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DEVELOPMENT OF A NOISE ANNOYANCE SENSITIVITY SCALE

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16. Abstract

Examining the problem of noise pollution from the psychological rather than the engineering view, a test of human sensitivity to noise was developed against the criterion of noise annoyance. Test development evolved from a previous study in which biographical, attitudinal, and personality data had been collected on a sample of 166 subjects drawn from the adult community of Raleigh. Analysis revealed that only a small subset of the data collected was predictive of noise annoyance. Item analysis yielded 74 predictive items that composed the preliminary noise sensitivity test. This was administered to a sample of 80 adults who later rated the annoyance value of six sounds (equated in terms of peak Sound Pressure Level) presented in a simulated home, living-room environment. A predictive model involving 20 test items was developed using multiple regression techniques, and an item weighting scheme was evaluated.

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I. INTRODUCTION

Noise as a pollutant and cause of stress is today a topic of considerable concern. It interferes with sleep, disrupts communication, may produce hearing loss, and has been called a major source of annoyance in the environment (3,4). While much effort is devoted to design and modification of man-machine-environmental systems in order to effect noise control, the generalization that man reacts to noise as a disturbance and typically views it as a hazard to his physical and psychological well-being can be questioned. Man has demonstrated a unique potential to perform tasks in the presence of noise, and frequently shows an amazing ability to adapt to, or apparently ignore, forms of noise in his home and work environments. Research from our laboratory (5,7) has shown wide individual differences in attitudes toward noise and in sensitivity to common noise sources.

Why do two people, exposed to the same noise stimuli, react differently? For a given noise generally perceived as noxious (e.g. an aircraft flyover low over one's home) some individuals indicate little annoyance, while others complain to their neighbors of the disturbance without taking action. A few may be severely annoyed to the point of complaining to authorities or of organizing protest groups. In reflecting upon his own research in the area, Borsky (1) concludes that the determinants of human sensitivity to noise are extremely complex, including such diverse variables as educational level, interest in aviation, kinds of activities disrupted by noise, attitudes toward noise sources, and personality. These individual differences in annoyance response to noise deserve more attention; they form the basis for the research described herein which has as its goal the development of a test for assessing human sensitivity to noise.

The use of a test to identify people along a dimension of sensitivity-insensitivity would permit new approaches to noise research and abatement efforts. The work performance and physical well-being of "sensitive" and "non-sensitive" individuals could be contrasted. Efforts to modify the attitudes of "noise-sensitive" persons could be evaluated. Applications to personnel selection in industry, government, and the military are apparent, as well as uses in urban planning and design. These possible applications constitute justification for our efforts to develop a test to assess individual sensitivity to noise. The approach taken proceeded from earlier work (7) which indicated that a small subset of biographical,

attitudinal, and personality data was predictive of annoyance responses of 166 adult subjects exposed to 82 dB noise.

II. METHOD

Preliminary Test Development. In the final phase of their 1968 study, Pearson and Hart (7) dealt with two types of data in trying to predict annoyance ratings. There were 38 attitude items and 16 personality scale scores of the Cattell 16 P.F. test. In developing a test the use of scale scores (summary data) loses accuracy unless those scales were constructed to measure the same trait as the test being developed. Therefore, it was deemed necessary to perform an item analysis on the total number of personality test items summarized by the 16 scale scores. Nine of the 38 attitude items had previously been identified as high predictor items. The preliminary test was composed of these 9 items plus those items selected by item analysis of the personality test data (the Cattell test includes 374 items). With data being available on only 166 subjects, sample size was insufficient for multiple regression procedures, so simple correlation was used. Pearson Product-Moment Correlation was used for its convenience in computer analysis.

For reasons discussed in detail elsewhere (2) a decision was made to use a three-fold analysis; males alone, females alone, and both together. This decision was made contrary to an earlier analysis (7) indicating the sex variable to be of little predictive value. There were 82 males and 84 females for a total of 166 subjects. All 374 items were correlated against empirical noise annoyance rating means for each of the three groupings of subjects. Of the 374 items 26 correlated significantly in the male group, 21 in the female group, and 38 in both. Only items which correlated beyond the .05 level of significance were retained in the preliminary test. Several items were found to be significant in two of the three groups and one was significant in all three (Table I); however, it was obvious by inspection that the 3-fold analysis yielded three different sets of items. Beyond inspection, Spearman's Rank Order Correlation applied to the ranked correlation score (between each item and the empirical noise annoyance rating mean) yielded r=.03 between Males and Females, r=.51 between Males and Both; and r=.45 between Females and Both. In all, there were 65 significant items. Added to the nine attitude items, these yielded a preliminary test of 74 items (see Appendix A).

TABLE I. ITEMS CHOSEN FOR THE PRELIMINARY TEST BY ITEM ANALYSIS CORRELATION PROCEDURE

Males Alone[a]		Females Alone[a]		Both[a]	
10	23	25	35	37	56*
11	24	26	36	38	57*
12	56*	27	66*	39	58*
13	57*	28	67*	40	59*
14	58*	29	68*	41	60*
15	59*	30	69*	42	61*
16	60*	31	70*	43	62*
17	61*	32	71*	44	63*
18	62*	33	72*	45	64*
19	63*	34	73*	46	65*
20	64*		74**	47	66*
21	65*			48	67*
22	74**			49	68*
				50	69*
				51	70*
				52	71*
				53	72*
				54	73*
				55	74**

[a] *Item common to two groups.
**Item common to three groups.

Note: Numbers in the table refer to the 74 items of the preliminary test in Appendix A.

Subjects. The subjects were 40 males and 40 females between the ages of 21 and 74. College students were not eligible for the study since the population for which the test was being developed was the general adult population. The adult community of Raleigh was contacted through employers, clubs, service organizations, and informal communications. All subjects were told that normal ("good") hearing was a requirement for participation. The time needed for participation and the use of a paper and pencil test were discussed, but no mention of noise annoyance was made. Other than college students and people with significant hearing loss, any adult was eligible. With such small restrictions, a very broad sample was obtained. The subjects were paid an hourly rate for their participation, plus a reasonable sum to cover transportation expense.

Of the subjects disqualified for hearing loss, all were males and each volunteered the fact that he had had military combat experience with explosions and gunfire. Trauma was vividly recalled. The experimenter made no purposeful effort to elicit such information.

Test Materials. Appendix A contains a reproduction of the test and instructions that each subject was given. The first part contains the nine items identified by Pearson and Hart (7) as being predictive of noise sensitivity; the second part contains the 65 items chosen by item analysis.[1]

Apparatus. A detailed description and engineering evaluation of the experimental room, electronic sound reproduction and measuring equipment, and experimental materials used in the present study appears elsewhere (5). A "living room" used for noise annoyance ratings was designed to permit controlled and monitored sound presentation to subjects in a simulated home environment. The room was 20' by 16' with 2" x 4" stud and dry wall construction with 1/4 inch plywood exterior.

