent of the sample - 3188 persons - had an average position of three or higher on the opinion thermometer scale.

Percentages of persons in the total sample who reported "extreme bother," that is, who reported a No. 5 response for disturbed activities are shown in table I. The most disturbed activity is television or radio reception; next is interruption of face-to-face conversation.

The disturbance index termed annoyance *(G)* was made up by simply adding the opinion thermometer scores for each activity disturbed. Each respondent was then eligible for a disturbance score of from 1 to 45, depending on his distribution of responses. The mean for this distribution was 24. Less than 2 percent of the sampled population had a score of zero.

The final summary annoyance measure was constructed by weighting and adding to this disturbance index the respondents' scores from other variables such as past annoyance with airplane noise, perception of neighbors being annoyed by the noise, and perception of airplane noise being a city-wide problem.

In an analysis of the interrelationships of these variables within the annoyance dimension, a Varimax factor analysis revealed the factor "loadings," which can be thought of as equivalent to within-class correlation coefficients between each item and the cluster of items that make up the annoyance dimension. See table II. On the basis of standardized weights, also determined by Varimax rotation, a new summary criterion measure, annoyance (R), was constructed, with a range of from 1 to 15.

Varimax factor weights were used to describe the relative influence of each item on the composite annoyance (R) scale, which consists of the highly intercorrelated annoyance-type responses being discussed. The summary annoyance (R) scale was thus constructed as follows:

$$\text{Annoyance (R)} = 0.1900(V6) + 0.2088(V3) + 0.2473(V1) + 0.2494(V2)$$

The simple product-moment correlation between exposure and annoyance (R) for the four-city sample is a rather low 0.35. However, in the presence of other conditions this correlation is increased to 0.65. By projecting the multiple correlation coefficient to population parameters, it is estimated that nearly all the persons in high exposure zones are annoyed under certain conditions. These specifying conditions will now be discussed.

## PREDICTORS OF ANNOYANCE

With this clarification of the operational meaning of annoyance, the question of the relative influence of aircraft noise exposure itself can be considered in comparison with other relevant variables in predicting annoyance reactions. For the sample as a whole in the four Phase I cities, aircraft noise exposure accounted for nearly 6 percent of the variance in annoyance. This result means that a significant portion of annoyance can be traced to noise exposure itself. In addition, however, high noise exposure accompanied by certain other conditions explains nearly half of the variance in annoyance scores - a total of 45 percent. Of these conditions, six are important in that they account for an accumulated total of one-third of the variation in annoyance reactions:

(1) Awareness of aircraft between midnight and 6 a.m., particularly between the hours of midnight and 3 a.m.

(2) High exposure, generally above the 90 PNdB level

(3) Respondent sensitivity to noise in general

(4) Underlying awareness of marked increases in the frequency of jet traffic for the past 5 years

(5) Unwillingness to adapt to additional increases in aircraft noise

(6) Having a past history of complaints to public officials about neighborhood inconveniences.

The analysis demonstrates that these predictors are independent, that is, are not significantly correlated among themselves for the range of noise exposure studied. It is possible, therefore, to estimate the contribution that each one makes to mean annoyance levels for the populations under study. It should be kept in mind that these predictors are valid for the combined sample of the four Phase I cities but may not be universally applicable. Greater confidence in the ordering of these specifying conditions at the conclusion of the study will follow analysis of the Phase II data.

The average annoyance levels are more than doubled when aircraft are heard during the sleeping hours between midnight and 6 a.m. These levels are increased by two-thirds under high average aircraft noise exposure and are increased by about one-third when high general noise sensitivity is present. The other factors – perception of increases in the frequency of jet traffic, unwillingness to adapt to increased aircraft noise, and having a past complaint history – lead to slight but notable increases in annoyance.

