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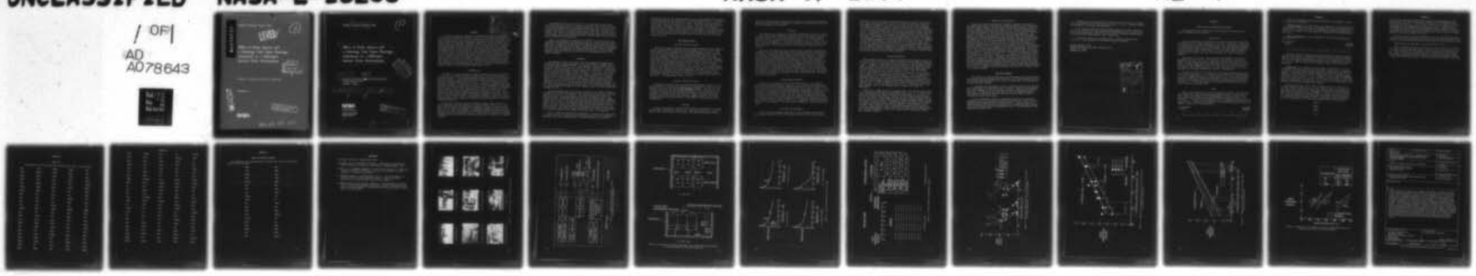

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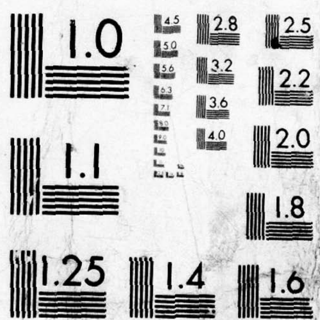

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NASA Technical Paper 1590

LEVEL II

Effect of Noise Spectra and a Listening Task Upon Passenger Annoyance in a Helicopter Interior Noise Environment

Sherman A. Clevenson and Jack D. Leatherwood

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NASA

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Effect of Noise Spectra and a Listening Task Upon Passenger Annoyance in a Helicopter Interior Noise Environment

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NASA
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Scientific and Technical
Information Branch

1979

SUMMARY

A laboratory study was conducted to determine the effects of helicopter interior noise on passenger annoyance. Both reverie and listening situations were studied as well as the relative effectiveness of several descriptors (i.e., overall sound pressure level, A-weighted sound pressure level, and speech interference level) for quantifying annoyance response for these situations. The noise stimuli were based upon recordings of the interior noise of the NASA Civil Helicopter Research Aircraft. These noises were presented at levels ranging from approximately 68 to 86 dB(A) with various gear clash tones selectively attenuated to give a range of spectra. The listening task required the subjects to listen to and record phonetically balanced words presented within the various noise environments. Results indicate that annoyance during a listening condition is generally higher than annoyance during a reverie condition for corresponding interior noise environments. Attenuation of the planetary gear clash tone results in increases in listening performance but has negligible effect upon annoyance for a given noise level. The noise descriptor most effective for estimating annoyance response under conditions of reverie and listening situations is shown to be the A-weighted sound pressure level.

INTRODUCTION

The interior noise environments of most helicopters consist of broad-band noise as well as a number of discrete frequencies or tones arising from the transmission gears. In developing passenger response criteria for such environments, the effects of these tones must be accurately represented by the noise descriptor used to quantify the noise level. In studies of helicopter noise control, for example, the question arises as to whether a passenger would find helicopter noise at a given level to be more or less comfortable than some other vehicle noise having the same level but without tones. Conversely, the question may be viewed in terms of the effectiveness of various noise descriptors for quantifying the noise of helicopters and other vehicles in order that equal levels give equal responses under representative passenger situations. The purpose of this study was to examine the subjective response to helicopter noise having a range of tonal content. Specifically, subjective response in terms of annoyance level was correlated with different noise descriptors for reverie and listening situations.

The physical characteristics of helicopter interior noise in terms of spectra and level have been reported in numerous studies. (See ref. 1.) However, very few studies have examined the passenger response to noises having spectra of the type in helicopters. In subjective studies of aircraft interior noise (refs. 2 and 3, for example) the passenger annoyance has been shown to be dependent upon the passenger activities. In the above two references, passenger annoyance was found to be higher when the subjects were listening to or engaged in speech.

The approach used in this study was (1) to investigate the effects of varying the spectral content of a typical helicopter interior noise spectrum on passenger annoyance and listening performance under both reverie and listening task conditions and (2) to determine the best descriptor (overall sound pressure level (OSPL), A-weighted sound pressure level (AL), and speech interference level (SIL)) for estimating annoyance response under these conditions. The helicopter noise spectrum selected for use in this study was that measured within the CH-53A civil helicopter.

Results are presented to illustrate the effects of various tones of the helicopter noise spectrum on annoyance for both the listening task and reverie conditions. Comparisons between annoyance responses for the task and reverie conditions are made for each descriptor. Additional comparisons of the present data with other published data are made where appropriate. Finally, annoyance correction factors (penalties) are proposed that account for the increased annoyance under task conditions as well as for a corresponding shift in discomfort threshold.

APPARATUS

The apparatus used in this study is the three-degree-of-freedom motion simulator called the Langley passenger ride quality apparatus (PRQA) located at the NASA Langley Research Center. The simulator is described in detail in references 4 and 5; the reader is referred to these references for information related to system operation, vibration capabilities, and design. Various photographs illustrating the PRQA are shown in figure 1. Figure 1(a) is a view of the test subject waiting room; figure 1(b) shows a test subject entering the cabin; figure 1(c) is an exterior view of the cabin; figure 1(d) is a model showing the three-axis drive system; figure 1(e) shows the control console; figure 1(f) is a view looking out of the simulator window showing the visual simulation; figure 1(g) is a view of the interior with the front bulkhead removed; figure 1(h) is a view through the rear one-way window; and figure 1(i) is a front view through the front one-way window. For this investigation, only the vertical degree-of-freedom (at a low vibration level) and noise capabilities of PRQA were used.