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[1] Note: In a related aspect of this study, the Zuckerman Sensation Seeking Scale was also administered. Correlations between Zuckerman scale scores and mean noise annoyance ratings were not significantly different from 0. These results are discussed in detail elsewhere (2).

An air conditioning unit, separated from the room itself to reduce ambient noise levels, provided controlled ventilation for both subjects and equipment. The room was by no means an anechoic chamber, but it was as quiet as a normal living room and was excellent for reading, working, or relaxing. The floor was carpeted with commercial grade sponge rubber padding and high density loop pile carpet. The windows had drapes. There were end tables with lamps that provided adequate light for reading. There were 12 seating positions in the room. For the present study half were hard wood school chairs and half were soft upholstered and cushioned. The floor plan of the room showing seating and equipment positions within the room is presented in Figure 1.

A Sony Model 530 stereo tape recorder was used for sound storage and playback. Two Altec Type 1586A power amplifiers with a 40-watt rated output drove two speaker systems both with a 30-inch Electrovoice low frequency speaker, a 12-inch Altec-Lansing midrange speaker, and a 3" X 9" Altec-Lansing exponential horn. A crossover network was constructed for both speaker systems. A B & K 1/2 inch microphone was located in the room with the speakers as shown in Figure 1. This microphone and its readout unit, a B & K microphone amplifier located with the tape recorder and amplifiers in the control room, composed a sound system that provided monitoring and control of the overall sound pressure level in the living room.

The stimuli used were sounds recorded on tape which were played through the sound system to subjects seated in the living room. There were six separate stimuli which were chosen as being broadly representative of environmental sounds of interest to industry and the funding agency. These were (1) a passenger jet fly-over, (2) a large propeller aircraft, (3) a helicopter, (4) a diesel truck "gearing down" to climb a hill, (5) factory noise emanating from a burnishing machine, and (6) a pneumatic chipping hammer.

Table II contains the order of presentation of these stimuli. Eight permutations of the six stimuli were generated so that 48 presentations could be made. The sounds were recorded at equal voltages so that they could be played at one amplifier setting and yield a constant peak Sound Pressure Level (SPL) of 82 dB in the living room.

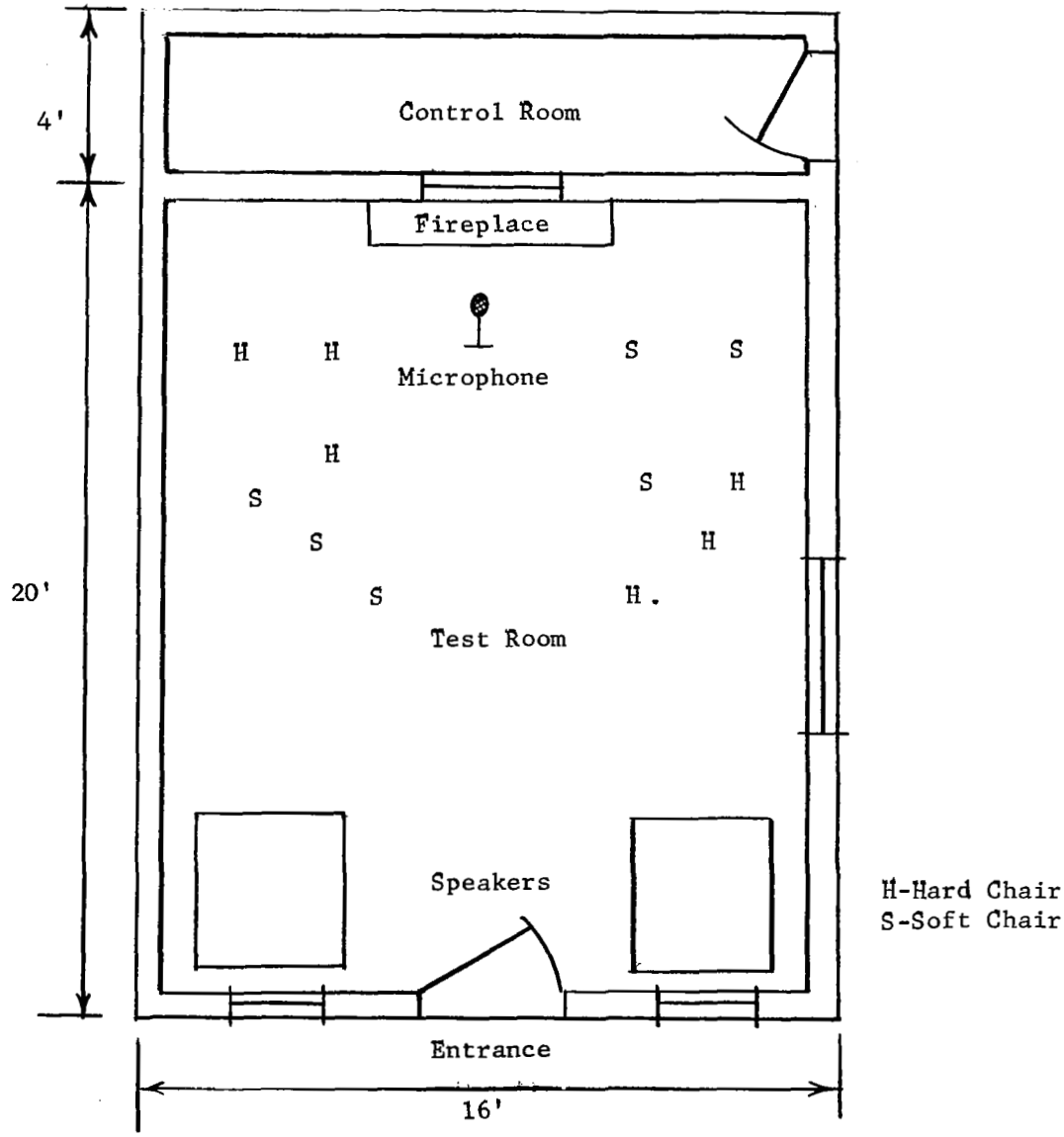

Figure 1. Floor plan of the experimental room showing speakers, microphone and chair positions

TABLE II. STIMULUS TAPE PRESENTATION ORDER

NOISE STUDY 1970

TAPE

Key for Sounds

1 = Truck
2 = Air Drill
3 = Factory Noise
4 = V-10
5 = Helicopter
6 = 707 Fly By

Trials # 1-12 = Warm up Session
Break - 2 min.
Trials # 13-48 = Final Session
Disregard Trials 1-18
Use Trials 19-48 for Data (30 scores)

Trial - Sound	Trial - Sound	Trial - Sound	Trial - Sound
#1-2	#13-5	#25-2	#37-4
2-4	14-6	26-3	38-5
3-1	15-4	27-1	39-3
4-3	16-1	28-4	40-6
5-5	17-3	29-6	41-2
6-6	18-2	30-5	42-1
#7-4	#19-1	#31-3	#43-6
8-5	20-2	32-4	44-1
9-3	21-6	33-2	45-5
10-1	22-3	34-5	46-2
11-6	23-5	35-1	47-4
12-2	24-4	36-6	48-3

Each sound was preceded by a voice "ready" signal and a presentation number so that subjects would not become lost in making their ratings.