To pinpoint these and other effects more precisely, a multiple regression analysis was conducted in which weights for each predictor variable were computed. In their simplest sense, these weights measure changes in mean annoyance scores in terms of standard deviation units of each predictor variable. This procedure assures the same variability of the predictors so that they can be directly compared in terms of their joint power in predicting differences on the annoyance (R) scale. In other words, the weights determine the slope of the regression of mean annoyance scores, shown as y in figure 3, for values of each predictor variable, expressed as x. Each person in this scattergram is a dot, the position of which represents his score on two variables – for example, his annoyance score along the ordinate or y-axis of the figure and his aircraft noise exposure score along the abscissa. The regression line is drawn through the midpoint or mean of the distribution of annoyance scores for each category of noise exposure.

The degree of slope of the line tells immediately whether there is an increase in average annoyance as noise exposure increases. As indicated earlier, there would be a slight rise in the line if only noise exposure was considered in attempting to predict annoyance. The line rises, however, if not only noise exposure but also social-psychological factors, the most important of which are nighttime noise exposure and high sensitivity to noise, are taken into account.

The equation used for determining the slope of the regression line and the standardized weighting factors for the variables discussed are shown in table III. The predictor variables are listed along the left side of this table, and their standardized weights are shown as the beta regression coefficient $b^*$.

The purpose of a multiple regression analysis such as this analysis is to predict a particular value or score for a person having a certain combination of characteristics; that is, to know how well all predictor variables acting together explain differences in the criterion measure. Thus, the amount of variation around mean annoyance levels is in part accounted for by the contribution of each predictor variable. The difference in mean annoyance levels not accounted for by these coefficients is an unexplained variation, that is, the error term in the regression equation. The research problem is to find the best set of variables to reduce error in predicting mean annoyance scores for different groups and different cities under study. Forty-five percent of the differences in mean annoyance levels with the primary set of predictors are accounted for, and the results are highly significant, at the 0.9999 confidence level.

## SECONDARY PREDICTORS OF ANNOYANCE

Early in the analysis, it was discovered that the best set of predictors of annoyance in one exposure zone was not necessarily the best set in other zones and that some conditions of annoyance have greater general applicability than others since they appear to be independent of degree of exposure to aircraft noise, whereas other conditions appear to be either a function of exposure or tend to mediate the relationship between exposure and annoyance. Thus, certain predictors are important in high noise exposure areas and are unimportant in low exposure zones.

For the purposes of this paper, table IV presents a summary typology of these predictors of annoyance within five mutually exclusive noise exposure classes. Here, as before, the larger the magnitude of the regression coefficient, the greater the reduction of error in predicting annoyance. This classification shows that persons living in high exposure ranges who scale high in annoyance are generally in high income brackets, were not aware of the extent of airport-related noise when they moved into the neighborhood, are generally dissatisfied with their neighborhood environments, and are aware of neighbors moving away because of the noise.

Persons living in moderate exposure ranges who show high annoyance tend to be women who are at home during most hours of the week and believe they cannot accept further increases in aircraft noise exposure, but believe that the airport industry is important to the economy of the city.

Persons living in low noise exposure ranges who are high in annoyance tend to be young adult males who are exposed to aircraft traffic mostly during the weekends, who occupy high occupational positions, have stable residence histories, and believe that neighbors have been influenced to leave because of aircraft noise.

Persons in all exposure ranges who say they are annoyed perceive a steady increase in the volume of air traffic over their neighborhoods and have a history of complaining to public officials about one problem or another. Thus, persons who appear to be the most annoyed know how and to whom to complain, and this knowledge appears to increase their apprehension about real or imagined noise exposure.

## CONCLUDING REMARKS

For the sample as a whole and across all exposure ranges, the predictors of annoyance with the greatest general applicability are, in their order of importance ·

(1) Aware of aircraft between midnight and 6 a.m.

(2) Live in high aircraft exposure areas

(3) Have high noise susceptibility

(4) Perceive a steady increase in the amount of air traffic

(5) Argue that they would be unable to adapt to increased exposure

(6) Have knowledge of how to complain effectively.

Secondary factors which explain additional variation in annoyance scores in some localities include

(1) Living from 3 to 6 miles from the airport

(2) High occupational status, high income, and expensive residence

(3) Having fear of aircraft crashing in the neightborhood

(4) Long-time residency in the neighborhood

(5) Knowledge of neighbors who have moved away due to aircraft noise

(6) Generally positive attitudes toward the aircraft industry

(7) Belief that the airport is important to the economy of the city.