The sound systems used in this study are shown in the diagram in figure 2. The spoken words were distributed over the top of the cabin using four midrange speakers 10.2 cm (4 in.) in diameter. The simulated helicopter noise was played through an octave-band equalizer and into a crossover network, where frequencies above 500 Hz were played through two high-frequency horn "tweeters" located near the top of the cabin; the low frequencies were played through two speakers 38.1 cm (15 in.) in diameter located in the front and rear doors of the cabin. The same signals were played through eight midrange speakers located under the seats. All noises were fed through speaker sentries to assure that the participants would not be subjected to greater noise levels than programmed. In the event of sentry failure, fuses limited the power to the speakers.

Prior to conducting experimental measurements, a survey of the sound levels at the head locations of the seated subjects was made for both the background helicopter noise and the spoken words. Broad-band random noise at 70 and

85 dB(A) was used for the background noise survey; tape-recorded speech (phonetically balanced (PB) words inserted in the sentence "Please write ____ now.") at 76 dB(A) was used for the spoken word survey. The speech level was measured with a Type 1 sound level meter set on "slow." The cabin measurement locations and the dB(A) differences between the reference level and those measured at locations of the subjects' heads (indicated by the numbers in parentheses) are shown in figure 3. The reference level is that measured by a microphone mounted just below the overhead rack and between the row of seats as indicated in figure 3. The differences were the same for both the PB words and the simulated helicopter noise.

EXPERIMENTAL METHOD

Vibration and Noise Stimuli

The interior noise of the NASA Civil Helicopter Research Aircraft (Sikorsky CH-53A) was prerecorded and played through appropriate filters into the PRQA sound system while the passenger cabin was simultaneously vibrated at a low level in the vertical direction with narrow-band (bandwidth of 9 Hz, centered at 4.5 Hz) random vibration at an rms acceleration level of 0.02g. This vibration provided a background level only and did not simulate the helicopter vibration environment. A total of four noise levels and four filter (spectral) conditions were investigated for the listening task and reverie (no-task) conditions. The various spectral conditions (SC) are shown in figure 4 and are referred to in subsequent discussions as SC = a, b, c, or d. As indicated in figure 4, the primary effect of spectral filtering was to selectively eliminate discrete tones from the interior noise spectrum. The tones at 1370 and 2700 Hz represent the fundamental first-stage planetary gear clash and tail-rotor-interconnect gear clash frequencies, respectively. The noise levels varied from 86 dB(A) (highest level with no filtering) to 68 dB(A) (lowest level with filtering). (See experimental design in fig. 5.)

Subjective Evaluation Scale

A nine-point unipolar scale, with associated numerical integers, was used by each subject to evaluate the annoyance of a test condition. The scale was anchored at zero with the words "ZERO ANNOYANCE, NEUTRAL." The anchor at the opposite end of the scale was "MAXIMUM ANNOYANCE." Thus, the scale continuum of increasing numbers was interpreted as representing increasing degrees of annoyance. The subjects were instructed to interpret the scale in an equal-interval fashion and to base their annoyance judgments upon the noises they experienced within each test condition. The detailed instructions are given in appendix A.

Subjects

A total of 84 subjects (15 males and 69 females) participated in the study. The volunteer subjects were obtained from a contractual subject pool and were paid for their participation in the study. The ages of the subjects ranged from 18 to 60 years, with a median age of 31 years. All subjects were audiometrically screened and were required to have hearing losses of no greater than 20 dB at frequencies up to 6000 Hz.

Procedure

The tasks for each subject (six subjects concurrently) were to (1) listen for and record PB words presented along with the interior noise for certain of the noise stimuli and (2) provide annoyance ratings of each noise stimulus using the nine-point unipolar scale described earlier. The actual PB words used are given in appendix B. Each noise stimulus lasted for 1 minute. At the end of each noise exposure, the subjects rated their annoyance using the scale mentioned above. The rating sheets and the experimental design are shown in figure 5.

The order of presentation of the noise and word exposures were separately randomized (twice without replacement) and counterbalanced for presentation to the subjects. Thus, each noise stimulus was presented twice to the subjects, once with words (listening task) and once without words (reverie). A typical day of testing involved exposing each group to 32 noise stimuli followed by a 15-minute rest period after which the remaining 32 stimuli were presented. Prior to presentation of the first noise stimulus, an orientation session was conducted in which each subject was given a complete word list and asked to read the words silently as they were simultaneously played over the waiting room loudspeaker. After being seated in the simulator, a list of 40 PB words (see appendix C) was played into the cabin under ambient noise conditions and the subjects were asked to write each word upon a recording sheet. This method was intended to familiarize the subjects with the procedure to be used under actual test conditions.

RESULTS AND DISCUSSION

The basic data collected in this study consisted of (1) the number of words correctly understood within each cell of the listening task conditions, and (2) the individual annoyance judgments obtained for each of the noise stimuli represented by the cells of the experimental design shown in figure 5. The means of all individuals' listening performances (percentages of words correctly understood) were computed for each cell that had a listening task condition. In addition, the means of all the individual annoyance responses within each cell were computed. The following sections discuss listening task performance and annoyance response for both reverie and listening task conditions as a function of noise level and spectral content, i.e., presence or absence of the planetary gear clash component. The final section compares the various descriptors used.