Figure 2 is the Rating Scale used by subjects in the present study. Each subject was given a booklet of 48 consecutively-numbered rating scales. In using the scale to rate the noise presentations, subjects could mark any of the 9 descriptive expressions on the scale or any of the 16 points between expressions. In effect, a 25-point continuum was used to cover the range of expected responses. It should be noted that all materials were developed and tested in a series of pilot studies conducted at the Center for Acoustical Studies, North Carolina State University at Raleigh. These studies were completed before the Pearson and Hart 1968 study (7) so that the materials and equipment used were known to be reliable.

A Beltone Audiometer was used to check the subjects' auditory acuity.

Procedure. After telephone contact was effected with prospective subjects, and preliminary screening had eliminated obvious ineligibles, arrangements were made so that 8 to 12 subjects would appear at each of 8 test sessions. Four sessions were held in the evening and four in the afternoon for the convenience of the subjects. Each subject attended only one session, and all sessions were identical except for the varying number of subjects in the group.

As the subjects entered the room they were asked to be seated. An attempt was made to keep an equal division between hard and soft chairs, so 40 subjects were in soft chairs. Other than this restriction, subjects sat where they pleased and kept the same seat throughout their participation in the experiment.

The chairs were arranged symmetrically in relation to the speakers (Figure 1) to avoid confounding position toward the speakers and chair condition, hard or soft. However, analysis of the room's sound environment revealed that for every position in the room except immediately in front of a speaker, the sound environment was virtually the same, so chair arrangements were of little consequence as long as no one sat too close to a speaker.

Each session was conducted in similar manner. When all subjects

Figure 2. Noise annoyance rating scale (A) as seen by subjects (B) with corresponding numeric score values

had arrived they were asked to be seated with half of those present in in hard and half in soft chairs. At no time did the experimenter tell anyone to sit anywhere. The subjects arranged themselves within the constraint of equal distribution.

While pencils, rating booklets, and test booklets were being distributed, the experimenter introduced himself and set the subjects at ease with informal conversation. The living room was then discussed, and subjects were asked to imagine that they were at home for a quiet evening of relaxation. It was explained that the study for which they had volunteered consisted of three parts: (1) a hearing check, (2) a paper and pencil test, and (3) a noise rating session. Instructions for the paper and pencil test were read, and questions were answered by repeating appropriate instructions. All questions about the nature or purpose of the experiment were deferred until after all data for a session were collected. The written test took approximately 1-3/4 hours. During the test session each subject was briefly called out of the room for an audiometric check. At this point, 9 subjects were identified as having suffered hearing loss. Disqualified subjects remained in the study and completed all phases, but their data were not included for analysis.

Upon completion of the written test, subjects were instructed to check that each item was answered properly and to be sure there were no unanswered items. There were no missing data. Test booklets were collected and instructions for the third and final phase of the experiment were read (Appendix B) so that each subject understood the use of the rating scale, and how to use the booklet so as not to become lost.

The stimulus tape contained forty-eight 15-second sound presentations each preceeded by a ready signal and its presentation number. Between each stimulus presentation, there were 15 seconds of quiet that served as a response interval. During that time the subjects reflected on the sound carefully and marked their scales, then, turned the page of their booklets to be ready for the next sound, and relaxed until they heard the next ready signal.

To be sure that all subjects understood the procedure, the tape was stopped after the twelfth response and questions were entertained. A quick visual check was made to see that all booklets were open to page 13. For all eight sessions, not a single question was asked that demonstrated any subject to be confused. Questions were usually about the rationale behind the experiment and answers were deferred until after response 48 was recorded. Also, for all eight sessions, not one subject failed to be on the proper page.

After the check at response 12 was completed, the remaining 36 stimuli were presented without further interruption. The first six responses after the interruption were not analyzed, however, as they probably were affected by the interruption and by warm-up phenomena previously noted in pilot work. In all, only the last 30 of the 48 responses were analyzed for each subject.

The booklets were collected after response 48, and any and all questions were then answered and discussed. Finally, dismissal instructions were read, and the subjects were free to leave.

III. RESULTS AND DISCUSSION

The data collected included the noise rating responses and the questionnaire responses. The noise rating responses were examined first since the mean annoyance score for each subject had to be calculated across the thirty noise presentations. This mean annoyance score subsequently served as the dependent, or criterion, variable in the multiple regression analyses of the questionnaire data.

Noise Rating Data. The collection of noise annoyance ratings in the experimental room conformed to an analysis of variance with repeated measures experimental design (also called a One-between and Two-within design). Seat condition was the between-subject variable with half of the subjects in hard desk chairs and half in soft upholstered chairs. The six sound conditions and five trials were repeated within each subject. The results are summarized in Table III. All main effects and the Trials X Sounds interaction were found to be statistically significant beyond the .01 level of significance. Examination of the cells means, however, does raise a question concerning the practical significance of experimental results.

The difference between the hard and soft seat conditions was a mean value of 15.14 versus a mean of 10.91; this corresponds on the rating scale (Figure 2) to "Quite annoying" versus "Moderately annoying." Such a spread is meaningful. The subjects in soft seats were less harsh in their ratings than subjects in hard chairs.

The means for Trials, in sequence, were 12.61, 12.76, 12.97, 13.23, and 13.57. Barely one scale point separates the first and last trial, and the respective means represent the same category on the scale, "Annoying" (Figure 2). This difference, though statistically significant, may not be very meaningful on a practical level, although it does indicate some growth in annoyance as a function of confinement to a noise environment. Practically speaking, the Trials effect has little significance. A similar argument probably eliminates the Trial X Sounds interaction as a significant result.