Thus, with a knowledge of aircraft noise exposure and knowledge of the distribution of certain sociopsychological characteristics in any given locality, the probable degree of annoyance can be predicted provided, of course, that the four cities studied are representative of high aircraft exposure areas. The reliability of these predictors can be established in Phase II of the research when the addition of more cities to the study allows between-city comparisons.

## REFERENCE

1. Connor, William· K.: Community Reactions to Aircraft Noise – Noise Measurements. Conference on Progress of NASA Research Relating to Noise Alleviation of Large Subsonic Jet Aircraft, NASA SP-189, 1968. (Paper No. 40 herein.)

TABLE I. - PERCENT HIGHLY BOTHERED BY ACTIVITIES DISTURBED

| Activity | Percent highly bothered |
|---|---|
| TV/radio reception | 20.6 |
| Conversation | 14.5 |
| Telephone | 13.8 |
| Relaxing outside | 12.5 |
| Relaxing inside | 10.7 |
| Listening to records/tapes | 9.1 |
| Sleeping | 7.7 |
| Reading | 6.3 |
| Eating | 3.5 |

TABLE II. - PRINCIPAL FACTOR IN VARIMAX FACTOR ANALYSIS

| V | Variable | Loading | Standardized weights |
|---|---|---|---|
| 1 | Neighbors annoyed | 0.8004 | 0.2473 |
| 2 | Annoyance (G) | .7843 | .2494 |
| 3 | City-wide annoyance | .6158 | .2088 |
| 4 | Complaint potential | .5759 | .1883 |
| 5 | Noise adaptability | -.5241 | -.1683 |
| 6 | Past annoyance | .5014 | .1900 |
| 7 | Perceives air traffic increase | .4554 | .1258 |
| 8 | Noise induced mobility | .4387 | .1178 |

TABLE III.- PREDICTORS OF ANNOYANCE BY MULTIPLE LINEAR REGRESSION

$$\overline{Y} = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + \text{Error}$$

where

$a$ $\overline{Y}$ intercept of the regression line

Error = Residual sum of squares (variance around the regression line that cannot be accounted for by the relationship of predictor variables and annoyance)

$b^*$ standardized regression coefficients

| | Variable (x) | Regression coefficient, $b^*$ |
|---|---|---|
| $\overline{Y}$ | Index of annoyance | |
| $x_1$ | Level of perception of aircraft between midnight and 3 a.m. | 0.243 |
| $x_2$ | Summary index of aircraft noise exposure | .239 |
| $x_3$ | Frequency of perceived flyovers | .207 |
| $x_4$ | Index of complaint potential | .201 |
| $x_5$ | Index of adaptability to noise | .168 |
| $x_6$ | Noise sensitivity | .165 |
| $x_7$ | Level of perception of aircraft between 3 a.m. and 6 a.m. | .131 |

TABLE IV.- PREDICTORS OF ANNOYANCE (R) BY AIRCRAFT NOISE

| Exposure class | Annoyance predictors (x) that are independent of degree of aircraft noise exposure | Regression coefficient, b* | Predictors (x) that mediate relationship between noise exposure and annoyance | Regression coefficient, b* |
|---|---|---|---|---|
| Very high exposure range | Perceives increase in air traffic | 0.174 | High house cost | 0.527 |
| | High individual complaint potential | .170 | Positive attitude toward aircraft industry | .383 |
| | | | Fear of airplane crashes | .344 |
| | | | Home ownership | .311 |
| | | | Low neighborhood satisfaction | .154 |
| | | | No prior awareness of airplane noise | .153 |
| | | | High income | .131 |
| | | | Low paranoia | .118 |
| High exposure range | High individual complaint potential | 0.166 | Unable to adapt to increased airplane noise | 0.195 |
| | Perceives increase in air traffic | .159 | Know of neighbors moving away due to noise | .185 |
| Moderately high exposure range | Perceives increase in air traffic | 0.292 | Unable to adapt to increase in air traffic | 0.242 |
| | High individual complaint potential | .230 | Sees airport as important to city | .166 |
| | | | Positive attitude toward aircraft industry | .154 |
| Moderate exposure range | High individual complaint potential | 0.165 | See airport as important to city | 0.171 |
| | Perceives increase in air traffic | .161 | Female | .160 |
| Low exposure range | High individual complaint potential | 0.302 | Positive attitude toward aircraft industry | 0.334 |
| | Perceives increase in air traffic | .263 | Male | .298 |
| | | | Low residential mobility | .213 |
| | | | No prior awareness of aircraft noise | .153 |
| | | | High occupational position | .148 |
| | | | No family connection with aircraft industry | .137 |
| | | | Fear of airplane crashes | .133 |
| | | | Young adult age range | .130 |
| | | | Know of neighbors moving away due to noise | .130 |