Listening Task Performance

Listening task performance (measured in terms of percent of words heard correctly) is shown in figure 6 as a function of noise level for each noise descriptor. The solid symbols represent the condition in which the planetary gear clash frequency was present in the interior noise spectrum, whereas the open symbols correspond to the conditions in which the gear clash frequency was removed by spectral filtering. The solid lines (gear clash) and dashed lines (no gear clash) represent the best-fit straight lines (linear regression) to the listening performance data for each noise descriptor and gear clash condition. As indicated in figure 6, the listening performance was generally best when the planetary gear clash frequency was removed from the interior noise spectrum. The decrements in listening task performance caused by the presence of planetary gear clash were greatest for OSPL and least for SIL. For example, the performance decrements in the regions where the curves of figure 6 overlap (in the vertical direction) varied from about 24- to 30-percent additional reduction in number of words correctly heard for the OSPL descriptor to about 6- to 12-percent additional reduction for the SIL descriptor. Thus, the use of the SIL descriptor better accounted for the effect of the gear clash component and could be used to obtain reasonable estimates of listening performance under both the gear clash and no gear clash conditions.

Annoyance Response

Mean annoyance rating as a function of A-weighted sound pressure level for both reverie and listening task conditions and for the four spectral conditions is shown in figure 7. Also shown is the regression line and correlation coefficient r computed for each task and reverie condition. The annoyance ratings obtained during the listening task condition were generally higher than those obtained during reverie for the range of noise levels shown. Furthermore, removal of the planetary gear clash frequencies (SC = c and SC = d; see fig. 5) reduced the noise level with a concurrent reduction in the mean annoyance ratings. For the limited data obtained, however, it was not possible to determine whether the decrease in annoyance ratings was attributable to the decreased noise level, the exclusion of the gear clash, or to a combination of both. The results shown in figure 7 imply that an annoyance "penalty" in the range of 3.8 to 2.5 dB(A) resulted when the subjects were asked to perform the listening task. This is discussed in more detail in a later section of this paper together with the mean annoyance data in terms of the other two descriptors.

Figure 8 is a comparison of the annoyance data of the present study (solid lines) with data from a similar study (dashed lines, ref. 3). In the reference study, the subjects were asked to converse with one another on any topic of their choice while being exposed to various aircraft interior noises including that of a helicopter. Even though the tasks were not identical between the two studies, for the noise levels investigated, reasonable agreement exists between the results of the two studies. Of particular note is the fact that the annoyance penalties obtained from the data of reference 3 range between 3.3 and 1.4 dB(A); these values are also in reasonable agreement with the results of the present investigation. These results serve to point out the possible need for an annoyance penalty to account for listening task interruption effects upon passenger annoyance.

Comparison of Descriptors

The previous section discussed the annoyance response as a function of A-weighted sound pressure level for the listening task and reverie conditions. Also of interest, however, is consideration of annoyance response in terms of two other commonly used descriptors, OSPL and SIL. Linear regression lines relating mean annoyance ratings to noise level for all three noise descriptors are shown in figure 9 for the reverie and listening task conditions. Also shown in the table at the top of the figure are the respective correlation coefficients between mean annoyance rating and noise level for each descriptor and condition. As indicated, the annoyance responses increased linearly with increasing noise level and were greater for the listening task than for the reverie condition for all three descriptors. Further, the differences in annoyance response between the task and reverie conditions were greatest for OSPL and least for SIL. For example, at an annoyance level of 4, the difference between the listening task and reverie condition is approximately 2.0 dB for SIL, 3.3 dB for the A-weighted measurements, and 5.0 dB for OSPL. These three numbers represent the noise level penalties introduced when passenger subjects are engaged in a listening situation, e.g., listening to conversational speech. From the table in this figure, the correlation coefficients were seen to be highest for the AL descriptor. Subsequent statistical tests indicated that for the reverie condition, AL correlated better (at 95-percent significance level) with mean annoyance response than did either OSPL or SIL. For the task condition AL correlated better than OSPL but did not differ significantly from SIL. Thus, within the context of the present study, AL was the most effective descriptor for use in estimating annoyance response within the civil helicopter interior noise environment.

CONCLUDING REMARKS

The effects of a typical helicopter noise environment upon the performance and annoyance response of passengers under both reverie and listening task conditions have been investigated. As a result of this study, the following conclusions have been reached:

1. Listening task performance (correct recording of phonetically balanced words) decreased as the background noise increased. Removal of the planetary gear clash frequency in the noise spectra resulted in improved performance for this task. The data imply that the improved listening performance may be attributable to removal of the gear clash tone and not simply a result of lowering the overall noise level.

2. For all spectral conditions, significant differences in annoyance responses for the listening task and reverie conditions were found. The subjects were more annoyed during the task condition. It was not possible to determine whether the increase of annoyance with increased noise was attributable to the increased overall sound pressure level or to the inclusion of the planetary gear clash tone.

3. Comparison of the results of this study with those of another investigator indicated generally good agreement with respect to overall annoyance ratings and decrements in listening task performance.

4. The increased annoyance ratings obtained under the listening task condition were equivalent to noise penalties of approximately 2.0, 3.3, and 5.0 dB for the noise descriptors, speech interference level, A-weighted sound pressure level, and overall sound pressure level, respectively.

5. Within the context of the present study, A-weighted sound pressure level was the best descriptor for estimating annoyance response.

Langley Research Center
National Aeronautics and Space Administration
Hampton, VA 23665
November 20, 1979

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DDC TAB
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APPENDIX A

DESCRIPTION OF INSTRUCTIONS AND TASKS

This appendix gives a description of the experiment instructions and tasks as presented to the subjects.

Instructions

You have volunteered to participate in a research program to investigate the annoyance due to noises encountered in aircraft. To do this, we have built a simulator which can expose passengers to realistic ride motions. The simulator essentially provides no risk to passengers. The system has been designed to meet stringent safety requirements such that it cannot expose subjects to motions which are known to cause injury. It contains many built-in safety features which automatically shut the system down if it does not perform properly.

The noises that you will receive today are representative of those you may experience in an aircraft. You will enter the simulator, take a seat, fasten the seat belt, and assume a comfortable position with both feet on the floor. You are to make yourself as comfortable and relaxed as possible while the test is being conducted. However, you must keep your feet on the floor and keep your seat belts fastened at all times. During the tests you will at all times be in two-way communication with the test conductor.