The means for Sounds were as follows: (a) Truck, 10.16; (b) 707 flyover, 11.46; (c) V-10 aircraft, 11.82; (d) factory, 12.85;

TABLE III. SUMMARY ANALYSIS OF VARIANCE FOR A REPEATED MEASURES DESIGN

Source	df	MS	F
Seat	1	10756.90	18.57*
Trials	4	69.78	6.54*
Sounds	5	3551.49	84.19*
Subjects within Seat	78	579.21	-
Seat X Trials	4	14.85	1.39
Seat X Sounds	5	4.82	<1.0
Trials X Sounds	20	17.52	3.72*
Subjects X Trials within Seat	312	10.66	
Subjects X Sounds within Seat	390	42.18	
Seat X Trials X Sounds	20	4.34	<1.0
Subjects X Trials X Sounds within Seat	1560	4.71	-

*p .01

(e) helicopter, 13.17; and (f) pneumatic drill, 18.70. A Duncan Multiple Range test was used to determine where the significant differences identified by the F-test were located. This test revealed no significant differences among the first five listed means (a-e above). The pneumatic drill mean alone was significantly higher than all the other five means. Although the present study does not differentiate between the first five sounds as in previous work (7) there is confirmation of the considerable annoyance value attributed to the pneumatic drill in both studies.

The room condition of the previous study (7) refers to: (a) Soft Room -- carpeted floor, couches, soft chairs, drapes . . . a simulated living room, or (b) Hard Room -- a complete "wood" environment with low sound absorbing furniture, only hard desks. The present study involved a soft room environment with half the seats hard and half soft. The previous study revealed no significant differences in annoyance ratings due to room conditions, but the present study did show a seat condition effect. From a strictly engineering viewpoint, the sound environments of the two studies were virtually identical in the soft room condition since the same amount and type of acoustical absorption was present in that condition for both studies. Thus, any difference in the results of these studies would be difficult to account for acoustically.

The results of the two studies suggested that there was no difference between noise ratings in a hard room with a hard chair compared to ratings in a soft room with soft chairs. On the other hand, there is a difference between noise ratings in a soft room with a soft chair compared to ratings in a soft room with a hard chair.

At first, it was thought that the two studies were in conflict and an explanation was postulated involving the inequity in the second study where a person in a hard chair would look over to another subject in a soft chair and be annoyed at the inequity of the seating arrangements. The full repeated measures design of the first study put all subjects through all conditions so there were

no inequities. Therefore, the absence of inequities in the first study could account for the lack of difference between room conditions, while the presence of inequities in the second study could account for the significant differences between seating conditions.

Further thought thus led to the view that the two studies were not in conflict. The room condition and the seating condition were not identical and not directly comparable. In fact, the second study was entirely a soft room study and no data for a hard room condition were collected. A full factorial experiment between room condition and seat condition would help clarify the relation between the overall reverberation environment examined in the first study and the individual chair variable examined in the second study.

Questionnaire Response Data. Multiple regression techniques for obtaining prediction of a dependent variable's value from a series of independent variable scores were used. The assumption was made and is now clearly stated that noise annoyance ratings reflect the sensitivity of the rater. For example, given two people rating the same sounds if one person rates the sounds higher on any annoyance scale, it is assumed that that person is more sensitive to noise. Under that premise, it is possible to use the mean annoyance rating score as the dependent variable when using multiple regression to predict the noise sensitivity of a subject. Noise sensitivity of an individual is, then, operationally defined as the noise rating score given by that individual. Assessing sensitivity involves collecting rating scores. If, however, rating scores can be accurately predicted on the basis of a written test, then sensitivity can be indirectly assessed by a written test. This was the rationale behind the use of multiple regression prediction of noise rating scores.

The preliminary test contained 74 items. Appendix C is a sample answer sheet showing how each item was scored for each possible

response. All 80 tests were scored and prepared for computer analysis using a Stepwise Multiple Regression routine. The program was loaded so that no variables were forced, and variables would be added to the equation by choosing that variable which made the greatest contribution to the equation at any step. "F-delete" and "F-include" values were set at 0.0 so all variables would be included in the final equation thus allowing the experimenter, rather than the computer, to choose the final model.

With N = 80, the use of all 74 variables in a full multiple regression equation would have yielded a spuriously high value owing to the fact that only one case per variable was available for error estimation. Based upon a full trial run of the program with all 74 variables it was possible to observe the contribution to the equation at each successive step. A graph of this phenomenon revealed by inspection that after approximately 20 steps the contribution of more variables to the equation becomes very small (2). With 80 subjects and 20 variables there were 4 cases per variable which was acceptable.

At this point the Pearson and Hart data (7) were subjected to further analysis. It was noted that the order of inclusion of variables in their data equation was similar to the order of inclusion in the new data equation. This concordance was taken as an indication of reliability since the concordant variables were found highly predictive across both samples. The 20 most highly predictive concordant variables were then used in a reduced multiple regression model and a Multiple R of .70 resulted. The reduced model was compared to the full model by use of an F distributed statistic where

$$F = \frac{\text{MS difference between Full and Reduced Models}}{\text{MS error}}$$

Computationally:

$$F = \frac{(R_F^2 - R_R^2)\ (N - M_F - 1)}{(1 - R_1^2)\ (M_F - M_R)}$$

where

R_F = R for the full model

R_R = R for the reduced model

N = Number of subjects

M_F = Number of variables in the full model

M_R = Number of variables in reduced model

and is distributed as F with $(M_F - M_R)$ and $(N-M_F - 1)$ degrees of freedom. An F less than 1.0 was calculated indicating that the amount of variance accounted for by the full model and that by the reduced model was not significantly different.

The final form of the questionnaire is presented in Table 4 with the partial regression weights used in optimal scoring procedures as prescribed by the reduced regression equation. To get optimal prediction of the mean noise annoyance rating score, one multiplies each item, scored according to Appendix C, by its coefficient and sums the resultant. This procedure statistically maximizes prediction efficiency, but is cumbersome. A shorter scoring method involves either adding or subtracting the item score (Appendix C) according to the sign of the coefficient. Since variable number 9 has a higher range of scoring (0-12) than the other items (0-4 maximum), its value should be attenuated. Therefore, the simplified scoring method should add only 1/4 of variable 9's score. The other 19 scores are then weighed either plus one or minus one which considerably simplifies computation and provides a good approximation of the optimun predictive procedure.

A Different Point of View. Traditionally, attempts to alleviate noise problems have involved reducing or isolating sounds. In general, for any situation where men must interact with machines, it is the machine that should be modified for the convenience of the man rather than attempting to modify the man

TABLE IV. FINAL SHORTENED FORM OF THE NOISE SENSITIVITY TEST WITH PARTIAL REGRESSION WEIGHTS FOR OPTIMAL SCORING PROCEDURE.

For Research Use Only QUESTION SHEET

Instructions: The following is a very brief attitude questionnaire. There are no "right" or "wrong" answers, rather we are interested in your opinion on a number of questions. Please answer all questions as honestly and objectively as possible. Do not merely mark what may seem to you to be "the right thing to say" in order to impress the examiner. Some questions may not apply to you in particular very well, but give your best guess. Some may seem personal, but remember that the answer sheets are kept completely confidential.

