NASA TECHNICAL MEMORANDUM

NASA TM X- 72673

NASA TM X-72673

(NASA-TM-X-72673) EFFECTS OF THREE ACTIVITIES ON ANNOYANCE RESPONSES TO RECORDED FLYOVERS (NASA) 47 p HC $3.75
CSCL 05E

N75-23157

Unclas
G3/53 14746

EFFECTS OF THREE ACTIVITIES ON ANNOYANCE RESPONSES TO RECORDED FLYOVERS

By

Walter J. Gunn and William T. Shepherd
Langley Research Center

and

John L. Fletcher
Memphis State University

This informal documentation medium is used to provide accelerated or special release of technical information to selected users. The contents may not meet NASA formal editing and publication standards, may be revised, or may be incorporated in another publication.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER, HAMPTON, VIRGINIA 23665

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM X-72673		

4. Title and Subtitle	5. Report Date
EFFECTS OF THREE ACTIVITIES ON ANNOYANCE RESPONSES TO RECORDED FLYOVERS	April 1975
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Walter J. Gunn, William T. Shepherd, and John L. Fletcher*	
9. Performing Organization Name and Address	10. Work Unit No.
NASA-Langley Research Center Hampton, VA 23665	504-09-11-01
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
National Aeronautics and Space Administration Washington, DC 20546	Technical Memorandum
	14. Sponsoring Agency Code

15. Supplementary Notes

*Memphis State University

16. Abstract

Subjects participated in an experiment in which they were engaged in TV viewing, telephone listening, or reverie (no activity) for a 1/2-hour session. During the session, they were exposed to a series of recorded aircraft sounds at the rate of one flight every 2 minutes. Within each session, four levels of flyover noise, separated by 5dB increments, were presented several times in a Latin Square balanced sequence. The peak level of the noisiest flyover in any session was fixed at 95, 90, 85, 75, or 70 dBA. At the end of the test session, subjects recorded their responses to the aircraft sounds, using a bipolar scale which covered the range from "very pleasant" to "extremely annoying." Responses to aircraft noises were found to be significantly affected by the particular activity in which the subjects were engaged. Furthermore, not all subjects found the aircraft sounds to be annoying.

17. Key Words (Suggested by Author(s)) (STAR category underlined)	18. Distribution Statement
Stress, Annoyance, Noise, Speech Interference, Aircraft 04	Unclassified Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	46	$3.75

*Available from { The National Technical Information Service, Springfield, Virginia 22151
STIF/NASA Scientific and Technical Information Facility, P.O. Box 33, College Park, MD 20740

EFFECTS OF THREE ACTIVITIES ON ANNOYANCE RESPONSES TO RECORDED FLYOVERS

By Walter J. Gunn and William T. Shepherd, NASA Langley Research Center, Hampton, Virginia, and John L. Fletcher, Memphis State University, Memphis, Tennessee

ABSTRACT

Subjects participated in an experiment in which they were engaged in TV viewing, telephone listening, or reverie (no activity) for a 1/2-hour session. During the session, they were exposed to a series of recorded aircraft sounds at the rate of one flight every 2 minutes. Within each session, four levels of flyover noise, separated by 5dB increments, were presented several times in a Latin Square balanced sequence. The peak level of the noisiest flyover in any session was fixed at 95, 90, 85, 75, or 70 dBA. At the end of the test session, subjects recorded their responses to the aircraft sounds, using a bipolar scale which covered the range from "very pleasant" to "extremely annoying." Responses to aircraft noises were found to be significantly affected by the particular activity in which the subjects were engaged. Furthermore, not all subjects found the aircraft sounds to be annoying.

INTRODUCTION

Interference with TV viewing is a major aircraft noise-related problem of airport community residents (ref. 1). Williams, Stevens, and Klatt (ref. 2) used a 10-point rating scale to obtain judgments of the acceptability of individual aircraft flyover noises while subjects either watched television or did not watch television. The ratings with or without TV viewing were almost identical. Langdon and Gabriel (ref. 3) conducted a series of experiments in which subjects watched videotaped television programs and, at the end of each period, rated the acceptability of the total noise exposure during that period. In these experiments, noise level was found to produce "significantly" less effect than predicted by the Williams, Stevens, and Klatt (ref. 2) data. The authors concluded further that "there is, however, almost certainly some positive effect, which contradicts a pure masking hypothesis." Given, however, the number of subjects per group and 95 percent confidence limits of about one unit, it is difficult to accept this conclusion without a test for significance. There is no obvious effect of level on acceptability which can be seen in their Experiments I and II data.

A model of human response to aircraft noise was recently developed by Gunn and Patterson (see Appendix A). This dynamic stress-reduction model predicts, among other things, that subjects engaged in different activities, when exposed to the same aircraft noise environment will respond with differing degrees of expressed annoyance. In order to test this hypothesis and learn the extent to which the specific activity engaged in effects one's annoyance reaction to aircraft noise, a laboratory experiment was performed as a part of a joint NASA/Memphis State University research program and is described in this report.

PROCEDURE

Subjects

Subjects were 324 members of the university community at Memphis State University. All were screened for normal hearing and those with HL greater than 20 dB (ISO) were excluded from the study. Hearing of subjects was evaluated by a graduate student in audiology at the Memphis Speech and Hearing Center. Subjects were paid for their participation in this experiment.

Method

The 324 subjects were randomly divided into three groups of 108. Each of these groups were exposed (in subgroups of 6) to 1/2-hour of recorded aircraft landing noises. At the end of the 1/2-hour session, subjects were asked to indicate their general response to the aircraft sounds they had heard. The first group (reverie group), which was comprised of 18 subgroups of 6, simply sat and listened to the aircraft noises. The second group watched a preferred TV show during exposure to the aircraft noise and the third group listened to a recorded Modified Rhyme Test over a telephone during the aircraft noise exposure. In short, three groups of subjects were exposed to recorded aircraft noises and made judgments of annoyance at the end of the 1/2-hour session. The only difference in conditions between the three groups was the activity in which the subjects were engaged during the exposure to the aircraft noises. Table 1 shows the test sequence for each of the three groups.

Reverie

Subjects were ushered into the test room and seated. Seats were arranged before a loudspeaker so that the noise exposure would be equivalent for all subjects who were then left to themselves for a period of 15 minutes. This time was needed to provide a uniform experimental situation compared to the other two activities. Talking was permitted in this pretest period. Near the end of the 15-minute period, the experimenter reentered the room and read the instructions given in Appendix B. After this, the experimenter left the room and a tape recording of aircraft flyover sounds was activated. The same aircraft recording was used during all three activities. These flyover sounds and the method of presentation are described in the Apparatus and Stimuli sections of this report. At the end of the experimental session, the experimenter entered the room and distributed copies of the response sheet which is shown in figure 1. The scale used was bipolar and subject responses were not biased by the use of plus or minus signs at either end of the scale. Similarly, the flyover stimuli were never described as "aircraft noises" but rather as "aircraft sounds."

TV Viewing

Subjects were ushered into the test room and seated in an arc before a color television set. The TV set was situated in front of the loudspeaker mentioned previously, as it was in the no-task condition. These subjects had earlier indicated that the program they were about to watch was one of their favorite programs. The TV set was turned on and the subjects were read the instructions shown in Appendix C and the TV audio volume control was adjusted to a level acceptable to all subjects. Two minutes prior to the beginning of the program, the subjects were read the instructions shown in Appendix B. The TV set was then turned on to the selected program and the experimenter left the room. The aircraft flyover noise tape was immediately activated at the beginning of the TV program. After the last aircraft flyover in this session, the television set was left on so as not to cause changes in subjects' annoyance that would be unrelated to the flyover sounds. The experimenter quietly distributed copies of the response sheet shown in figure 1 and indicated that they were to complete this form according to the written instructions. After all subjects had completed this response form, the experimenter collected them and distributed copies of the response form shown in figure 2.

Telephone Listening

Prior to the beginning of this phase of the experiment, a pilot study was conducted with several listeners to determine the playback levels that would be required to achieve an average of about 90 percent correct on the speech interference tests, in quiet. This was done so that performance on the tests would be degraded even further during simulated aircraft flyovers. It must be remembered that the measure of primary concern here was annoyance related to the interference with telephone use, not speech intelligibility, per se. It was necessary to use an intelligibility test to provide a device that would hold subjects' attention to verbal stimuli.

Subjects in this phase of the study were ushered into the test room and seated. Beside each seat was a telephone handset. The subjects heard the instructions shown in Appendix D. The first instruction was read to the subjects by the experimenter. The second instruction was tape recorded and given to the subjects over the telephone handsets. Following these recorded instructions, the experimenter read to the subjects the instructions shown in Appendix B. (These latter instructions were read to all subjects in each phase of the experiment, thus providing maximum uniformity in instructions.) The experimenter then left the room and the recorded speech and aircraft noise stimuli were presented.