You have the option at any time and for any reason to terminate the tests in any one of three ways: (1) by pressing the overhead button labeled "STOP," (2) by voice communication with the test conductor, or (3) by unfastening your seat belt. Because of individual differences in people, there is always the possibility that someone may find the motions objectionable and may not wish to continue. If this should happen to you, please do no hesitate to stop the tests by one of the methods above.

Tasks

There are two tasks that you will be required to perform. The first task will require you to evaluate the annoyance associated with various ride segments. Each ride segment will last approximately 1 minute. The start of a ride segment will be indicated by the words "We will now begin ride ____ of session ____." The end of a ride segment will be indicated by the words "Please rate ride ____." Evaluate the annoyance of the noise contained within each ride segment in terms of the following scale:

Zero Annoyance
Neutral — Maximum
Annoyance

0 1 2 3 4 5 6 7 8

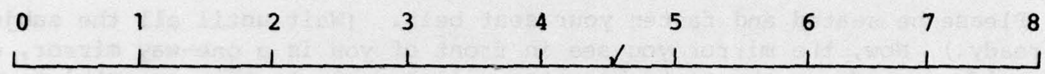
APPENDIX A

There will be several seconds between successive ride segments to allow you to mark your evaluation.

Evaluation marks.- You should record your evaluation of the annoyance due to the noise associated with each ride segment by placing a checkmark (e.g., ✓) upon the scale. Try to be careful in recording your evaluations because the point of the checkmark (✓) will be used for interpretation of distance along the scale.

Scale interpretation.- Score interpretation of the rating shown below would be 4-1/2.

Zero Annoyance Neutral | Maximum Annoyance



The scale should be treated as representing the total range of annoyance that you will experience. Furthermore, your evaluation should be based only upon the noises that you experience. Certainly, you could evaluate the annoyance of a ride segment based upon other factors such as temperature, pressure, or vibration. However, restrict your annoyance evaluations to that due to noise only.

Consistency.- It is typical for participants in the study to "try to be consistent." Instead of trying to be consistent with previous ride segments, try and evaluate each segment without looking at evaluations of previous ride segments. Please do not be concerned about whether your ratings agree with the others in the simulator with you. Remember, we want to know how different people feel about the noise. It is also typical for participants to feel that they are not doing well at this task. It is usually true, however, that particpants are doing better than they think they are, so don't be discouraged if you find the task difficult or monotonous at times.

The second task you will be asked to perform will be to listen for the following sentence "Please write ____ now." When you hear this sentence, you will have several seconds to write down the required word on the appropriate space below your rating scales. For example, if you hear "Please write deck now," then you should write the word "deck" on the first available space in the column corresponding to the particular ride segment you are experiencing. If, during the same ride segment you hear the sentence "Please write class now," you should enter this in the next available space as shown below:

Ride 3

deck

class

____

If you do not understand the word, then enter "x" in the appropriate blank. The sentences will occur intermittently throughout the test and some rides will have no words at all. If you do not know the correct spelling of a word, then please try to indicate how it sounds to you; that is, "sound it out." For example, the word "tough" would be counted correct if spelled as "tuf" or "tuff" and the word "turf" would be acceptable if spelled "terf." The three individuals who score the most words correctly will receive additional compensation for their participation in the test.

Prior to the start of actual testing, you will have an orientation session during which you will be asked to write down a series of practice words. This is merely to help you become familiar with the work task and will not be scored.

(Upon entering the simulator, the subject should be told:)

Please be seated and fasten your seat belt. (Wait until all the subjects are ready.) Now, the mirror you see in front of you is a one-way mirror, and as I told you before, the test conductor will be able to hear everything you say. Also, if you wish to end the test, you can undo your seat belt, press one of these little buttons (point to both), or you can ask the test conductor to stop the test and let you out. This first test will take about a half hour.

APPENDIX B

WORD LIST

This appendix lists the phonetically balanced words used in the experiment.

WHY	SIZE	BADGE	FLOAT	NEW
TURF	WEDGE	CLOTH	SAGE	RUT
GNAW	DECK	KEPT	CLOAK	NEAT
DROP	HURL	FLOP	RACE	DODGE
JAM	WHARF	FALL	TICK	SKETCH
FLUSH	LEAVE	WASP	TOUCH	MERGE
ROUSE	CRAVE	ODE	HOT	BATH
NECK	VOW	HULL	POD	COURT
SOB	LAW	FEE	FROWN	OILS
TRIP	STAG	LAG	RACK	SHIN
DILL	OAK	THIGH	BUS	PECK
THRASH	NEST	CHART	BLONDE	BEAST
DIG	SIT	WAIT	PERT	HEED
RATE	CRIME	COB	SHED	EEL
FAR	MUCK	MASH	KITE	MOVE
CHECK	FAME	EYES	RAW	EARN
AIR	TAKE	RAISE	HISS	BUDGE
BEAD	WHO	DEEP	FIN	SOUR
SPED	TOIL	SHANK	SCAB	RAVE
CAST	PATH	RAY	HOW	BEE
CLASS	PULSE	GAP	STRAP	BUSH
LUSH	FIG	CRIB	SLAP	TEST
SHOUT	BARB	PUS	PINCH	HATCH

