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MEASURING RESIDENTS' REACTIONS TO NOISE WITH A MAGNITUDE SCALE

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1. INTRODUCTION

Acousticians, researchers, community activists and noise source operators have long searched for the most accurate, unbiased measure of residents' reactions to transportation and other community noise. Direct categorical rating scales have gained near universal acceptance as satisfactory measures. However, laboratory studies of loudness perception have long benefited from more powerful magnitude rating scales [4] that could also offer advantages for community noise studies. This paper reports upon an initial test of procedures for obtaining magnitude ratings of environmental noise in a residential setting.

2. ADMINISTERING THE SURVEY QUESTIONS

Residents in 13 communities in two regions in the western United States gave their reactions to local sonic booms in 30-minute, interviewer-administered questionnaires in a three-phase survey conducted from April 1993 to November 1995 under the auspices of the National Aeronautics and Space Administration. The 1578 interviews came from a probability sample of 2082 selections. The 537 interviews from the eight communities in one region are analyzed in this paper. Noise measurements were conducted but their evaluation is not completed.

After an extensive set of questions about reactions to the sonic boom environment, respondents were trained to make numeric magnitude estimates. Respondents were first given verbal instructions of approximately 100-words in length. Next they scored the lengths of seven practice lines relative to that of a "baseline" scored at 100. Six percent were unable to understand this exercise and were not asked the later annoyance magnitude scaling nuisance questions. A total of nine percent either could not complete the exercise or showed a weak understanding by misjudging even the direction of the difference from the baseline for two or more of the practice lines.

Respondents were then asked this direct, category scale question:

Q.35 Please look at CARD I to choose your next answer. [HAND CARD I TO RESPONDENT] Considering everything about the sonic booms in the last six months, would you say that you have been not at all annoyed by sonic booms, slightly annoyed by sonic booms, moderately annoyed by sonic booms, very annoyed by sonic booms or extremely annoyed by the sonic booms?

After examining the card with the five alternatives, respondents indicating any degree of annoyance were asked the next question, the annoyance magnitude estimation question.

Q36. For this next question you compare things against a baseline of how you feel about sonic booms around your home. This time your feeling that you are ...(ANSWER TO PREVIOUS QUESTION)... annoyed by sonic booms is scored one hundred. Use the sonic boom score of one hundred to measure everything else. For example if you think you would be twice as annoyed by some other noise, give that other noise a score of two hundred. If you think you would be half as annoyed by the other noise, give that noise a score of fifty and so on. There is no upper limit: use <u>any</u> number so long as it shows your annoyance. If <u>you</u> would not be at all annoyed by something give that a score of zero.

So, compared to the sonic booms around here with a score of one hundred, what score would you give to ...(having a dog next door that regularly barks in the middle of the night) ...?

	SCORE
i. having a dog next door that regularly barks in the middle of the night	
And compared to the sonic booms with a score of 100, what score would you give to..	
ii. having a front door that squeaks	
If you do not have some of these things we mention, just imagine what they might be like. Now, compared to the sonic booms with a score of 100, what score would you give to..	
iii. having unhealthy air pollution in the area	
...(Nuisances # 4 to 16 followed here)..	

The question included 16 nuisances. To maintain the focus on the comparative task, every forth or fifth nuisance was preceded by the phrase: *"And still compared to the sonic booms with a score of 100, what score would you give to.."* About 95 percent of those asked the questions scored all 16 nuisances. Interviewers reported that respondents found the questions to be interesting, enjoyable, and occasionally humorous.

3. DATA ANALYSIS

The data are analyzed to provide a sonic boom annoyance measure that is normalized relative to the feelings towards the 16 common, hypothetical nuisances that all respondents are assumed to evaluate similarly. Extensive research in both psychophysics and opinion polling has determined that people use these magnitude scales as ratio scales. [2, 4, 5] The analysis therefore proceeds by analyzing the common logarithms (base 10) of the judgements and calculating geometric means of the magnitude scores.