Do not spend time pondering the "correct" answer. Just make the first, natural response as it comes to you. Try not to fall back on the middle, "uncertain" answers except when the other alternatives really do not apply. Read all questions in the order in which they appear; do not skip around. Be sure to answer all questions. Place all answers on the answer sheets provided. DO NOT MARK ON THIS QUESTIONNAIRE. Are there any questions? . . . . .

Item # on Pre-Test	Questions	Weighting
3	1. On the whole, would you say that you were more bothered by aircraft this year than in the past, or have you become used to aircraft? (a) Have become used to aircraft (b) About the same (c) More bothered now.	+ (1.13)
58	2. I think the spread of birth control is essential to solving the world's economic and peace problems. (a) no, (b) uncertain, (c) yes.	+ (0.41)
50	3. I believe in: (a) being properly serious in everyday business, (b) in between, (c) the motto "laugh and be merry" on most occasions.	- (1.10)

TABLE IV. (continued)

Item # on Pre-Test	Questions	Weighting
29	4. I think I am better described as: (a) forceful, (b) in between, (c) polite & quiet	+(0.81)
1	5. In your opinion can aircraft noise be prevented? (a) no, (b) yes.	-(0.76)
23	6. Upsetting the dignity of teachers, judges, and "cultured" people always amuses me. (a) yes, (b) in between, (c) no.	+(1.08)
38	7. I would rather mix with polite people than rough, rebellious individuals. (a) yes, (b) in between, (c) no.	+(0.91)
41	8. I like to take an active part in social affairs, committee work, etc. (a) yes, (b) in between, (c) no.	-(0.17)
6	9. The taking of private property (including homes) for airport expansion and highway construction should be accepted by all citizens as a necessary step in the community growth. (a) strongly agree, (b) agree, (c) Indifferent, (d) disagree, (e) strongly disagree	+(0.82)
12	10. People sometimes call me careless even though they think me an attractive person. (a) yes, (b) in between, (c) no.	+(0.36)
71	Going around selling things, or asking for funds to help a cause I believe in, is, for me: (a) quite enjoyable, (b) in between (c) an unpleasant job.	+(0.15)

TABLE IV. (continued)

Item # on Pre-Test	Questions	Weighting
69	12. When bossy people try to "push me around," I do just the opposite of what they wish. (a) no, (b) in between, (c) yes.	+(0.70)
9	13. Here is a list of noises which sometimes annoy people. List any that ever bother you. (a) Lawn mowers (b) Dripping water faucet (c) Dogs barking (d) Banging doors (e) Someone turning on the radio when you want quiet (f) Jack hammers and pneumatic drills, air compressors (g) Air conditioning units (h) Sound of a knife grating on a plate (i) Church bells (j) Automobile horns (k) Motor bikes, motor cycles, and scooters (l) Someone whistling out of tune (m) Not bothered by any of the above	+(0.77)
39	14. I tend to keep quiet in the presence of senior persons (people of greater experience, age, or rank.) (a) yes, (b) in between, (c) no.	-(1.49)
48	15. It embarrasses me to have servants waiting on me. (a) no, (b) in between (c) yes.	+(0.51)
13	16. When people are unreasonable, I just: (a) keep quiet, (b) in between, (c) despise them.	-(0.21)
4	17. Do you believe noise has any effect on your health? (a) Yes -- definitely (b) Probably -- perhaps indirectly (c) No -- I don't think so	+(1.04)

TABLE IV. (continued)

Item # on Pre-Test	Questions	Weighting
67	18. When I am called in by my boss (or teacher) I: (a) see a chance to put in a good word for things I am concerned about, (b) in between, (c) fear something has gone wrong.	-(1.02)
49	19. In my newspaper, I like to see: (a) good coverage of all local news, (b) in between, (c) debate on basic social issues in the modern world.	+(0.64)
2	20. If the world in which you live gets noticeably noisier in the future, would this matter much to you? (a) Hardly at all (b) It would matter a little (c) It would matter very much	+(1.89)

for the convenience of the machine. That dichotomy--either modify machines or modify men--could profitably be broken in the fight against noise. Without reducing efforts to reduce noise to a minimum, programs to increase man's tolerance toward a maximum would permit a doubly efficient attack on the problem. An outline view of this concept is presented below:

Alleviate noise problems by:

A. Controlling noise:
   1. At the source.
   2. Through conduction media
   3. At the receiver, i.e. the ear

B. Controlling man as receiver: (Human response to noise after reception, i.e. sensation, of noise is determined by):
   1. Past associations.
   2. Customs and mores.
   3. Attitudes.
   4. Invasion of privacy.
   5. Activity disrupted.

The most desirable solution to noise problems is prevention. The problem can be circumvented by reducing noise levels at their source. Design of hardware and proper operation and use of that hardware may eventually make all other methods of noise pollution control superfluous, but until ways of avoiding noise generation are available, other steps can be taken.

Conduction media may be used to attenuate sound. For example, sonic boom is a seemingly unavoidable by-product of supersonic flight. The preferred solution to the noise problem of sonic boom is to engineer a supersonic craft that somehow does not generate a boom. Alternatively, a controversial preventative solution to sonic boom problems is to abandon supersonic flight. Both of these solutions would prevent sonic boom, but neither seems to be acceptable. The second way to control the problem is by the use of conduction media. Assume that traffic noise is not

prevented. If truck routes are located away from residential neighborhoods, their noises can be attenuated over long distances through the air before reaching sensitive ears. The same principle applies (to some extent) in allowing supersonic flight only over the oceans or locating new airports far outside city limits in rural or uninhabited swamp or desert environments. This approach is not ideal since it still permits the environment to be polluted with noise. The noise is, however, isolated from people as much as possible. The effects of these sounds on wildlife are as yet undetermined. It may be that a jetport located in a swamp may, by noise and other factors, destroy the ecology of the area. Clearly, the problem is not solved by this approach, but is shunted off to other parts of the environment. This approach is useful, however, and should not be overlooked.

Thirdly, the receiver of acoustic energy can be insulated against noise. Houses and offices can be acoustically designed and treated to keep out noises. Taken a step further, ear muffs and plugs may be used to protect the receiver. This approach has the same drawbacks as the second approach, but unlike the second approach, it restricts behavior. It would be nice to have an office or residence insulated from unwanted noises, but it could be extremely inconvenient for residents wandering outside their protected areas.

These three approaches are the engineering point of view. They are only effective in that they keep acoustic energy away from the receiver. Beyond this point, the sound has already reached the receiver. If any further effort toward reducing the effects of noise pollution is to be made, the characteristics of the receiver must be taken into account.

