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VARIABILITY IN INDIVIDUALS' RESPONSES TO NOISE: COMMUNITY DIFFERENCES

James M. Fields

The Bionetics Corp., NASA Langley Research Center, Hampton, VA, 23665

INTRODUCTION

Community differences in individuals' responses to equal noise levels from the same source have not been documented. Community differences measured in social surveys provide data needed to (1) design efficient social survey samples and (2) estimate the strength of community characteristics such as unmeasured aspects of community noise environmemts.

DATA AND METHODS

Data on community differences come from comparisons of annoyance levels at different study sites contained in a single social survey. The effects of differences in measured noise levels are removed before the community response differences are calculated by analyzing only the residual annoyance scores from a linear regression of annoyance on noise level. For a small number of communities the reactions can then be compared by using the means of the residual annoyance scores of the communities. For many communities the community variations can be summarized by the standard deviation of the normalized community differences corrected for the random variation within communities in individual annoyance scores. This "community effect" (σ_α) and the remaining "error" or individual effect (σ_e) are the square roots of the between-group and within-group variance components in a one-way, random effects analysis of variance.

These statistics have been computed for eight surveys (15,730 respondents). To adjust for differences in the surveys' annoyance scales, the group (σ_α) and individual (σ_e) effects are expressed in standardized units "Decibel Equivalent Units", the number of decibels which would create an equivalent effect on annoyance. The Decibel Equivalent values are computed by dividing a statistic (the standard deviation or difference of means which was measured in annoyance scale units) by the regression coefficient from the regression of that annoyance scale on noise level.

FINDINGS

The noise adjusted annoyance scores for each of the airports in the USA Nine Airport Study [1] have been calculated in terms of their differences from the least annoyed city, Chattanooga. The decibel equivalents of these differences are the following: Denver, + 1 dB; Chicago, + 3 dB; Dallas, + 3 dB; Miami, + 4 dB; Reno, + 5 dB; Los Angeles, + 11 dB; New York, + 16 dB; and Boston, + 18 dB. This produced a community effect of σ_α = 7.1 dB. (Differences were not reduced by alternatives to the logarithmic transformation of the number of events.)

The remaining surveys' 11 estimates of the community effect pertain to small neighborhood community units (usually adjoining homes on a single street). The community effects found in Table 1 are significant ($p < .01$) and vary from σ_α = 3.4 to 10.0 dB (median of 6 dB).

TABLE 1: EFFECT OF COMMUNITY DIFFERENCES

Study and Noise Source[a]	Community Groups: Number of Groups	People per group	Additional Variance Explained[b]	Group Effect (σ_α)	Individual Effect (σ_e)
1968 London-Road Traffic [2]	11	81	7.3%	8.2 dB	28.0 dB
1972 London-Road Traffic [3]	53	54	11.7%	7.8 dB	22.3 dB
London panel study-Road Traffic [4]					
Round #1	6	61	4.8%	5.5 dB	20.7 dB
Round #2	6	46	10.1%	10.0 dB	24.8 dB
Round #3	6	41	8.3%	6.3 dB	17.0 dB
Round #4	6	37	6.6%	6.0 dB	19.4 dB
1975 So. Ontario - Community [5]	28	30	11.0%	5.2 dB	15.2 dB
1976 So. Ontario - Community [5]	33	25	8.7%	7.8 dB	31.5 dB
Western Ontario-Road [6]	44	25	10.0%	4.7 dB	15.0 dB
Toronto Airport [7]					
-Main Road	56	12	15.0%	3.4 dB	8.3 dB
-Aircraft	56	12	14.8%	5.0 dB	16.2 dB

a Noise is measured in L_{10} for the 1968 London study and in L_{eq} dB(A) for all others.

b This is the increase in sq. multiple correlation coefficient (R^2) when communities are added as dummy variables into a multiple regression equation which previously only included noise level.

The individual effects in the last column (σ_e) are from 2 to 4 times greater than the community effects. The estimates of the community effect were not reduced when other annoyance questions, noise metrics, or shapes of noise-annoyance relationships were considered.

DISCUSSION

The community effects are of potential practical importance because they concern a level of aggregation, communities, which are the units for noise policy. The causes of the observed community effects must be factors which are shared in a community, such as public information about the noise source, history of community exposure, timing of noise events, ambient noise levels, and characteristics of the noise source not represented in a noise index. The estimated "community effects" are to some extent inflated by any errors in noise or social survey measurements which are relatively constant within communities.

Although community differences are of practical importance they can not be a major explanation for the large variation in individual annoyance scores which is found in social surveys. Table 1 shows that the community effects increase the explained variance in individual annoyance scores by about 10% but never more than 15% beyond that which is due to noise level. These results do not support the belief that better community noise measurements or noise metrics will explain most of the large variation in individual responses.

GUIDELINES FOR SAMPLE SIZE DECISIONS

The existence of community effects means that social surveys must carefully sample both communities and individuals. The guidelines for making sample size design decisions offered below are based on the assumptions that a single noise level is used for each community, there are approximately equal numbers of interviews in each community ($\bar{n}$), and the ratios of community and individual effects will be simi- liar to those found in Table 1. The guidelines can be applied to estimates of either mean annoyance levels or regression coefficients. The guidelines are appropriate for regression when the standard regression assumptions are met and noise level is not correlated with the community effects.[8]

The optimal number of interviews per study area ($\bar{n}_{opt}$) is assumed to be a simple function of the average cost of obtaining each interview (c_2), the average cost of including each study area (c_1), and the area effects (σ_α) and the individual effects (σ_e).

$$\bar{n}_{opt} = (c_1/c_2)^{1/2} \cdot (\sigma_e/\sigma_\alpha)$$

Thus if, for example, it cost 50 times more to include one study area (mainly noise measurement costs) than to include one individual (mainly interviewers' salaries) and if a survey near the median (London Panel study, Round 4) were taken as a guide ($\sigma_\alpha = 6.0$, $\sigma_e = 19.4$) then the optimum design would have 23 interviews per area.

Because of the community effect the total number of interviews (n) needed to achieve a given level of precision will be greater than the number (n_{srs}) which would be calculated based on the standard Simple Random Sampling assumptions implicit in standard inferential statistics. The required number of interviews for a multi-community, cluster sample is

$$n = n_{srs} \cdot \left\{ 1 + (\bar{n}_{opt}-1) \cdot [\sigma_\alpha{}^2/(\sigma_e{}^2 + \sigma_\alpha{}^2)] \right\}$$

Thus, to continue with the hypothetical example used above, if 1,000 interviews would be required of a simple random sample, then the community sample with $\bar{n}_{opt} = 23$ and $\sigma_\alpha{}^2/(\sigma_e{}^2 + \sigma_\alpha{}^2) = .09$, would need $n = 2921$ interviews.

CONCLUSION

The community effects found in these surveys after noise level differences have been removed are large enough to be of interest for noise policy but not large enough to explain the large variation in individual annoyance responses. The present data on community differences provide a basis for determining how many study sites and interviews are needed for social surveys.

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