Figure 1 succinctly summarizes the annoyance with sonic booms in eight communities relative to the baseline provided by the 16 hypothetical nuisances. The abscissae for Figure 1 is a noise index, expressed in decibels. The data points represent the geometric means of the sonic boom ratings relative to the 16 nuisances.[1] The upper set of data points include only the respondents who answered the magnitude questions

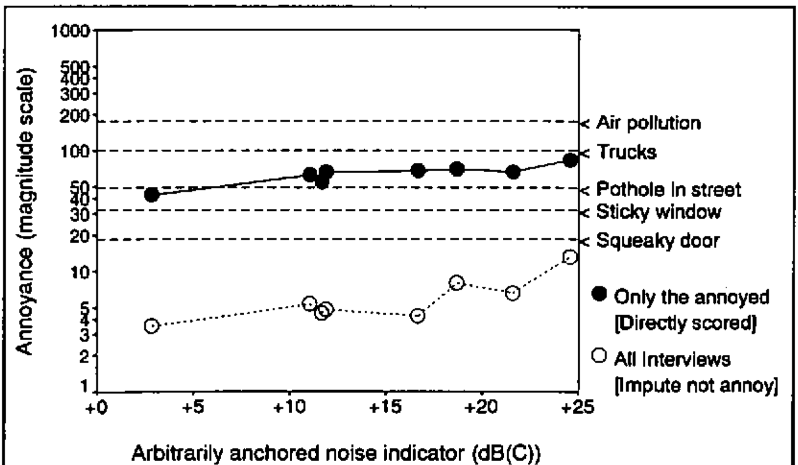

Figure 1: Annoyance with sonic booms for two interview groups

[1] In Fig. 1 the noise index is not identified because the data are still preliminary. Extremely high and low magnitude scores were truncated at the scale's limits of 1,000 and 1 respectively. Distances between the 16 nuisances are the geometric mean distances calculated for respondents who rated all 16 nuisances. These distances are unaffected by the varying (sonic boom) reference point. Once the 16 nuisances' values are expressed relative to an arbitrary point (100 for "big noisy truck", Q4), each respondent's location is the geometric mean of the respondent's scores calculated from the respondent's sonic boom-to-nuisance ratios.

(only those annoyed on the category scale were asked the magnitude questions). The lower data points add in the remaining (not annoyed) respondents by somewhat arbitrarily assigning them a score of one. The magnitude scale is logarithmically scaled as is, of course, the noise exposure scale that is expressed in decibels. Geometric means of scores for five of the 16 shared nuisances are shown on the ordinate.

This magnitude scale produces study findings for public consideration about the relative intensity of reactions to sonic booms and the 16 other, common hypothetical nuisances.[2] A categorical scale, on the other hand, only produces findings about the extensiveness of reactions. If report readers and respondents share the same feelings toward a hypothetical pothole in a street near their homes, then Figure 1 indicates that this is about the same feeling experienced, on the average, by the annoyed respondents at the lowest noise exposure. Respondents at the highest noise level felt that the sonic booms were about as annoying as they imagined "having a junkyard business that you can see from your house" would be (score of 87). With this magnitude scale the comparisons between groups of respondents can be expressed as ratios. The average annoyance at the lowest noise level (40) is approximately half that found at the site with the highest noise exposure (80). These sonic boom exposures were judged (depending on the site) to be from two to eight times more annoying than "having a front door that squeaks" and from about 1/4 to 1/2 as annoying as "having unhealthy air pollution in the area".

The correlations with the measured sonic boom exposure are similar for the magnitude estimation annoyance scale (log10) and for three of the questionnaire's category annoyance scales. The magnitude estimation scale is more closely related to noise than a measure of high annoyance (the top point on a 4-point verbal scale), or the immediately preceding, 5-point verbal category scale.[3] The shape of the noise/magnitude scale

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[2]Each of the 16 nuisances (ordered by its relative magnitude score) is preceded in the following list by the order in which it was asked ("Q..") and then followed by the geometric mean of its score on the ordinate in Fig. 1. All scores are relative to the score of 100 arbitrarily assigned to "big noisy truck" (Q4): Q3, having unhealthy air pollution in the area (176); Q16, the telephone calls you get from salespeople at home (123); Q12, having mice in your house (119); Q11, being so near a noisy, busy highway that you must raise your voice in the yard (117); Q1, having a dog next door that regularly barks in the middle of the night (106); Q4, hearing big noisy trucks if you lived at a busy intersection (100); Q6, having a junkyard business that you can see from your house (87); Q15, having a neighbor whose drink cans get onto your property (72); Q7, having a smoke detector that goes off at least once a week when someone is cooking (65); Q13, a neighbor's security light that shines into your bedroom (61); Q9, having a neighbor with power tools that sometimes make your TV picture flicker (54); Q5, having cars often pull into your driveway to turn around (53); Q14, being occasionally woken up by a neighbor's car with a bad muffler (50); Q10, having a pothole in the street near your house (49); Q8, having a sticky window that's hard to open (32); Q2, having a front door that squeaks (19).