Human response to noise may be conceptualized as being determined by five factors:

(1) Past associations: The amount of experience a person has had with sound and whether or not this experience was good or bad may determine sensitivity. In extreme examples, traumatic exposures to sounds may precipitate

mental illness, but more generally nothing more serious than high sensitivity to noise may result. It may be possible, therefore, to reduce sensitivity to noise by providing pleasant experiences with it.

(2) Customs and mores of specific populations or geographical areas may affect sensitivity. In some cultures, it is customary to belch after a meal to signify satisfaction. By recognizing customs, it may be helpful to either change them, or to otherwise alter the noise environment to conform to existing customs. Flight patterns over a mid-western farming town where the populace customarily retires before 10:00 p.m. should be different than flight patterns over a community that retires later.

(3) Attitudes toward noise may be reflected by noise sensitivity. An individual with unfavorable attitudes toward air travel may be more sensitive to overflights than others. If an attitude can be changed by education, advertising, persuasion, or just the passing of time, then, sensitivity could change.

(4) Invasion of privacy or intrusion of territory are unpleasant. If a noise is felt to threaten the sanctity of either home or privacy, it will be more annoying than a non-threatening noise. The home then would be expected to be the site of more annoyances than say work or recreation areas. McKennel (6) has confirmed that expectation.

(5) The actions of the subject at the instant of noise presentation may affect the response to noise. If an interesting television or radio show or a conversation is disrupted, or if an important train of thought is lost, more annoyance will result than if the noise occurs during uninteresting activities.

If noise cannot be prevented, it should be controlled to minimize discomfort; keeping disruption of activity to a minimum, respecting privacy, eliciting more favorable attitudes, respecting customs, and making noise less obnoxious by education should be adjuncts to the prime effort toward noise prevention.

IV. CONCLUSIONS

Human response to noise stimuli can be viewed as being dependent on inputs from two sources: (1) from the environment and (2) from within the listener. Most research deals directly with the former and has attempted to control the latter. At best, the effects of individual differences between listeners have been lumped into the all-exclusive error term of linear statistics. The success of this study in developing a test to indicate individual sensitivity to noise as an annoyance has demonstrated the possibility of dealing with the inputs from within the listener. A coefficient of determination of .49 is not spectacularly high, but it does indicate that a significant proportion of variability has been accounted for in a situation where environmental input was held constant.

The use of multiple regression techniques has proven helpful, but it should be noted that abuse of these techniques is an extremely easy trap in which to fall. For proper use, a subject pool at least 3 times larger than the number of variables and preferably 10 times larger is recommended. With small samples, a Multiple R of 0.99 is common, but spuriously high. If large enough samples are not available, simple correlational techniques may be used to rank the items in a pool. The highest items can then be selected so that N is sufficiently large in relation to the smaller selected item pool to permit the proper use of multiple regression.

This study has demonstrated the ability to assess individual sensitivity to noise. With that demonstration, a new point of

view, a model of noise annoyance, was presented that may be useful in understanding why one individual is more sensitive than another. The next step would be to see whether the internal inputs as outlined by the model can be manipulated to yield a change in individual noise sensitivity. Such research should be conducted concurrent with, not in lieu of, engineering efforts to reduce noise problems at the most desirable point--their source.

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APPENDICES

Appendix A. Preliminary Test

For Research Use Only

INFORMATION AND DATA QUESTIONS

Part 1

Instructions. Please respond to ALL questions. Read each question carefully and answer as honestly and objectively as possible. Most questions require only a single check ("X") response; a few may require more than one check or a few words for your answer. Read and answer all questions in the order in which they appear -- do not skip around. A separate answer sheet is provided. DO NOT MARK ON THIS QUESTION SHEET. Answer all questions on the answer sheet. Read instructions on answer sheet before starting.

Questions: Part 1

1. In your opinion can aircraft noise be prevented? (a) No, (b) Yes

2. If the world in which you live gets noticeably noisier in the future, would this matter much to you? Check one.

   (a) Hardly at all
   (b) It would matter a little
   (c) It would matter very much

3. On the whole, would you say that you were more bothered by aircraft this year than in the past, or have you become used to aircraft? Check one.

   (a) Have become used to aircraft
   (b) About the same
   (c) More bothered now

4. Do you believe noise has any effect on your health? Check one.

   (a) Yes -- definitely
   (b) Probably -- perhaps indirectly
   (c) No -- I don't think so

5. To what extent have you been exposed during your lifetime to noise in your work and in other experiences (war, travel, home, etc.)? Check one.

   (a) None -- hardly any exposure
   (b) A little exposure
   (c) A moderate amount of exposure
   (d) A great deal of exposure

Instructions: Please indicate how you feel on each of the following statements. Check the appropriate column for each.

6. The taking of private property (including homes) for airport expansion and highway construction should be accepted by all citizens as a necessary step in the community growth.

   (a) Strongly agree
   (b) Agree
   (c) Indifferent
   (d) Disagree
   (e) Strongly disagree

7. Sources of noise are a minor consideration when it comes to buying a home.

   (a) Strongly agree
   (b) Agree
   (c) Indifferent
   (d) Disagree
   (e) Strongly disagree

---

8. How often are you distrubed in your present job or work by noise? Check one.

   (a) Never -- rarely
   (b) Sometimes
   (c) Moderately often
   (d) Quite often
   (e) Most of the time -- continually

9. Here is a list of noises which sometimes annoy people. Check any that ever bother you.

   (a) Lawn mowers
   (b) Dripping water faucet
   (c) Dogs barking
   (d) Banging doors
   (e) Someone turning on the radio when you want quiet
   (f) Jack hammers and pneumatic drills, air compressors
   (g) Air conditioning units
   (h) Sound of a knife grating on a plate
   (i) Church bells
   (j) Automobile horns
   (k) Motor bikes, motor cycles, and scooters
   (l) Someone whistling out of tune
   (m) Not bothered by any of the above

Instructions: Here are some questions to see what attitudes and interests you have. There are no "right" and "wrong" answers because everyone has the right to his own views. Answer questions on the answer sheet. Answer them exactly and truly. There are three possible answers to each question. When you answer keep these four points in mind:

1. You are asked not to spend time pondering. Give the first, natural answer as it comes to you.
2. Try not to fall back on the middle, "uncertain" answers except when the answer at either end is really impossible for you--perhaps once every two or three questions.
3. Be sure not to skip anything, but answer every question, somehow. Some may not apply to you very well, but give your best guess. Some may seem personal; but remember that the answer sheets are kept confidential.
4. Answer as honestly as possible what is true of you. Do not merely mark what seems "the right thing to say" to impress the examiner. If everything is clear, you may begin.