Six lists of the Modified Rhyme Test (MRT) as developed by House, et al., 1963 (ref. 4) were presented to subjects. The answer ensembles in these tests consist of six words each with a total of 50 ensembles per test. Prior to tape recording the tests, the correct word from each ensemble was selected by use of a table of random numbers. The tests used are shown in Appendix E. The recorded test word is underlined in each ensemble. Subjects' response forms were identical to the lists shown in Appendix E, except that no words were underlined, of course. Subjects were required to draw a line through the correct word in each ensemble per the instructions given in Appendix D. At the end of the experimental session, the experimenter collected the speech test response forms and distributed copies of the response form shown in figure 1. These forms were then completed by the subjects and collected by the experimenter.

Apparatus

The apparatus used in this experiment is shown in block diagram form in figure 3. During the TV viewing and reverie conditions, the speech track was disconnected at the tape recorder. The voltmeter was used to set noise and speech levels prior to each experimental session. The color TV set was positioned in front of the Klipschorn speaker in such a way that it did not significantly block the sound output from the speaker during presentation of aircraft flyover sounds. The test room was a 15 x 24 ft room furnished to resemble a living room. Ambient noise level in the room was 43 dBA as determined with a sound level meter set on slow reading position.

Stimuli

Aircraft noise.- Each subgroup of subjects was exposed to a 1/2-hour duration playback of recorded Boeing 747 landing sounds at the rate of one overflight every 2 minutes. In order to make the noise exposure a little more realistic, the peak levels of the individual flyover noise were varied from one overflight to the next. Within any session, there were four peak levels of aircraft noise, designated A, B, C, and D. There were 16 overflights during each 30-minute session and there were four overflights at each level A, B, C, and D, in a balanced Latin Square sequence. Table II shows the corresponding sound levels for each peak flyover level and figure 4 shows a plot of noise level, in dBA, versus time. For each activity, the aircraft noises, in general, were presented at six intensities, designated "Intensity 1, 2, 3, 4, 5, 6." As can be seen by inspection of Table II and figure 4, the most intense aircraft sound in intensity 1 is 70 dBA peak and the other peak levels within that session decrease to 55 dBA in 5 dB increments. Likewise, in intensity 2, the most intense aircraft sound is 75 dBA and the quietest is 60 dBA, and so on.

Speech stimuli.- The experiment involved the presentation of speech as well as aircraft flyover sound stimuli. The same flyover stimuli were presented during all three activities, i.e., reverie, TV viewing, and telephone listening. Controlled speech stimuli were presented only during the telephone listening phase of the experiment. The two sets of stimuli (aircraft and speech) were recorded on two tracks of a single tape. This provided synchrony between the speech and flyover stimuli. The speech stimuli were recorded in a commercially available sound treated room by a speaker of general American English. Speech stimuli were recorded at the rate of approximately one word every 6 seconds. The test word was appended to the phrase; "number ______ is ______," where the last blank corresponds to the position of the test word. The talker monitored his voice level with a VU meter during recording of speech stimuli. Speech stimuli were recorded on one tape track on a high quality audio tape recorder with a commercially available dynamic microphone. The recorded speech material is shown in Appendix E. Speech stimuli were played to listeners at constant level such that the speech peaks were approximately 50 dBA in the telephone handsets as measured in a 6cc coupler.

The aircraft flyover stimuli were recorded on the second track of the tape. The two tracks were juxtaposed so that the first word of the speech stimuli and the beginning of the first flyover occurred at about the same time. Flyover levels were calibrated in the test room using a sound level meter. A corresponding voltage for a calibration tone on the tape was observed and recorded. These voltages were used in subsequent sessions to set the correct flyover levels. These calibrations were checked periodically during the experiment to insure consistency of stimuli presentation. A diagram showing the level of stimuli presented to subjects and the activity they were performing is shown in Table III.

Stimuli analysis.- The aircraft flyover sounds were recorded as they occurred in the test room using commercially available acoustic analysis recording equipment. The sounds were recorded at the extreme levels of 95 and 70 dBA at several seat positions normally used by subjects. In addition, a recording of the speech signal was made with one of the handsets coupled to the microphone while the aircraft flyover sounds emanated simultaneously from the loudspeaker. These recorded stimuli will be analyzed at a computer facility and results will be available sometime in the near future for a more detailed analysis of the relationships between actual speech interference and the physical description of the noise.

RESULTS

Figure 5 shows the median annoyance scores versus session intensity level for each activity in which S's were engaged during the aircraft noise exposure. The three regression lines were significantly different from each other, i.e., the slope of the "telephone listening" line was significantly ($p < .05$ by t test) different than the slopes of the "TV Viewing" and "Reverie" regression lines and median values of the "TV Viewing" regression line differed significantly ($p < .05$ by median test) from those of the "Reverie" regression line. Median tests of the differences of annoyance at each session intensity show that annoyance resulting from noise interruption of TV viewing at intensity 1 was significantly ($p < .05$) greater than that for either "Reverie" or "Telephone Listening," while at intensity level 5, the relation is reversed for "TV viewing" and "telephone listening." That is to say, in the session in which the loudest aircraft noise was 70 dBA peak, those subjects viewing TV expressed greater annoyance than those listening to speech stimuli on the telephone or those engaged in reverie (no task). As the aircraft noise intensity increased to the point where the loudest aircraft sound was 90 dBA peak, the annoyance of those engaged in the telephone listening task grew to the point where it was significantly greater than the annoyance of those engaged in the other two tasks.

Table IV shows the frequency distribution of annoyance scores for all intensity levels and activities. Note that 17 subjects (over 5 percent of the 324 who participated in this experiment) reported that the aircraft sounds were "pleasant" to hear.

DISCUSSION

The results suggest that the "telephone listening" task provides a much more sensitive indicator of peoples' overall annoyance response to aircraft noise than either "TV viewing" or "reverie" situations. While on the surface the results might at first seem to be at variance with past studies which show fairly high correlations between noise level and the resulting annoyance reaction in the no-task situation, careful consideration of the procedures and conditions of this experiment makes the results of this study more understandable. To begin with, it is widely known that laboratory subjects judging the loudness or noisiness of individual noises covering a given intensity range will quite neatly order the stimuli as an increasing monotonic function of the intensity level, clearly demonstrating that they can discriminate intensity levels, if nothing else. Note, however, that the subjects in these experiments made only one judgment of the effect of a 1/2-hour exposure to aircraft noises presented at various intensity levels at the rate of about one flight every 2 minutes. The experimental situation was contrived such that the subjects were not required to discriminate one intensity from another, but rather that they were to report their reactions to one specific exposure condition. This is not to say that the subjects did not use a standard against which to compare their reactions to the experimental stimuli. They could, conceivably, have an existing internal standard developed from real life experiences against which to compare the integrated effects of the laboratory noise exposure. The practice of obtaining only one response from each subject has much in common with the assessment of individual reactions of airport community residents to their own neighborhood noise environment. It is common practice in social surveys dealing with community response to aircraft noise to ask individuals to rate their own noise environment on various numerical category scales. In such studies, the respondents are not usually asked to rate more than one noise environment, their own. It is not surprising, therefore, that most such studies have found rather poor correlations between noise levels in the environment and reported annoyance reactions. It is clear from our data that the growth and absolute level of annoyance differ depending on which specific activity is interrupted by the intruding aircraft noise. With reference to the stress-reduction model of Appendix A, the data support the hypothesis that reaction to noise is modified by the nature of the activity engaged in at the time of the noise. A viable predictor of annoyance reaction to aircraft noise must then account for the "dominant" activity in a given community during each noise exposure period. It would not be surprising to find in future experiments still another (and totally different) psychophysical function relating annoyance and noise level which occurs during and possibly interrupts sleep. The same could be said for the reactions of people engaged in various other activities. While both our TV viewing task and telephone listening task involved aural communications, the telephone listening task differed in a number of important ways. Firstly, there was no redundancy built into the speech test presented over the telephone while there is a certain amount inherent in the usual TV show. Secondly, the importance of speech intelligibility was artifically increased in the telephone listening task by offering a bonus for superior speech reception scores. The differences in annoyance during TV viewing and reverie suggest a possible different basis for the annoyance reaction in each situation. One might speculate that the significantly greater annoyance reported by the TV viewers in intensity level 1 (where the loudest overflight was only 70 dBA peak) may have been due to distraction, rather than communication interference from masking, per se.