APPENDIX B

BALD	PLEASE	EAT	OR	COURSE
CAPE	ACHE	DAD	STARVE	DUPE
CANE	PEST	TANG	BLUSH	AS
THERE	SLIP	FATE	NAB	ARE
DISH	RUB	SUCK	BAIT	ROUGH
HID	FEAST	ELSE	BUD	BAD
HEAP	DEED	PIT	RAP	BEST
PANTS	CLEANSE	GILL	MOOSE	CLOVE
HUNT	FOLK	CHARGE	TRASH	TONGUE
NO	NOOK	BOUGHT	GLOSS	FERN
BAR	MANGE	CLOUD	PERK	BOG
PAN	SUCH	MUTE	VAMP	LOG
FUSS	USE(YEWS)	BEAN	START	FOWL
CREED	CRASH	SCYTHE	EARL	SNUFF
BOX	RIDE	VAST	CORPSE	WRIT
STRIFE	PILE	RIB	SLUDGE	HIRE
DIKE	RAT	PICK	TAN	CLOTHES
NOT	RAG	HOCK	WAYS	SHOE
FORD	IS	OUR	BOUNCE	FORGE
END	WHEAT	HIT	NIECE	PRIG
THEN	RISE	JOB	AWE	SCAN
BASK	HIVE	WISH	THEM	FLICK
FRAUD	GROVE	NUT	NEED	SUP
SMILE	TOE	DAB	QUART	SLOUCH
DEATH	PLUSH	FROG	FIVE	THUS

APPENDIX C

WORDS FOR PRACTICE SESSION

This appendix lists the phonetically balanced words used for the practice session of the experiment.

CANE	BAD
PEST	FERN
BADGE	DAD
TANG	SNUFF
BLUSH	SHOE
HUNT	WHY
FOLK	SIZE
ODE	FLOAT
CHARGE	NEW
TRASH	AS
BOX	ROUSE
RIDE	HOT
WAIT	BATH
VEST	TONGUE
CORPSE	DIG
THEN	SIT
RISE	PERT
SHANK	HEED
JOB	WRIT
AWE	CRAVE

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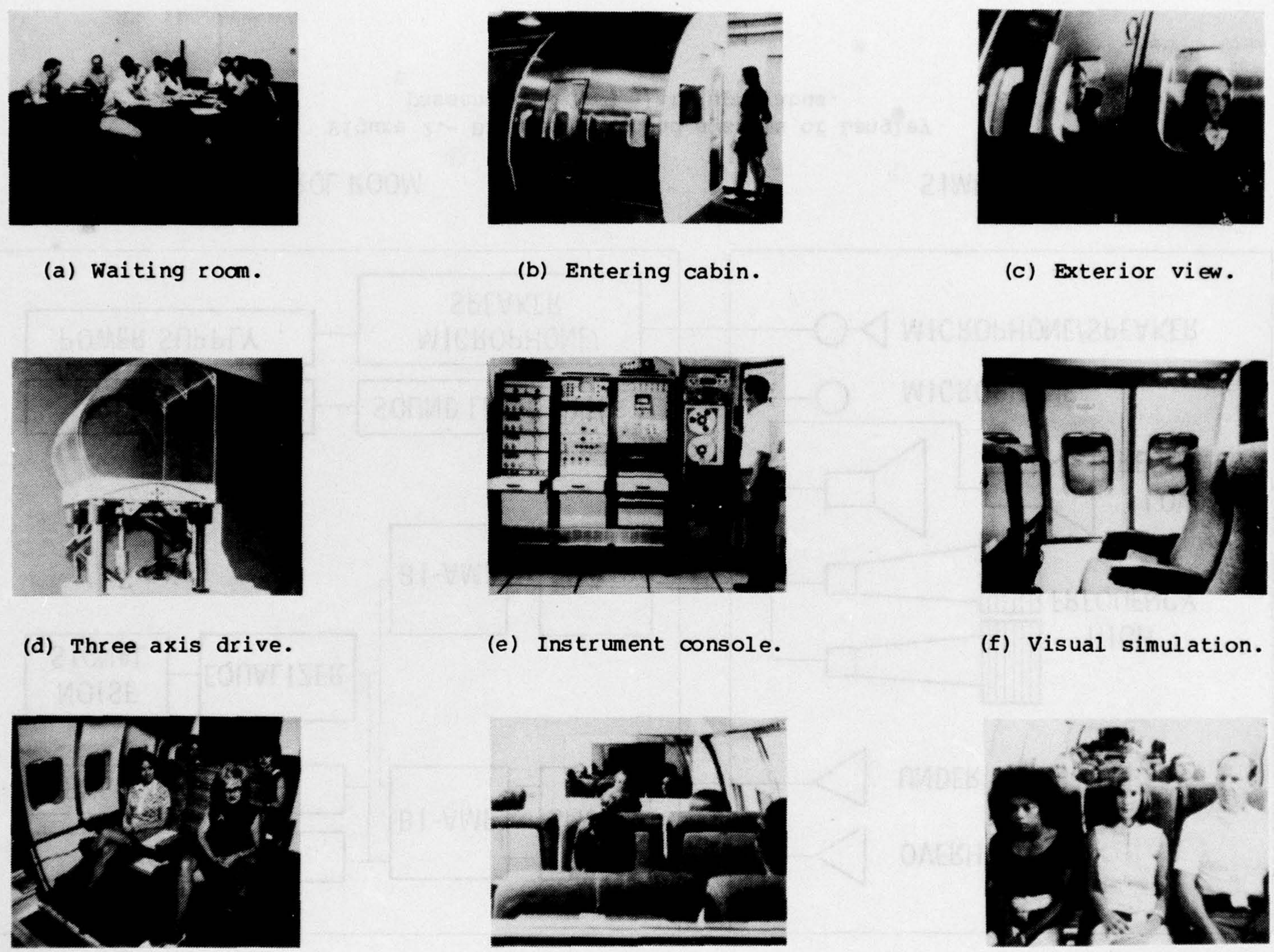
2. Pearsons, Karl S.; and Bennett, Ricarda L.: Effects of Interior Aircraft Noise on Speech Intelligibility and Annoyance. NASA CR-145203, 1977.

3. Rupf, J. A.: Annoyance Judgments of Interior Aircraft Noises: A Comparison of Speech and Reverie Conditions. J. Acoust. Soc. America, vol. 62, suppl. no. 1, Fall 1977, pp. S94-S95.