10. Most of the people I know would rate me as an amusing talker (a) yes, (b) uncertain, (c) no.

11. If I make an awkward social mistake, I can soon forget it. (a) yes, (b) in between, (c) no.

12. People sometimes call me careless, even though they think me an attractive person. (a) yes, (b) in between, (c) no.

13. When people are unreasonable, I just: (a) keep quiet, (b) in between, (c) despise them.

14. If I am quite sure that a person is unjust or behaving selfishly, I show him up, even if it takes some trouble. (a) no, (b) in between, (c) yes.

15. I think I am better at showing: (a) tolerance of other people's wishes, (b) uncertain, (c) nerve in meeting challenges.

16. My ideas appear to be: (a) with the times, (b) uncertain, (c) ahead of the times.

17. In the midst of social groups, I am nevertheless sometimes overcome by feelings of loneliness and worthlessness. (a) no, (b) in between, (c) yes.

18. In joining a new group, I seem to fit in immediately, (a) yes, (b) uncertain, (c) no.

19. I occasionally have periods of feeling depressed, miserable, and in low spirits for no sufficient reason. (a) no, (b) in between, (c) yes.

20. A person whose ambitions hurt and damage a close friend may yet be considered an ordinary, decent citizen. (a) yes, (b) in between, (c) no.

21. When looking for a place in a strange city, I would: (a) just ask people where places are, (b) in between, (c) take a map with me.

22. "Clock" is to "time" and "tailor" is to: (a) cloth, (b) scissors, (c) suit.

23. Upsetting the dignity of teachers, judges, and "cultured" people always amuses me. (a) no, (b) in between, (c) yes.

24. I get as many ideas from reading a book myself as from discussing its topics with others. (a)no, (b) in between, (c) yes.

25. "Spade" is to "dig" as "knife" is to: (a) shovel, (b) cut, (c) sharp.

26. I sometimes get in a state of tension and turmoil as I think of the day's happenings. (a) no, (b) in between, (c) yes.

27. I have some characteristics in which I feel definitely superior to most people. (a) no, (b) uncertain, (c) yes.

28. I would rather live in a town: (a) which is rough, prosperous, and booming, (b) uncertain, (c) artistically laid out, but relatively poor.

29. I think I am better described as: (a) forceful, (b) in between, (c) polite and quiet.

30. To be cautious and expect little is better than to be happy at heart, always expecting success. (a) false, (b) uncertain, (c) true.

31. I always make a point, in deciding anything, to refer to basic rules of right and wrong. (a) yes, (b) in between, (c) no.

32. In physical and mental work I have to plan rest pauses more than most people, if I am to keep up my best level of work. (a) no, (b) in between, (c) yes.

33. My nerves get on edge, so that certain sounds, for example, a screechy hinge, are unbearable and give me the "shivers." (a) never, (b) sometimes, (c) often.

34. When given a set of rules, I follow them whenever personally convenient, rather than exactly to the letter. (a) false, (b) uncertain, (c) true.

35. I am sometimes so very happy that I get afraid my happiness cannot last. (a) false, (b) in between, (c) true.

36. I never find myself so annoyed in discussions that I cannot control my voice. (a) false, (b) uncertain, (c) true.

37. It would be good for everyone if vacations (holidays) were longer and everyone had to take them. (a) disagree, (b) uncertain, (c) agree.

38. I would rather mix with polite people than rough, rebellious individuals. (a) yes, (b) in between, (c) no.

39. I tend to keep quiet in the presence of senior persons (people of greater experience, age, or rank). (a) yes, (b) in between, (c) no.

40. I can work carefully on most things without being bothered by people making a lot of noise around me. (a) yes, (b) in between, (c) no.

41. I like to take an active part in social affairs, committee work, etc. (a) yes, (b) in between, (c) no.

42. If the odds are really against something's being a success, I still believe in taking the risk. (a) yes, (b) in between, (c) no.

43. I would rather dress with quiet correctness than with eye-catching personal style. (a) true, (b) uncertain, (c) false.

44. I somewhat dislike having a group watch me at work. (a) no, (b) in between, (c) yes.

45. If asked to work with a charity drive, I would: (a) accept, (b) uncertain, (c) politely say I'm too busy.

46. For relaxation I prefer: (a) sports or games, (b) uncertain, (c) debates or intellectual games.

47. I would prefer the life of: (a) public accountant or insurance man, (b) uncertain, (c) an artist or naturalist.

48. It embarrasses me to have servants waiting on me. (a) no, (b) in between, (c) yes.

49. In my newspaper, I like to see: (a) good coverage of all local news, (b) in between, (c) debate on basic social issues in the modern world.

50. I believe in: (a) being properly serious in everyday business, (b) in between, (c) the motto "laugh and be merry" on most occasions.

51. I practically never have to listen and take orders from people who are really stupid. (a) true, (b) uncertain, (c) false.

52. When quick decisions must be made, I: (a) rely on calm, logical, and objective reasoning, (b) in between, (c) become tense, excitable, and unable to think clearly.

53. "Black" is to "gray" as "pain" is to: (a) wound, (b) discomfort, (c) illness.

54. "Combine" is to "mix" as "team" is to: (a) football, (b) army, (c) crowd.

55. In social groups I am bothered by self-conscious shyness. (a) never, (b) sometimes, (c) often.

56. Careless folks who say "the best things in life are free" usually haven't worked to get much. (a) true, (b) in between, (c) false.

57. "Better" is to "worse" as "slower" is to" (a) fast, (b) best, (c) quickest.

58. I think the spread of birth control is essential to solving the world's economic and peace problems. (a) no, (b) uncertain, (c) yes.

59. Talk with ordinary, habit-bound, conventional people: (a) is often quite interesting and has a lot to it, (b) in between, (c) annoys me because it deals with trifles and lacks depth.

60. I think it is wiser to keep the nation's military forces strong than just to depend on international goodwill. (a) yes, (b) in between, (c) no.

61. Sometimes I feel that I do not do so well as I should socially, because I am unsure of myself. (a) false, (b) in between, (c) true.

62. In some moods I get easily put off my work by distractions and daydreams (a) no, (b) in between, (c) yes.

63. In my work more troubles arise from people who: (a) are constantly changing methods that are already O.K., (b) uncertain, (c) refuse to employ up-to-date methods.

64. If someone annoys me, I: (a) can keep it to myself, (b) in between, (c) must speak to someone else to "let off steam."

65. I get irritated by people who adopt morally superior attitudes. (a) no, (b) in between, (c) yes.

66. I like a friend (of my sex) who: (a) is efficient and practical in his interests, (b) in between, (c) seriously thinks out his attitudes to life.