CONCLUDING REMARKS

It is concluded that the results of this experiment support the Gunn/Patterson Stress Reduction Model in that the degree of annoyance experienced by people exposed to aircraft noise depends upon the nature of the specific activity in which they are engaged at the time of the noise exposure. The finding that some laboratory subjects, over 5 percent, find the aircraft noises to be somewhat pleasant indicates the need for a closer look at the validity of laboratory studies, especially those in which subjects are required to respond on a unipolar scale of annoyance which does not allow for the possibility of some subjects who find the noises, at least in a laboratory setting, to be pleasant to hear. The speech communication task appears to be the most sensitive procedure for the laboratory assessment of the effects of different levels of aircraft noise exposure.

REFERENCES

1. Galloway, W. J.; and Bishop, D. E.: Noise Exposure Forecasts, Evolution, Evaluation, Extensions, and Land Use Interpretations. Bolt Beranek and Newman, Inc. Tech. Rep. FAA-NO-70-9, 1970.

2. Williams, C. E.; Stevens, K. N.; and Klatt, M.: Judgments of the Acceptability of Aircraft Noise in the Presence of Speech. J. Sound Vib., vol. 9, 1969, pp. 263-275.

3. Langdon, L. E.; and Gabriel, R. F.: Judged Acceptability of Noise Exposure During Television Viewing. J. Acoust. Soc. Am., vol. 56, 1974, pp. 510-515.

4. House, A. S.; Williams, C.; Hecker, M.; and Kryter, K.: Psychoacoustic Speech Tests: A Modified Rhyme Test. TDR No. ESD-TDR-63-403, Decision Sciences Laboratory, U. S. Air Force.

TABLE I - TEST SEQUENCE

15 MINUTES	30 MINUTES	5 MINUTES	5 MINUTES
Reverie (no task)			
S's sit and talk freely, Instruction "A" read to S's	S sits; talking not permitted	S's complete Data Sheet 1	
TV Viewing			
TV audio adjusted and instructions "B" and "A" read to S's	S views TV program previously selected	S's complete Data Sheet 1	S's complete Data Sheet 2
Telephone Listening			
Instruction "C" and practice given to S's; then instruction "A"	S listens to telephone for speech reception test	S's complete Data Sheet 1	

TABLE II - PEAK AIRCRAFT FLYOVER LEVEL IN dBA

Stimulus Designator	Session Intensity Level					
	1	2	3	4	5	6
A	70	75	80	85	90	95
B	65	70	75	80	85	90
C	60	65	70	75	80	85
D	55	60	65	70	75	80

TABLE III - SUBJECT ASSIGNMENTS

	Session Noise Intensity Level					
	1	2	3	4	5	6
Peak Level of Most Intense Aircraft Noise During Exposure, in dBA	70	75	80	85	90	95
Activity						
No Task	S1-S18	S19-S36	S37-S54	S55-S72	S73-S90	S91-S108
TV Viewing	S109-S126	S127-S144	S145-S162	S163-S180	S181-S198	S199-S216
Telephone Listening	S217-S234	S235-S252	S253-S270	S271-S288	S289-S306	S307-S324

TABLE IV - FREQUENCY DISTRIBUTION OF SCORES

Very Pleasant					Neutral					Extremely Annoying	Subject Response Scale	
-5	-4	-3	-2	-1	0	1	2	3	4	5	Median	Condition
				3	5	6		2	2		.67	70 Rev
					4	4	2	6	1	1	2.0	75 Rev
		1		1	2	1	2	2	2	1	1.2	80 Rev
1			2		1	6		2	5	1	1.3	85 Rev
	1	1			3	3	5	5			1.7	90 Rev
				1	4	1	1	4	1		1.93	95 Rev
					2	3	4	7	2		2.50	70 TV
				1			3	8	4	2	3.12	75 TV
					3	1	3	4	3	4	3.0	80 TV
				1	2	4	4	2	3	2	2.0	85 TV
						4	2	5	3	3	2.9	90 TV
						2	2	7	3	4	3.21	95 TV
		1	1		9	1	2	2	1		0.2	70 Tel
		1			1	5	5	2	1	3	1.9	75 Tel
					1	1	4	8	3	1	2.87	80 Tel
						2	4	7	1	4	2.93	85 Tel
						1	1	3	6	7	4.17	90 Tel
						1	4	4	4	5	3.5	95 Tel

PLEASE INDICATE YOUR GENERAL REACTION TO THE AIRCRAFT SOUNDS WHICH WERE PRESENTED DURING THE SESSION BY PLACING A CHECK MARK NEXT TO THE APPROPRIATE POINT ON THE SCALE SHOWN BELOW.

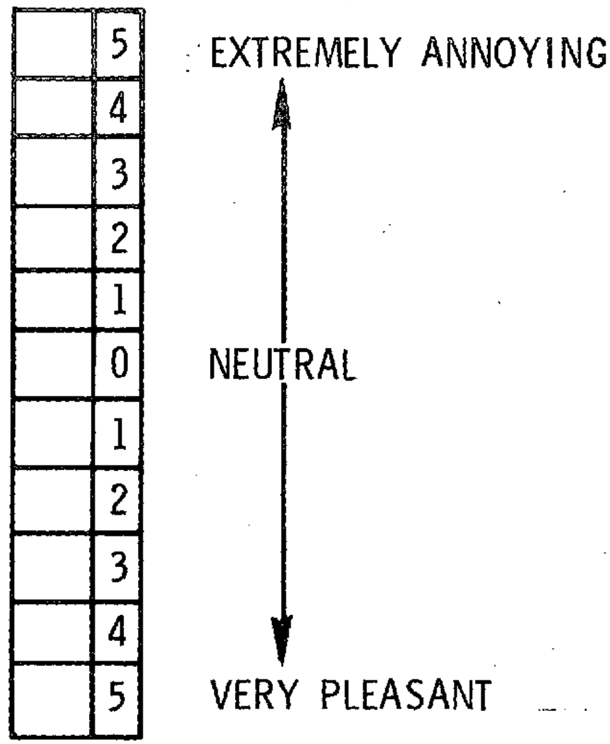

Figure 1.- Subject response sheet 1.

PLEASE ANSWER THE FOLLOWING QUESTIONS BY CHECKING THE APPROPRIATE BOX.

- HOW WOULD YOU RATE THE TV SHOW YOU WATCHED?

  ☐ EXCELLENT ☐ GOOD ☐ FAIR ☐ POOR

- HOW WOULD YOU RATE THE TV SOUND LEVEL?

  ☐ TOO QUIET ☐ JUST RIGHT ☐ TOO LOUD

- WHAT BOTHERED YOU THE MOST ABOUT THE AIRCRAFT SOUNDS? (WRITE A FEW WORDS TO DESCRIBE YOUR FEELINGS.)

Figure 2.- Subject response sheet 2.