4. Clevenson, Sherman A.; and Leatherwood, Jack D.: On the Development of Passenger Vibration Ride Acceptance Criteria. Shock & Vib. Bull., Bull. 43, Pt. 3, U.S. Dep. Def., June 1973, pp. 105-111.

5. Stephens, David G.; and Clevenson, Sherman A.: The Measurement and Simulation of Vibration for Passenger Ride Quality Studies. Proceedings of the Technical Program, NOISEXPO - National Noise and Vibration Control Conference, c.1974, pp. 86-92.



(a) Waiting room. (b) Entering cabin. (c) Exterior view.

(d) Three axis drive. (e) Instrument console. (f) Visual simulation.

(g) First class cabin. (h) Rear view. (i) Subjects.

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Figure 1.- Langley passenger ride quality apparatus.

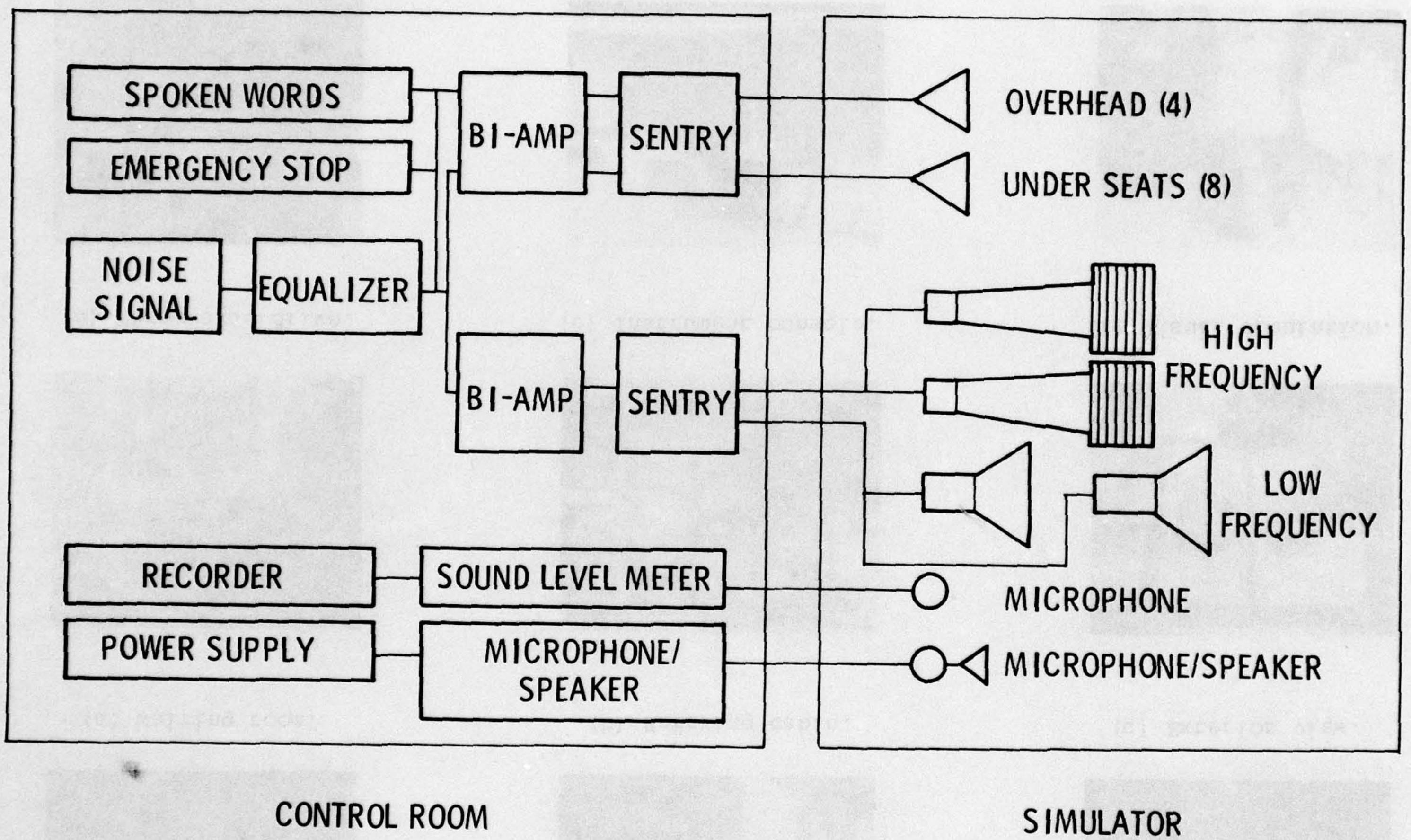
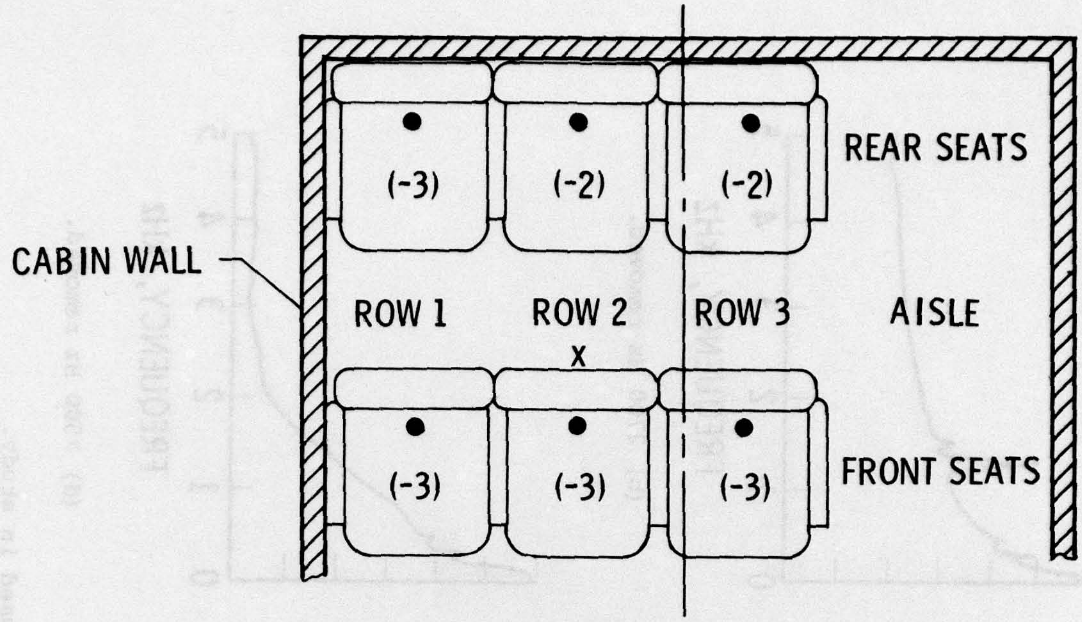
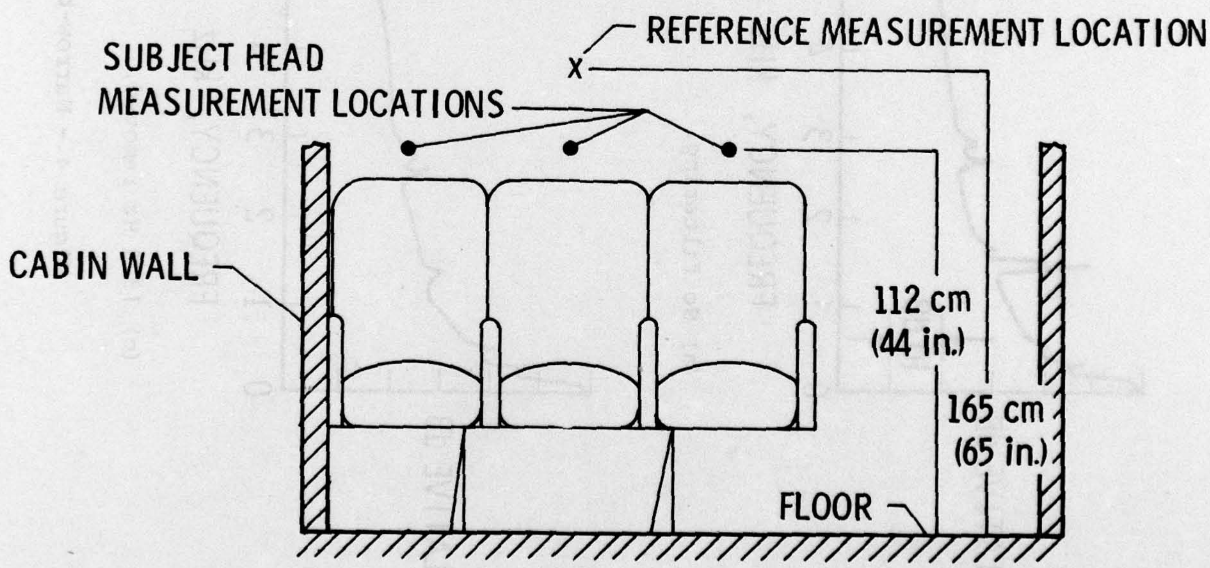