[3] Q.35, presented above, was scored from one to five in this correlation analysis.

relationship is not significantly different from a linear shape.

4. COMPARATIVE ADVANTAGES AND DISADVANTAGES

Category scales provide useful information on empirical relationships between noise exposure and the extent of reactions more efficiently than do magnitude scales. Category scales are relatively rapidly and easily administered.[2, 3] Magnitude scales cannot even be understood by about five to 10 percent of the population. Previous research has drawn valuable information from multiple-regression and other analyses of category scales by making widely-accepted, but controversial, assumptions. This study's magnitude scale was not superior to the category scales on the single, most cited criterion for noise studies; the noise/annoyance correlation for the magnitude scale was approximately equal to that for the category scales.

One practical advantage of the magnitude scale is that it offers repeated annoyance measurements without appearing to be repetitious. Repeated telephone followups could be enlivened with these questions.

The face validity of magnitude scales is enhanced by constraining the respondent to anchor responses relative to feelings about other nuisances. The conventional category scale, on the other hand, allows the respondent to respond without reference to any explicit criteria.

The most often cited advantages of magnitude scales are theoretical. Both the nature of the numerical task and the results of psychophysical studies show that respondents use the scales to make proportional, quantitative judgments. Respondents thus place themselves on continuous, numeric scales that are consistent with the assumptions required of multiple regression and other powerful analysis techniques. Laboratory studies have repeatedly supported the basic psychophysical law that equal stimulus ratios produce equal subjective ratios and thus that the relationship between logarithmically transformed stimulus measurements and subjective judgements is linear.[1, 4] Despite the obvious differences between the laboratory and the residential settings and noise exposures, these theories provide the firmest available theoretical basis for predicting a particular form (linear) of the relationship between noise exposure and residents' reactions.

5. LESSONS LEARNED FROM THIS STUDY

The particular magnitude scale question used in this study has several strengths for community noise studies. By referring to repetitive, ongoing experiences rather than to single events (the common practice for magnitude scales[1]) the scale was expected to encourage respondents to provide ratings relative to the total sonic boom environment (both the frequency and level of boom events) and not to only an average sonic boom event. The first three nuisances in the scale were chosen to span the full range of intensity and help respondents establish the boundaries of the scale. The explanatory sentence before item iii ("..just imagine..."), seems to have solved the problem in pretests with respondents who had difficulty rating hypothetical situations. The repeated reference to "...sonic booms with a score of 100..." may have enhanced the value of the scale for rating this noise source. The base of 100 probably helped respondents with the relatively difficult task of rating nuisances that were less than those for sonic booms. The introductory category scale probably helped to associate the respondent's own annoyance with the score of 100. The almost total reliance on numerical estimation without visual cues suggests that the technique could have been used for the follow-up telephone interviews that had initially been considered for this study.

The most serious weakness in the procedures used in this study is apparent from the lower set of data points in Figure 1; the respondents who were not classified as annoyed on the category scale are not scored on the magnitude scale. The magnitude scale should be revised to obtain ratings from all respondents; perhaps, by modifying the bipolar scale approaches used in previous magnitude scales of opinions.[2] Attempts should also be made to ask the annoyance magnitude question of those respondents who could not complete the line-estimation training exercise.

6. NEXT STEPS

The analysis and discussion in this paper address some of the practical issues in obtaining and using magnitude scales, but have neglected some measurement issues and most validation issues. These data could be analyzed to address some issues concerning the internal consistency of respondents' ratings and the performance of the different nuisance items.

A thorough evaluation of the validity of magnitude scaling techniques for residential noise surveys requires new data gathering. Ratings using response modalities in addition to numeric estimation (e.g. line production) are needed in both the training and response measurement sections of questionnaires. Analyses based on the resulting cross-modality matching are needed to validate the scale, understand departures from predicted relationships with noise exposure and correct for regression bias. Laboratory studies, pretests and survey experiments are needed to identify nuisances that are uniformly evaluated and to refine study techniques that reduce error. A balanced judgment about the relative advantages of magnitude and category scales will need to await such developments.

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