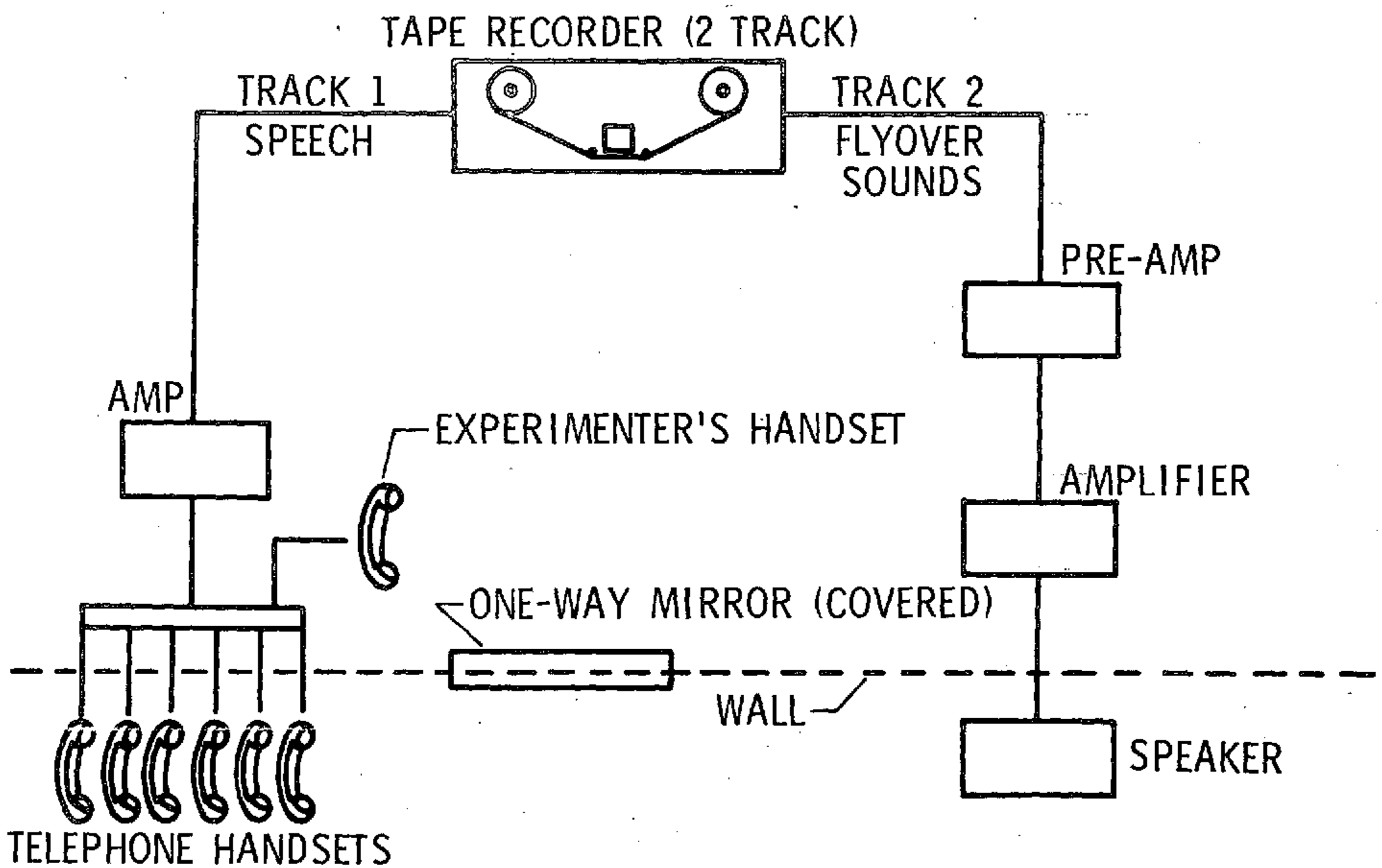

Figure 3.- Apparatus.

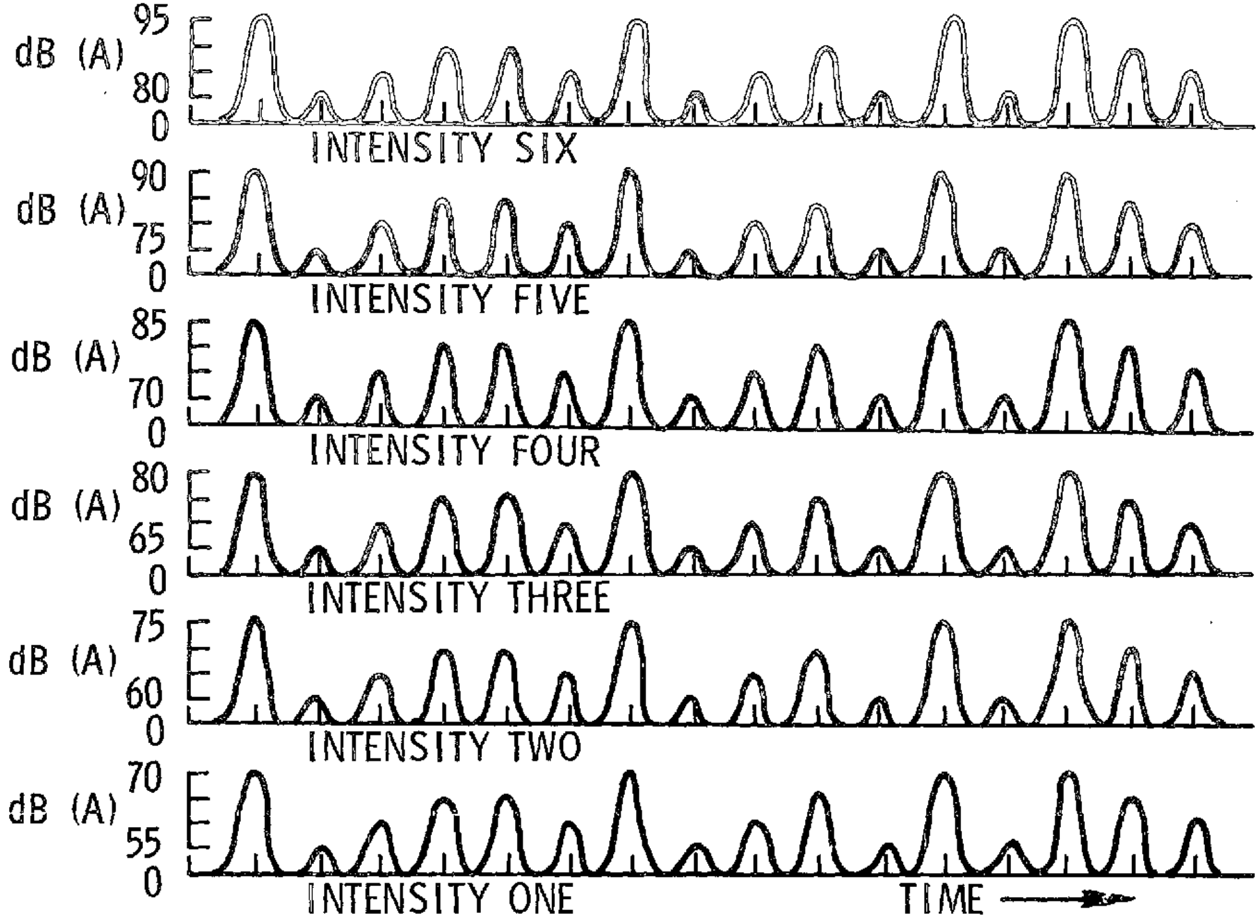

Figure 4.- Aircraft flyover noises.

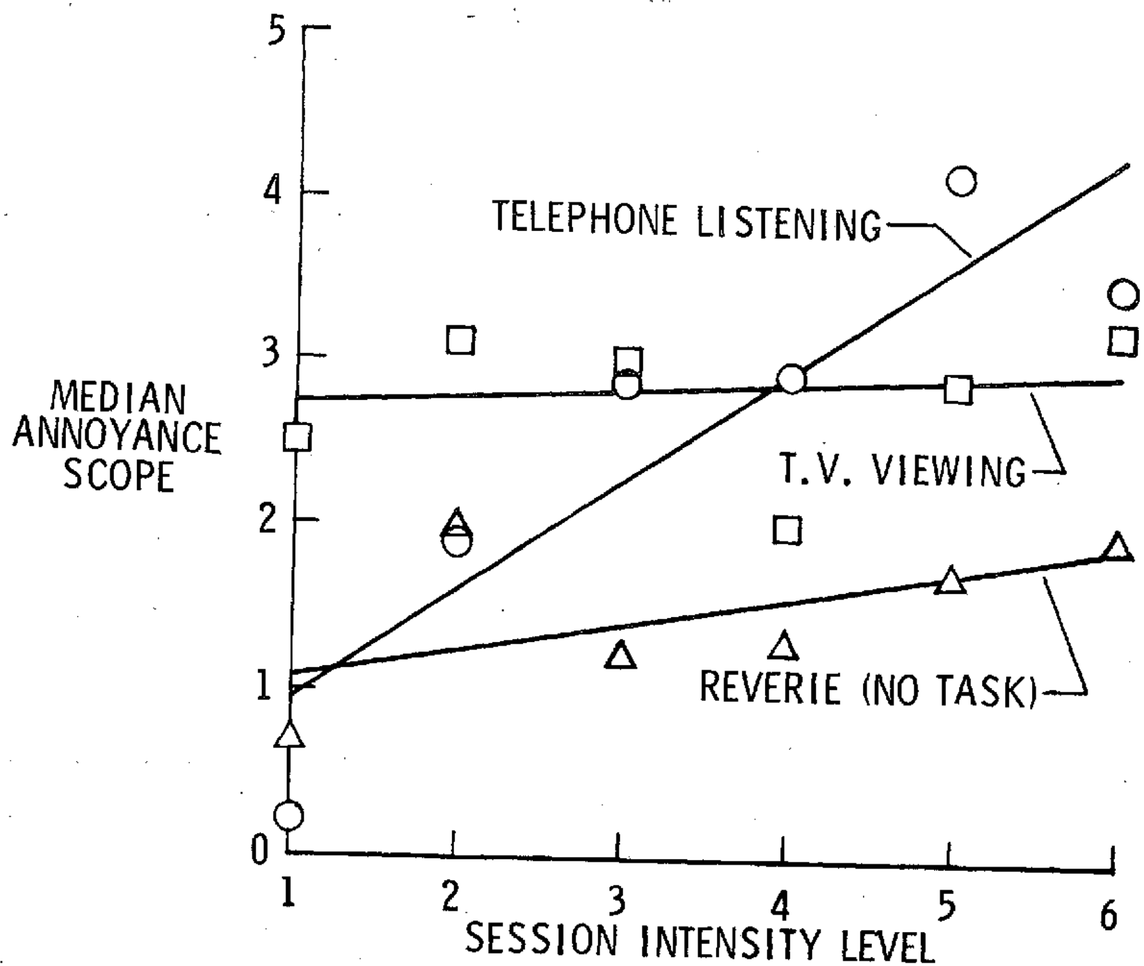

Figure 5.- Effects of activity interruption

APPENDIX A

THE GUNN/PATTERSON STRESS REDUCTION MODEL

Walter J. Gunn
NASA Langley Research Center
Hampton, Virginia

Harrold Patterson
Tracor, Inc.
Austin, Texas

In the development of a methodology for the assessment of community response to aircraft noise, an important concern is the identification of specific measurable changes exhibited by the exposed community. Following this, the psychophysical relationships between the cause (noise) and effect (community response) need to be determined. To increase the meaningfulness of the predicted response, relationships between response categories should also be determined. For example, if the mean annoyance of a given community is 4.8 (on a scale of 6) and this is designated as "very annoying," very little information regarding the actual state of mind of the average community resident is known. If, however, the relationship between annoyance, desire to move out of the neighborhood, health effects, sleep loss, hearing loss, activity interruption, and degradation of the perceived quality of life are predictable from knowledge of the degree of annoyance, for instance, then the information becomes considerably more meaningful to the various users, such as aircraft designers, airport operators, pilots, legislators, and public administrators.