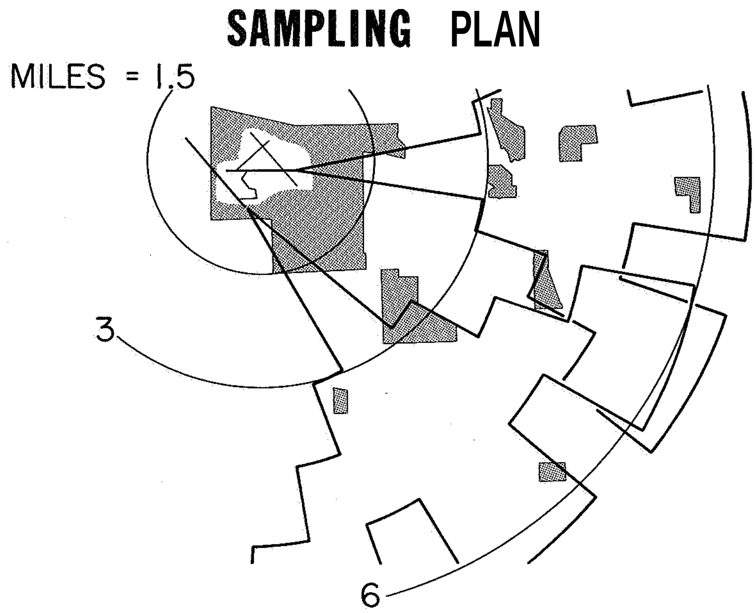



Figure 1

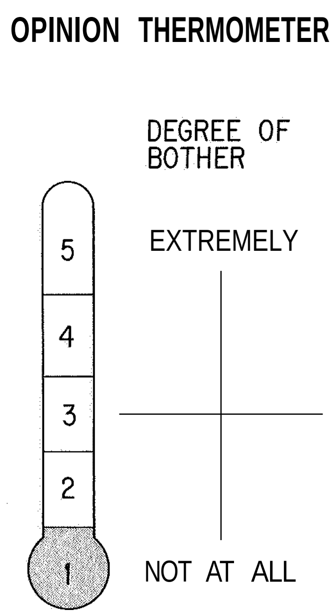
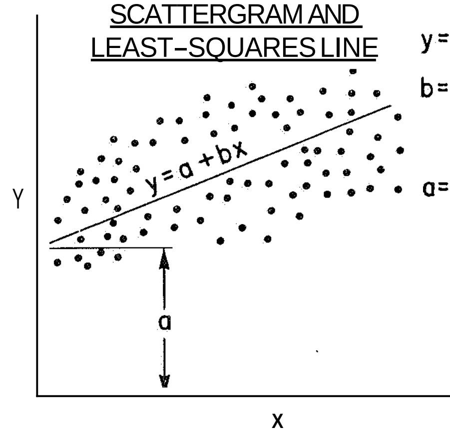



Figure 2

REGRESSION OF y ON x




$y = a + bx$ where

$b = \frac{\sum xy}{\sum x^2}$ (Regression coefficient that determines slope of regression line)

$a = y - bx$ (y-Intercept of regression line)

Figure 3