67. When I am called in by my boss (or teacher) I: (a) see a chance to put in a good word for things I am concerned about, (b) in between, (c) fear something has gone wrong.

68. As a teenager, if I differed in opinion from my parents, I usually: (a) accepted their authority, (b) in between, (c) kept my own opinion.

69. When bossy people try to "push me around," I do just the opposite of what they wish. (a) no, (b) in between, (c) yes.

70. If people shout suggestions when I'm playing a game, it does not upset me. (a) true, (b) uncertain, (c) false.

71. Going around selling things, or asking for funds to help a cause I believe in, is, for me: (a) quite enjoyable, (b) in between, (c) an unpleasant job.

72. Is it more important to: (a) get along smoothly, (b) in between, (c) get your own ideas put into practice.

73. It generally makes me unhappy when I have to move all my belongings to a new place. (a) false, (b) in between, (c) true.

74. What this world needs is: (a) more steady and "solid" citizens, (b) uncertain, (c) more "idealists" with plans for a better world.

Appendix B. Instructions to Subjects

You are about to participate in an experiment that hopefully will help us in studying peoples' reactions to their environment. As you can see we have constructed a home environment and we would like you to imagine that this is your own home. Please sit quietly and relax as if you were in your own home, but hearing a series of loud sounds. Given that you are in your home environment we are interested in knowing your reaction to each of the sounds. At this time let me assure you that there is absolutely no danger involved in this experiment and you are perfectly safe.

Once the experiment begins you will hear a series of sounds. What we would like you to do for us is to rate each sound in terms of its annoyance, in other words how much does it disturb or bother you. A slip of paper containing a rating scale for each sound will be provided. We would like you to use this scale by completing the following statement, "I found that sound to be _____." After hearing each flyover, find a point on the scale that corresponds to the degree of annoyance you would rate it and then draw a line through the scale at that point.

Use Example Card (Example of rating scale)

Is this clear?

Each flyover will be taken for approximately 15 seconds, then you will have 10 seconds to rate it, then 5 seconds to relax before the next sound is presented. You will have a separate scale for each flyover, so after you rate a sound, turn over to the next page and await the next sound. Please do not at any time look back to any of your previous ratings.

Prior to the presentation of each sound, its number will be announced and this should be the same as the one at the top of your page. Please refer to this number so as not to lose your place. If at any time you have a problem or need more time, raise your hand.

When a sound occurs, wait for it to end, then rate its annoyance value carefully. You should have ample time to rate each sound so take your time to make your judgment. There are no right or wrong answers; we are simply interested in knowing how you react to these flyovers. To the extent that you do your job carefully, you will be contributing to a research project bearing on a problem of considerable interest to our federal government.

Now are there any questions at this point?

Remember -- try to relax after each rating and to imagine yourself in your own home environment while hearing some loud sounds during the evening. How much do you think they will bother you is the answer we are looking for.

Dismissal Instructions

Thank you very much for helping us out today. Before you go, there is one final point I would like to mention, and it is a very important one. Please do not discuss this experiment with anyone including those who are participating in the experiment. It could be that someone you know will get to serve as a S in this experiment and if they have any knowledge of the experiment before participating in it, this could bias the results. So we would appreciate very much if you would say nothing about this experiment to anyone else.

Thank you again for being so helpful today.

Appendix C. Preliminary Test Scoring Weights

For Research Use Only

Subject Number _____

ANSWER SHEET

Instructions. Do not mark on question sheet. Answer all questions by marking the appropriate boxes on this sheet. Read all instructions and fill in background information before answering questions. If anything is unclear, ask NOW before you begin. When everything is clear, you may begin.

Background Information:

A. Your Name: _____ Home Phone No._____
(please print) last first middle initial

B. Address:_____ Office Phone No. _____
street city

C. Year of Birth:_____D. Sex: Male ( ), Female ( )

E. Race: Caucasian ( ), Negroid ( ), Other ( )

F. Occupation (please be specific):_____

Answers: Part 1

(Variable #1)

	A	B
1.	(0)	(1)

	A	B	C
2.	(0)	(1)	(2)
3.	(0)	(1)	(2)
4.	(2)	(1)	(0)

	A	B	C	D
5.	(3)	(2)	(1)	(0)

	A	B	C	D	E
6.	(0)	(1)	(2)	(3)	(4)
7.	(0)	(1)	(2)	(3)	(4)
8.	(0)	(1)	(2)	(3)	(4)

	A	B	C	D	E	F	G	H	I	J	K	L	M
9.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	(0)

Score M zero, otherwise
Score 1 for each item checked A through L and sum them

	A	B	C		A	B	C		A	B	C		A	B	C
10.	(1)	(2)	(3)	15.	( )	( )	( )	20.	( )	( )	( )	25.	( )	( )	( )
11.	( )	( )	( )	16.	( )	( )	( )	21.	( )	( )	( )	26.	( )	( )	( )
12.	( )	( )	( )	17.	( )	( )	( )	22.	( )	( )	( )	27.	( )	( )	( )
13.	( )	( )	( )	18.	( )	( )	( )	23.	( )	( )	( )	28.	( )	( )	( )
14.	( )	( )	( )	19.	( )	( )	( )	24.	( )	( )	( )	29.	( )	( )	( )

	A	B	C		A	B	C		A	B	C		A	B	C
30.	( )	( )	( )	35.	( )	( )	( )	40.	( )	( )	( )	45.	( )	( )	( )
31.	( )	( )	( )	36.	( )	( )	( )	41.	( )	( )	( )	46.	( )	( )	( )
32.	( )	( )	( )	37.	( )	( )	( )	42.	( )	( )	( )	47.	( )	( )	( )
33.	( )	( )	( )	38.	( )	( )	( )	43.	( )	( )	( )	48.	( )	( )	( )
34.	( )	( )	( )	39.	( )	( )	( )	44.	( )	( )	( )	49.	( )	( )	( )

	A	B	C		A	B	C		A	B	C		A	B	C
50.	( )	( )	( )	55.	( )	( )	( )	60.	( )	( )	( )	65.	( )	( )	( )
51.	( )	( )	( )	56.	( )	( )	( )	61.	( )	( )	( )	66.	( )	( )	( )
52.	( )	( )	( )	57.	( )	( )	( )	62.	( )	( )	( )	67.	( )	( )	( )
53.	( )	( )	( )	58.	( )	( )	( )	63.	( )	( )	( )	68.	( )	( )	( )
54.	( )	( )	( )	59.	( )	( )	( )	64.	( )	( )	( )	69.	( )	( )	( )

	A	B	C
70.	( )	( )	( )
71.	( )	( )	( )
72.	( )	( )	( )
73.	( )	( )	( )
74.	( )	( )	( )

Score items 10 through 74 A = 1
B = 2
C = 3

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