Some of the specific measurable changes exhibited by airport community residents resulting from aircraft noise can be determined by answers to questions in social surveys, while certain behavioral changes can be directly observed or traced through official records, such as those of the telephone company, real estate offices, and hospitals. However, a specific model of individual reaction to aircraft noise is needed in order to determine better which specific changes may be anticipated and how they can be measured.

The initial attempt at formulation of a model* is shown in figure A1. This model is based upon the premise that individuals will attempt to reduce,

*The Stress Reduction Model was developed by W. J. Gunn of NASA, Langley Research Center and H. P. Patterson of Tracor, Inc.

avoid, or eliminate stress in their lives. Stress may be defined here as a general state of physical or psychological unrest. The model suggests that aircraft noise is perceived within two general contexts: situational and human factors. That is, qualities of the individual's physical, social, and psychological environments are important in his perception of the noise.

Only when the perception is "filtered" through the various meanings associated with the noise, through the interruption of activities and/or through evaluations of the aversive nature of the noise per se, is stress produced. The stress is manifested primarily in the development of negative feelings about the noise and in health problems. However, the individual will make every attempt to relieve this stress. Two methods are shown: overt behavior and internal adjustment. Overt behavior may be of various types, including complaint, retreating indoors or out of the neighborhood, and soundproofing the home. Internal adjustment is seen in adaptation, habituation, rationalization, and resignation to the noise. It is important to note that individuals who do not or cannot take overt action or who do not or will not make internal adjustments will develop more stress since the development of negative feelings and health problems themselves produce stress.

A. Stimulus Factors - The stimulus factors considered important in the model are divided into two general categories: noise and vibration.

(1) Noise

1. Level

2. Spectral characteristics

   a. General shape

   b. Discrete frequency content

3. Temporal characteristics

a. Time of occurrence

b. Duration

c. Impulsiveness

d. Dwell (temporal concentration)

4. Other characteristics

a. Rate of change of above

b. Directionality and movement

(2) Vibration

1. Level

2. Spectral content

3. Onset/offset characteristics

4. Correlation with the aircraft noise

5. Generation of secondary sounds (rattles, buzzes, etc.)

B. Situational Factors - The situational factors include the following: activity engaged in, setting, temporal factors, and other environmental conditions.

(1) Activity engaged in

The various activities which may be interrupted by aircraft noise are:

1. Relaxation (reverie)

2. Aural communications, whether active or passive, with or without visual cues

3. Sleep

4. Higher order cognitive functioning such as concentration, learning, problem solving, or reading

5. Physical activities

(2) Setting

The settings at times of noise exposure which may influence individual reaction are as follows:

1. At home or away

2. With others or alone

3. Indoors or out

(3) Temporal factors

The temporal factors which must be taken into consideration are:

1. Season

2. Day of week

3. Time of day

(4) Other environmental conditions

Other environmental factors which might effect stimulus conditions are as follows:

1. Presence and characteristics of nonaircraft sounds

2. Climatological conditions

    a. Temperature

    b. Relative humidity

    c. Atmospheric pressure

    d. Wind

    e. Precipitation

3. Illumination

4. Esthetics of surroundings, auditory, visual, tactile, and olfactory

C. Human factors - The human factors which may be influential in determining one's response to aircraft noise are divided into three general categories as follows: psychological factors, biological-physiological factors, and demographic factors.

(1) Psychological factors

There are at least seven psychological factors to be considered:

1. Attitudes
2. Intelligence
3. Traits
4. Needs
5. Self-concept
6. Values
7. State

(2) Biological-physiological factors

Important biological-physiological factors are:

1. Auditory sensitivity
2. Kinesthetic sensitivity
3. Condition: rested versus fatigued
4. General health
5/ State: relaxed versus tense

(3) Demographic factors

Possibly important demographic factors are:

1. Age
2. Sex
3. Occupation
4. Income
5. Education
6. Race
7. Class
8. Owner/Renter

9. Length of residence

10. Previous noise exposure

11. Dependence on aviation

D. Meaning associated with the noise - Kerrick, et al. (ref. A1) found that while noises from a variety of sources were rated equally on the basis of loudness or noisiness, they were not equally acceptable. Gunn, et al. (unpublished results of a study conducted by Langley Research Center personnel at NASA Wallops Station, Virginia) found that aircraft perceived as flying over an individual were rated as more annoying than aircraft perceived as flying off to the side, even at the same PNL. Connor and Patterson (ref. A2) found that "fear" of aircraft crashes was an important determinent of annoyance with aircraft noises. Wilson (ref. A3) found that aircraft noises were more acceptable and less noisy than motor vehicles at the same level. This suggests that the meaning associated with the source of the sound may have an important bearing on the degree of annoyance we feel about various sounds.

E. Activity interruption - In addition to the way we may feel about exposure to unpleasant sounds or the aversive meaning we attach to them, annoyance may result if the noise interferes with an ongoing activity, such as TV viewing, radio listening, sleeping, or activities requiring concentration. The extent of activity interruption could be assessed by questions on a social survey or through prediction based on controlled laboratory tests. There is good reason to think that interruption of these activities may contribute heavily to one's overall annoyance with aircraft noise.

F. Unpleasant characteristics of aircraft noise, per se - The range of possible feelings about the characteristics of a sound, per se, run the gamut from very pleasant, such as enjoyable music, to very unpleasant, such as a circular saw cutting sheetmetal. Similarly, certain aircraft sounds, at some levels, may actually be pleasant to hear, while other sounds may be perceived as neutral or unpleasant. Molino (ref. A4) developed what he calls "an equal aversiveness curve" for various bands of sound. The shape of the curve most closely resembled that of the inverse of the standard A-weighting characteristic. It is suggested that sounds above the threshold of aversiveness are "punishing" to the ear. Since the Molino data confounds aversiveness of the sound, per se, and interruption of concentration (the subjects were learning Russian during the experiment), the contour might be different under the condition of reverie. Clearly, there is a need to determine the psychophysical relationship between noise parameters and pleasantness or unpleasantness for various sounds. If a sound is perceived as being unpleasant to the ear, then continued exposure may lead to the development of stress in the unwilling listener.

G. Reported feelings - Airport community residents are often polled in order to determine how they feel about aircraft noise, airport operations, the people who are responsible, or the aircraft industry in general. The most commonly asked questions have to do with reported annoyance with aircraft noise. Sometimes people are asked for their overall annoyance, while in other cases they are asked about the annoyance they feel about the interruption of specific activities. In the latter case, the annoyance ratings for the interruption of various activities are usually combined in some way to form a single scale of annoyance. Although such a scale is typically well correlated with the single-question self-rating of annoyance (McKennell, ref. A5), it obviously represents only one particular dimension of annoyance and thus might best be termed "annoyance through disturbance of activities."

Questions are sometimes asked about feelings of "misfeasance" (feelings that those in authority are not doing all they could do to alleviate problems). Feelings of "fear of aircraft crashes" are also probed. The scales used to assess the various feelings are many and varied. Validity of the scales is, for the most part, assumed.

H. Health problems - While the evidence is scanty and sometimes in conflict, certain health-related problems resulting from aircraft noise may be:

1. Permanent hearing loss
2. Gastro-intestinal disorders
3. Increased nervousness
4. Cardio-vascular problems
5. Loss of sleep

Hospital and doctor's records might be helpful in assessing these aircraft noise related health effects.

I. Overt behavior - Few substantive studies have been conducted regarding the overt reaction of people to aircraft noise. Some important forms of overt behavior might be:

1. Moving family out of the noisy area
2. Complaints to authorities
3. Decrease in outdoor activities
4. Decrease in activities involving aural communications
5. Increased time spent out of neighborhood
6. Organizing to reduce the noise

J. Internal adjustment - The increased stress and the development of negative feelings and health problems represent an imbalance of the individual's normal or preferred state. In an effort to return to the normal state (homeostasis), the individual either takes overt action or makes internal adjustments, both of which serve to reduce the stress. Four types of internal adjustment are identified:

1. Adaptation
2. Habituation
3. Rationalization
4. Resignation

Thus, the individual may adapt to the noise or become habituated to it. Or, the individual may also rationalize his experience and convince himself that his situation is not so bad after all and that others are much worse off than himself.

K. Feedback loops - Every action or nonaction of the individual has a consequence. If the individual cannot or will not take overt action to reduce the stress, or if he does not make internal adjustments, then the development of negative feelings and health problems will themselves increase the stress. These relationships are shown in figure A1 by dashed lines from negative feelings and health problems back to stress. They represent positive feedback loops.

However, if the individual does take some overt action or makes an internal adjustment, then the stress will be relieved through an indirect process. Taking direct action has implications for both the stimulus and the situational factors. For example, through lobbying efforts, the individual may persuade the noise maker to reduce the noise or to change its characteristics so as to make it more tolerable. Or, the individual may change the situation by insulating his home, by spending less time outdoors (thereby decreasing his outdoor exposure time), or by moving out of the noise impacted area. If the individual makes an internal adjustment, this has implications for the human factors context. For example, the individual, in response to stress, may develop qualities of an "imperturbable" person. Such a person would deny that the noise ever bothered him and, in fact, might report difficulty in even perceiving the noise. These consequences of overt behavior and internal adjustment are represented by dashed lines back to the stimulus and situational factors for the former and back to human factors for the latter. Both are negative feedback loops.

L. The nature of the "filter" variables - As shown in the model diagram, there are no feedback loops to the boxes representing "meaning," "activity interruption," and "unpleasant characteristics." This means only that later elements within the model are not thought to affect these elements. Certainly, events outside the model have an effect. For example, if an aircraft crashes in the near vicinity, the individual may very well associate the next flyover event with a feeling of fear of crash. In a like manner, outside events are thought to produce a certain condition within the individual which tends to "color" his perception of aircraft noise. At any one point in time, these conditions work to predispose individuals to react in certain ways. Over time, however, the conditions can change and the individual's predispositions take on a dynamic character.

M. Hypotheses - A number of specific hypotheses are suggested by the stress reduction model. These are as follows:

1. Increased stimulus from aircraft operations will result in:
    a. increased development of negative feelings about the noise and/or
    b. increased development of health problems.

These results will be obtained provided the following elements are held constant:

(1) Situational factors

(2) Human factors

(3) Meaning associated with the noise

(4) Activity interruption

(5) Unpleasant characteristics of the noise, per se

2. The greater the development of negative feelings about the noise

   a. the greater the amount of overt behavior directed toward reducing or eliminating the noise, and/or

   b. the greater the internal adjustment of the individual.

The model thus suggests that once the situational and human factors are "controlled," and once the individual's perceptions are "filtered," then the following typical outcomes would be expected:

(1) A reduction in outdoor activities

(2) An exodus of noise sensitive individuals from the noise impacted area (provided there is an opportunity to move)

(3) An increase in overt behavior to reduce the noise exposure, e.g., soundproofing

(4) An increase in health problems

(5) A rise in atypical living habits, e.g., less conversation

(6) An increase in positive attitudes toward the noise source for those who make an internal adjustment

(7) An increase in indicators of other types of stress, e.g., family arguments

REFERENCES

A1. Kerrick, J. S.; Nagel, D. C.; and Bennett, R. L.: Multiple Ratings of Sound Stimuli. J. Acoust. Soc. Am., Vol. 45, 1969, pp. 1014-1017.

A2. Connor, William K.; and Patterson, Harrold P.: Community Reaction to Aircraft Noise Around Smaller City Airports. NASA CR-2104, 1972.

A3. Wilson, A. H.: Noise. Her Majesty's Stationery Office, London, 1963.

A4. Molino, John A.: Equal Aversion Levels for Pure Tones and 1/3-Octave Bands of Noise. J. Acoust. Soc. Am., Vol. 55, 1974, pp. 1285-1289.

A5. McKennell, A. C.: Methodological Problems in a Survey of Aircraft Noise Annoyance. The Statistician 19:(1), 1968.

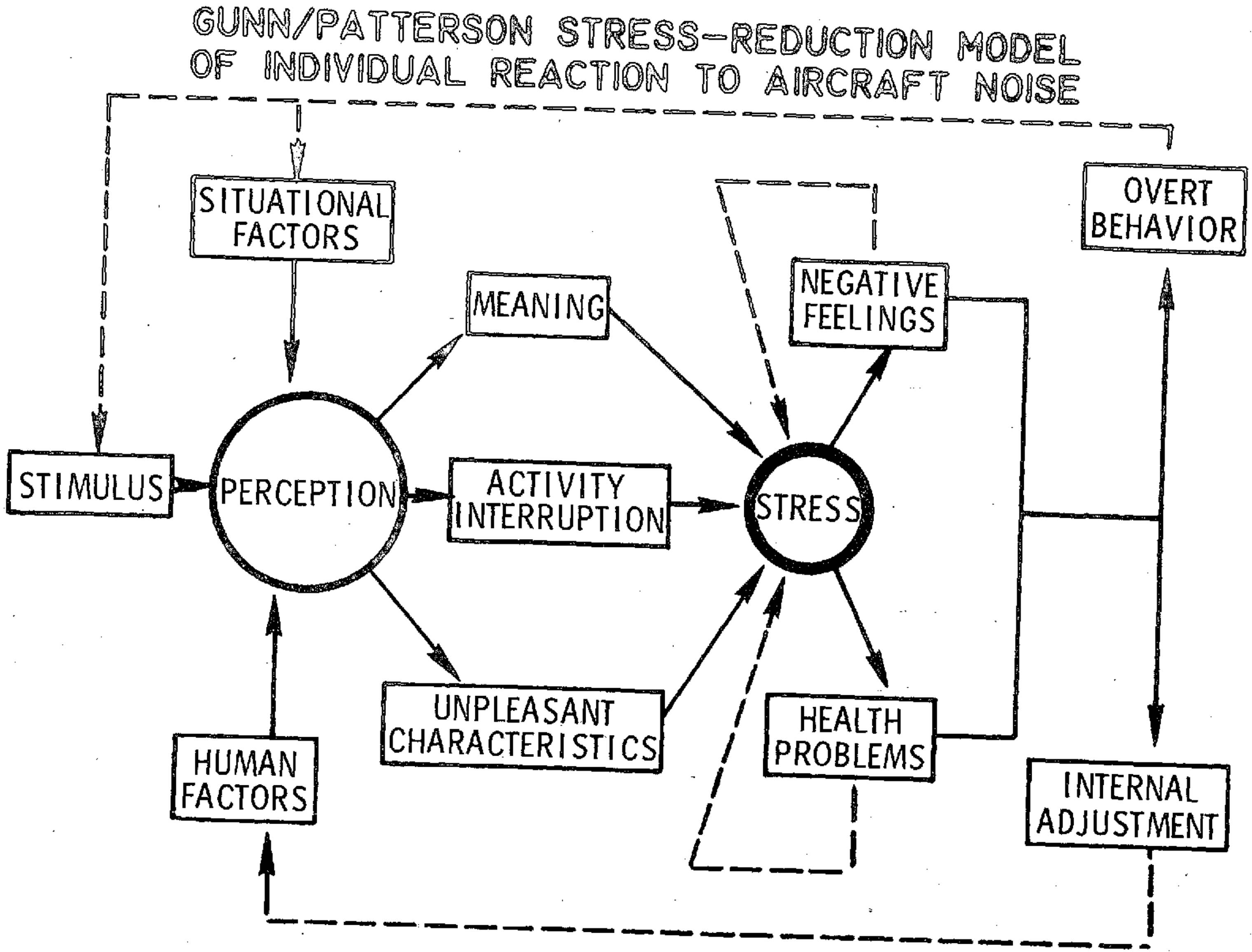

Figure A1.- Gunn/Patterson stress reduction model of individual reaction to aircraft noise.

APPENDIX B

INSTRUCTION A

"We would like you to help us in this experiment which has to do with how you feel about the airplane sounds you will hear during the next 30 minutes. During the experiment, you are not to talk to each other. You will be asked for your reaction to the airplance sounds at the end of the session, which, as I said, will last about 1/2-hour."

APPENDIX C

INSTRUCTION B

"We will need to set the listening level of the TV so that it is acceptable to your group. Let's try to find a level which is a good compromise and generally comfortable for all of you."

EXPERIMENTER - FIND ACCEPTABLE LEVEL BY CONSENSUS (IN QUIET).

THEN TURN OFF TV

"Do not readjust the level during the program, please. It is imperative for the purpose of the study that the sound level stay where it is presently set."

APPENDIX D

INSTRUCTIONS TO SUBJECTS IN LISTENING PHASE OF THE EXPERIMENT

Instructions to Subjects in Telephone Listening Phase of the Experiment

"You are about to take a listening test in which you will be identifying words spoken over the telephone. The two best scoring subjects on the test will receive $7 each. The four lower scoring subjects will receive $4 each. If you will pick up your telephone, you will receive more detailed instructions. Remember, during the test, do not cover your open ear and do not switch the phone to the other ear. Listen for the item number that accompanies each word. Some words may be completely masked out in the background noise. Make sure you are checking off a word in the correct box."

Recorded Instructions

"Your attention, please.
You are going to hear some one syllable words presented along with different loudness levels of background noise, each word will be presented in a carrier phase giving its particular item number. For example, you will hear phrases like the following:

NUMBER ONE IS TREE
NUMBER 46 IS MILE

The word presented will be one of the six words printed in a block on your answer sheet for that particular item number. Your task is to identify the word by drawing a line through it on your answer sheet. Look now at the answer sheet marked practice.

Here are some practice words:

NUMBER THREE IS TOW

Within block no. 3 is the correct word tow.

If this is the word you thought you heard, you will have drawn a line through "tow" on the practice answer sheet.
Here is another word.

NUMBER 14 IS BAT

In this case, the correct word was "bat." If this is the word you thought you heard, you will have drawn a line through "bat" within block 14 on the practice answer sheet. In the following exercise, some words will be easier to hear than others.

If you are not sure what the word is--guess. Always draw a line through one of the six words for each item number. If there are any questions, please ask the person in charge now. (Pause)

Please turn now to the answer sheet marked number one and prepare to begin. Remember, always draw a line through a word even if you must guess. After drawing a line through a word, move down to the next numbered block and prepare for the next word. After completing each of the 50 items, turn to the next answer sheet and continue, starting again with item no. 1.

A total of 300 words will be given at the rate of approximately one word every 6 second. The exercise will begin in about 30 seconds."

APPENDIX E

WORD LISTS

1	lick	pick	tick	wick	sick	kick
2	seat	meat	beat	heat	neat	feat
3	pus	pup	pun	puff	puck	pub
4	look	hook	cook	book	took	shook
5	tip	lip	rip	dip	sip	hip
6	rate	rave	raze	race	ray	rake
7	bang	rang	sang	gang	hang	fang
8	hill	till	bill	fill	kill	will
9	mat	man	mad	mass	math	map
10	tale	pale	male	bale	gale	sale
11	sake	sale	save	same	safe	sane
12	peat	peak	peace	peas	peal	peach
13	king	kit	kill	kin	kid	kick
14	sad	sass	sag	sat	sap	sack
15	sip	sing	sick	sin	sill	sit
16	sold	told	hold	cold	gold	fold
17	buck	but	bun	bus	buff	bug
18	lake	lace	lame	lane	lay	late
19	gun	run	nun	fun	sun	bun
20	rust	dust	just	must	bust	gust
21	pan	path	pad	pass	pat	pack
22	dim	dig	dill	did	din	dip
23	wit	fit	kit	bit	sit	hit
24	din	tin	pin	sin	win	fin
25	teal	teach	team	tease	teak	tear
26	tent	bent	went	sent	rent	dent
27	sung	sup	sun	sud	sum	sub
28	red	wed	shed	bed	led	fed
29	hot	got	not	tot	lot	pot
30	dud	dub	dun	dug	dung	duck
31	pip	pit	pick	pig	pill	pin
32	seem	seethe	seep	seen	seed	seek
33	day	say	way	may	gay	pay
34	rest	best	test	nest	vest	west
35	pane	pay	pave	pale	pace	page
36	bat	bad	back	bath	ban	bass
37	cop	top	mop	pop	shop	hop
38	fig	pig	rig	dig	wig	big
39	tap	tack	tang	tab	tan	tam
40	cave	cane	came	cape	cake	case
41	game	tame	name	fame	same	came
42	oil	foil	toil	boil	soil	coil
43	fin	fit	fig	fizz	fill	fib
44	cut	cub	cuff	cuss	cud	cup
45	feel	eel	reel	heel	peel	keel
46	dark	lark	bark	park	mark	hark
47	heap	heat	heave	hear	heath	heal
48	men	then	hen	ten	pen	den
49	raw	paw	law	saw	thaw	jaw
50	bead	beat	bean	beach	beam	beak

1	went	sent	bent
	dent	tent	rent
2	hold	cold	told
	fold	sold	gold
3	pat	pad	pan
	path	pack	pass
4	lane	lay	late
	lake	lace	lame
5	kit	bit	fit
	hit	wit	sit
6	must	bust	gust
	rust	dust	just
7	teak	team	teal
	teach	tear	tease
8	din	dill	dim
	dig	dip	did
9	bed	led	fed
	red	wed	shed
10	pin	sin	tin
	fin	din	win
11	dug	dung	duck
	dud	dub	dun
12	sum	sun	sung
	sup	sub	sud
13	seep	seen	seethe
	seek	seem	seed
14	not	tot	got
	pot	hot	lot
15	vest	test	rest
	best	west	nest
16	pig	pill	pin
	pip	pit	pick
17	back	bath	bad
	bass	bat	ban
18	way	may	say
	pay	day	gay
19	pig	big	dig
	wig	rig	fig
20	pale	pace	page
	pane	pay	pave
21	cane	case	cape
	cake	came	cave
22	shop	mop	cop
	top	hop	pop
23	coil	oil	soil
	toil	boil	foil
24	tan	tang	tap
	tack	tam	tab
25	fit	fib	fizz
	fill	fig	fin
26	same	name	game
	tame	came	fame
27	peel	reel	feel
	eel	keel	heel
28	hark	dark	mark
	bark	park	lark
29	heave	hear	heat
	heal	heap	heath
30	cup	cut	cud
	cuff	cuss	cub
31	thaw	law	raw
	paw	jaw	saw
32	pen	hen	men
	then	den	ten
33	puff	puck	pub
	pus	pup	pun
34	bean	beach	beat
	beak	bead	beam
35	heat	neat	feat
	seat	meat	beat
36	dip	sip	hip
	tip	lip	rip
37	kill	kin	kit
	kick	king	kid
38	hang	sang	bang
	rang	fang	gang
39	took	cook	look
	hook	shook	book
40	mass	math	map
	mat	man	mad
41	ray	raze	rate
	rave	rake	race
42	save	same	sale
	sane	sake	safe
43	fill	kill	will
	hill	till	bill
44	sill	sick	sip
	sing	sit	sin
45	bale	gale	sale
	tale	pale	male
46	wick	sick	kick
	lick	pick	tick
47	peace	peas	peak
	peach	peat	peal
48	bun	bus	but
	bug	buck	buff
49	sag	sat	sass
	sack	sad	sap
50	fun	sun	bun
	gun	run	nun

1	gold	hold	sold
	told	fold	cold
2	lame	lane	lace
	late	lake	lay
3	bust	just	rust
	dust	gust	must
4	did	din	dip
	dim	dig	dill
5	sin	win	fin
	din	tin	pin
6	sun	sud	sup
	sub	sung	sum
7	lot	not	hot
	got	pot	tot
8	pill	pick	pip
	pit	pin	pig
9	may	gay	pay
	day	say	way
10	pave	pale	pay
	page	pane	pace
11	pop	shop	hop
	cop	top	mop
12	tang	tab	tack
	tam	tap	tan
13	keel	feel	peel
	reel	heel	eel
14	heal	heap	heath
	heave	hear	heat
15	paw	jaw	saw
	thaw	law	raw
16	pub	pus	puck
	pun	puff	pup
17	meat	feat	heat
	neat	beat	seat
18	kit	kick	kin
	kid	kill	king
19	cook	book	hook
	shook	look	took
20	race	ray	rake
	rate	rave	raze
21	bill	fill	till
	will	hill	kill
22	sap	sag	sad
	sass	sack	sat
23	gale	male	tale
	pale	sale	bale
24	peas	peal	peach
	peat	peak	peace
25	rent	went	tent
	bent	dent	sent
26	sun	nun	gun
	run	bun	fun
27	bus	buff	bug
	buck	but	bun
28	tick	wick	pick
	kick	lick	sick
29	sin	sill	sit
	sip	sing	sick
30	name	fame	tame
	came	game	same
31	safe	save	sake
	sale	sane	same
32	map	mat	math
	mad	mass	man
33	gang	hang	fang
	bang	rang	sang
34	sip	rip	tip
	lip	hip	dip
35	beach	beam	beak
	bead	beat	bean
36	hen	ten	then
	den	men	pen
37	cuff	cuss	cub
	cup	cut	cud
38	park	mark	hark
	dark	lark	bark
39	fizz	fill	fib
	fin	fit	fig
40	soil	toil	oil
	foil	coil	boil
41	came	cape	cane
	case	cave	cake
42	wig	rig	fig
	pig	big	dig
43	ban	back	bat
	bad	bass	bath
44	test	nest	best
	west	rest	vest
45	seen	seed	seek
	seem	seethe	seep
46	dun	dug	dub
	duck	dud	dung
47	led	shed	red
	wed	fed	bed
48	tease	teak	tear
	teal	teach	team
49	bit	sit	hit
	wit	fit	kit
50	pad	pass	path
	pack	pan	pat

No.			
1	kick	lick	sick
	tick	wick	pick
2	neat	beat	seat
	meat	feat	heat
3	pun	puff	pup
	pub	pus	puck
4	hook	shook	book
	took	cook	look
5	lip	hip	dip
	sip	rip	tip
6	rake	rate	ray
	raze	race	rave
7	fang	bang	hang
	sang	gang	rang
8	will	hill	kill
	bill	fill	till
9	map	mat	math
	mad	mass	man
10	pale	sale	bale
	gale	male	tale
11	sane	sake	safe
	save	same	sale
12	peak	peach	peas
	peal	peace	peat
13	kin	kid	kick
	king	kit	kill
14	sack	sad	sap
	sag	sat	sass
15	sit	sip	sill
	sick	sin	sing
16	fold	sold	gold
	hold	cold	told
17	but	bug	bus
	buff	bun	buck
18	late	lake	lay
	lame	lane	lace
19	run	bun	fun
	sun	nun	gun
20	dust	gust	must
	bust	just	rust
21	path	pack	pass
	pat	pad	pan
22	dip	dim	din
	dill	did	dig
23	fit	hit	bit
	sit	kit	wit
24	tin	fin	sin
	win	pin	din
25	tear	teal	teak
	team	tease	teach
26	dent	tent	rent
	went	sent	bent
27	sup	sub	sud
	sum	sun	sung
28	wed	fed	bed
	led	shed	red
29	pot	hot	lot
	not	tot	got
30	duck	dud	dung
	dun	dug	dub
31	pit	pin	pig
	pill	pick	pip
32	seethe	seek	seen
	seed	seep	seem
33	say	pay	may
	gay	way	day
34	best	rest	nest
	vest	test	rest
35	page	pane	pace
	pave	pale	pay
36	bass	bat	ban
	back	bath	bad
37	hop	cop	shop
	mop	pop	top
38	dig	wig	big
	fig	pig	rig
39	tack	tam	tab
	tan	tang	tap
40	cake	came	cave
	cane	case	cape
41	tame	came	fame
	same	name	game
42	toil	boil	foil
	coil	oil	soil
43	fig	fizz	fit
	fib	fin	fill
44	cuss	cud	cup
	cut	cub	cuff
45	heel	peel	keel
	feel	eel	reel
46	mark	bark	dark
	lark	hark	park
47	heath	heave	heap
	heat	heal	hear
48	then	den	ten
	pen	hen	men
49	law	saw	paw
	jaw	raw	thaw
50	beat	beak	beach
	beam	bean	bead

1	sent	rent	dent
	tent	bent	went
2	told	fold	cold
	gold	hold	sold
3	pass	pat	pack
	pan	path	pad
4	lay	lame	lake
	lace	late	lane
5	sit	kit	wit
	fit	hit	bit
6	just	must	dust
	gust	rust	bust
7	team	tease	teach
	tear	teal	teak
8	dill	did	dig
	dip	dim	din
9	shed	bed	wed
	fed	red	led
10	win	pin	din
	tin	fin	sin
11	dung	dun	dud
	dub	duck	dug
12	sud	sum	sub
	sung	sup	sun
13	seed	seep	seem
	seethe	seek	seen
14	tot	lot	pot
	not	got	not
15	nest	vest	west
	rest	best	test
16	pick	pig	pit
	pin	pip	pill
17	bath	ban	bass
	bat	bad	back
18	gay	way	day
	say	pay	may
19	rig	dig	pig
	big	fig	wig
20	pace	pave	pane
	pay	page	pale
21	cape	cake	case
	cave	cane	came
22	mop	pop	top
	hop	cop	shop
23	boil	soil	coil
	oil	foil	toil
24	tab	tan	tam
	tap	tack	tang
25	fill	fig	fin
	fit	fib	fizz
26	fame	same	came
	game	tame	name
27	reel	heel	eel
	keel	feel	peel
28	bark	park	lark
	hark	dark	mark
29	hear	heath	heal
	heap	heat	heave
30	cud	cuff	cut
	cub	cup	cuss
31	saw	thaw	jaw
	raw	paw	law
32	den	men	pen
	hen	ten	then
33	puck	pun	pus
	pup	pub	puff
34	beak	bead	beam
	bean	beach	beat
35	beat	heat	meat
	feat	seat	neat
36	hip	tip	sip
	rip	dip	lip
37	kid	kill	king
	kit	kick	kin
38	rang	fang	gang
	hang	sang	bang
39	shook	look	took
	cook	book	hook
40	man	map	mass
	math	mad	mat
41	rave	rake	race
	ray	raze	rate
42	sale	sane	same
	safe	save	sake
43	till	will	fill
	kill	bill	hill
44	sick	sin	sing
	sit	sip	sill
45	sale	tale	gale
	male	bale	pale
46	sick	tick	lick
	pick	kick	wick
47	peach	peat	peal
	peace	peas	peak
48	buff	bun	buck
	but	bug	bus
49	sass	sack	sat
	sap	sag	sad
50	nun	fun	run
	bun	gun	sun

No.			
1	cold	gold	fold
	sold	told	hold
2	lace	late	lane
	lay	lame	lake
3	gust	rust	bust
	just	must	dust
4	dig	dip	did
	din	dill	dim
5	fin	din	win
	pin	sin	tin
6	sub	sung	sum
	sun	sud	sup
7	got	pot	tot
	lot	not	hot
8	pin	pip	pill
	pick	pig	pit
9	pay	day	gay
	way	may	say
10	pay	page	pale
	pace	pave	pane
11	top	hop	pop
	shop	mop	cop
12	tam	tap	tan
	tang	tab	tack
13	eel	keel	heel
	peel	reel	feel
14	heat	heal	hear
	heath	heave	heap
15	jaw	raw	thaw
	law	saw	paw
16	pup	pub	puff
	puck	pun	pus
17	feat	seat	neat
	beat	heat	meat
18	kick	king	kid
	kill	kin	kit
19	book	took	shook
	look	hook	cook
20	raze	race	rave
	rake	rate	ray
21	kill	bill	hill
	till	will	fill
22	sat	sap	sack
	sad	sass	sag
23	male	bale	pale
	sale	tale	gale
24	peal	peace	peat
	peak	peach	peas
25	bent	dent	sent
	rent	went	tent
26	bun	gun	sun
	nun	fun	run
27	bug	buck	buff
	bun	bus	but
28	pick	kick	wick
	sick	tick	lick
29	sing	sit	sin
	sill	sick	sip
30	came	game	same
	name	fame	tame
31	sake	sale	save
	same	safe	sane
32	math	mad	mat
	man	map	mass
33	sang	gang	rang
	fang	bang	hang
34	rip	dip	lip
	hip	tip	sip
35	beam	bean	bead
	beat	beak	beach
36	ten	pen	den
	men	then	hen
37	cub	cup	cuss
	cud	cuff	cut
38	lark	hark	park
	mark	bark	dark
39	fib	fin	fill
	fig	fizz	fit
40	foil	coil	boil
	soil	toil	oil
41	case	cave	cake
	came	cape	cane
42	big	fig	wig
	rig	dig	pig
43	bad	bass	bath
	ban	back	bat
44	west	rest	vest
	test	nest	best
45	seek	seem	seed
	seep	seen	seethe
46	dub	duck	dug
	dung	dun	dud
47	fed	red	led
	shed	bed	wed
48	teach	tear	tease
	teak	team	teal
49	hit	wit	sit
	kit	bit	fit
50	pack	pan	pat
	pad	pass	path

National Aeronautics and Space Administration
WASHINGTON, D. C. 20546

OFFICIAL BUSINESS

Penalty For Private Use, $300.00

POSTAGE AND FEES PAID
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION

NASA-

NASA SCIENTIFIC & TECHNICAL INFO.
FACILITY POST OFFICE BOX 8757
BALTIMORE-WASHINGTON INTERNATIONAL
AIRPORT
MARYLAND 21240

25