Figure 2.- Diagram of sound systems of Langley passenger ride quality apparatus.

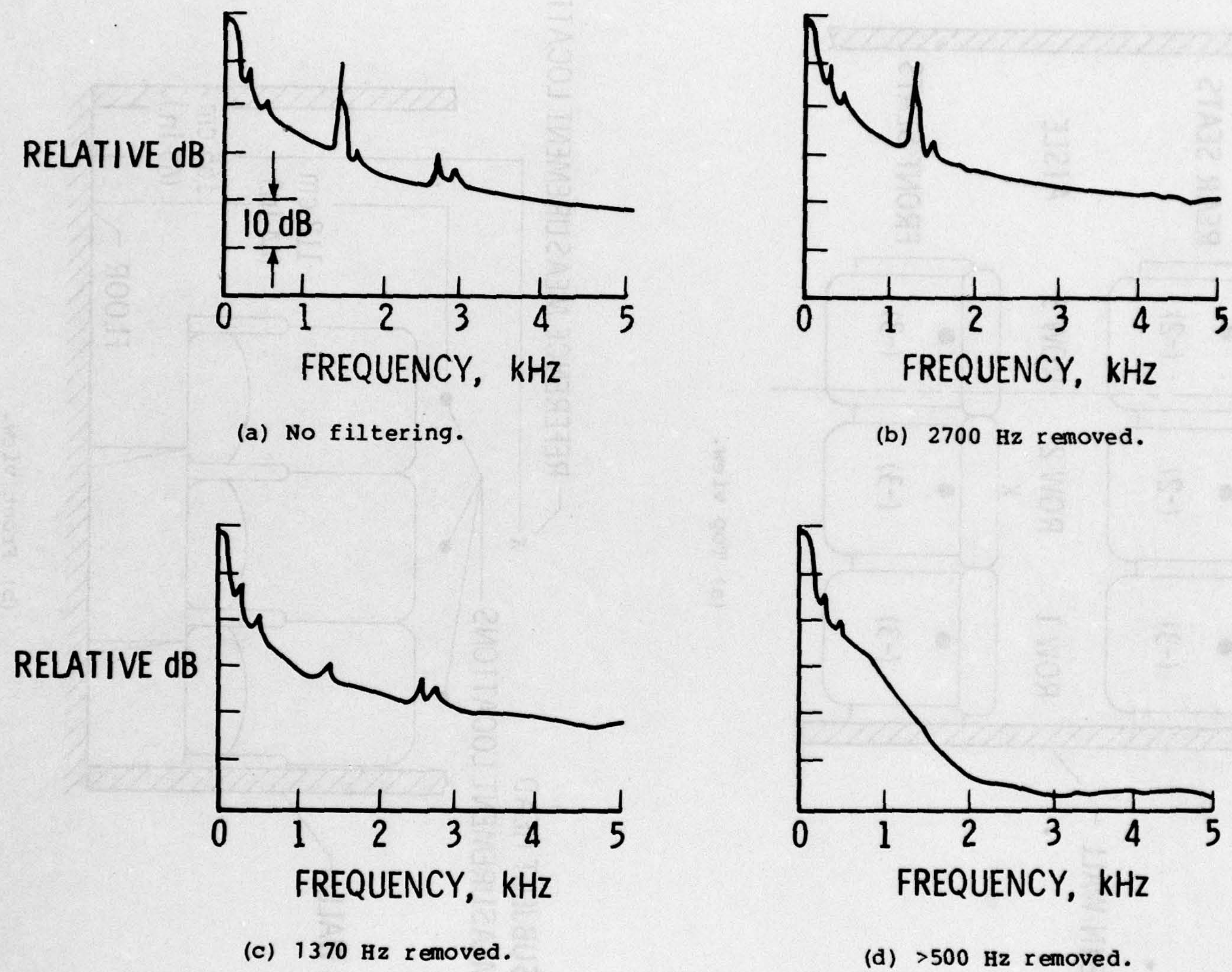


(a) Top view.



(b) Front view.

Figure 3.- Measurement locations and dB(A) level differences from reference in Langley passenger ride quality apparatus.



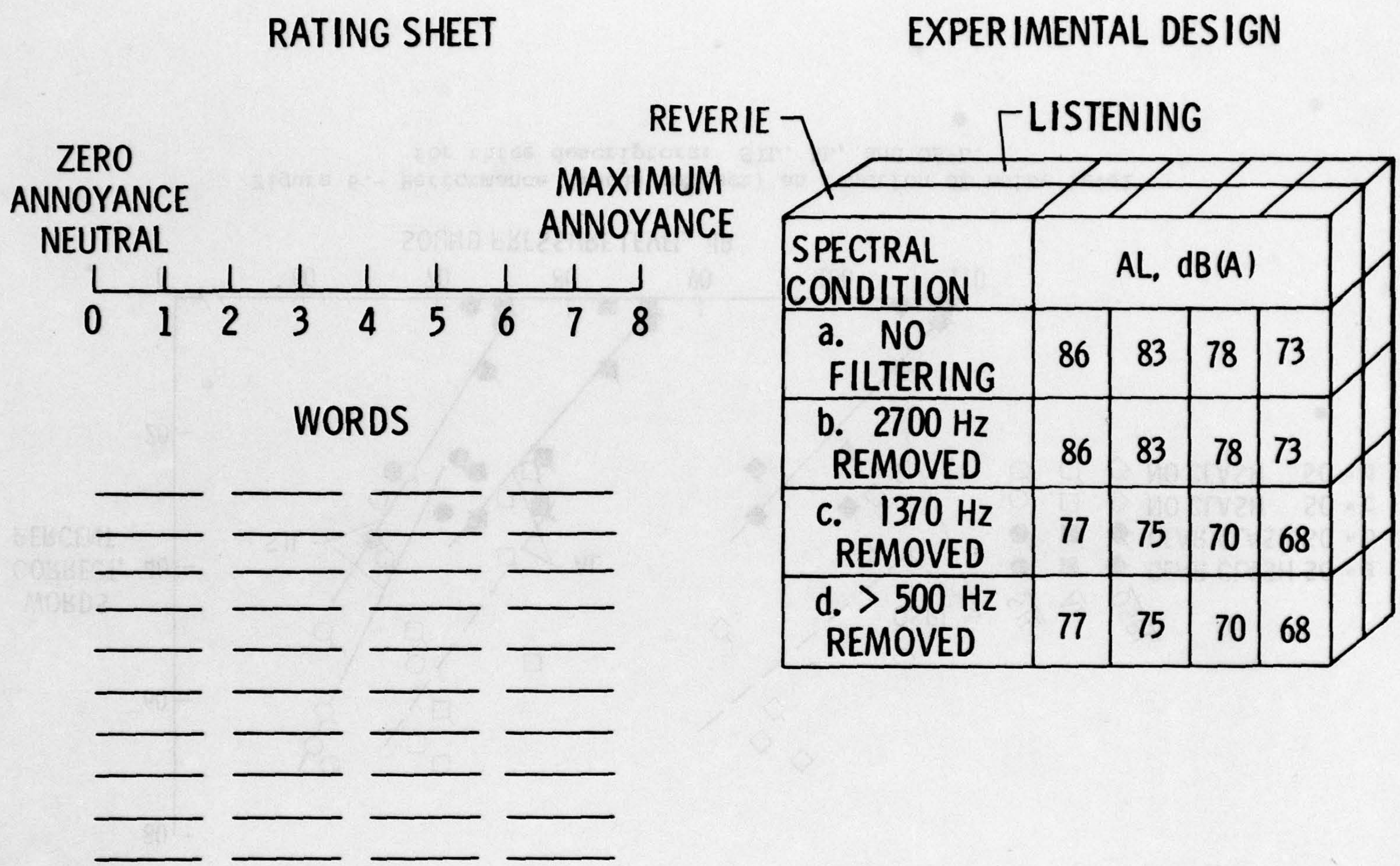
(a) No filtering.

(b) 2700 Hz removed.

(c) 1370 Hz removed.

(d) >500 Hz removed.

Figure 4.- Narrow-band spectra used in study.



(a) Rating sheet.

(b) Experimental design.

Figure 5.- Rating sheet and experimental design.

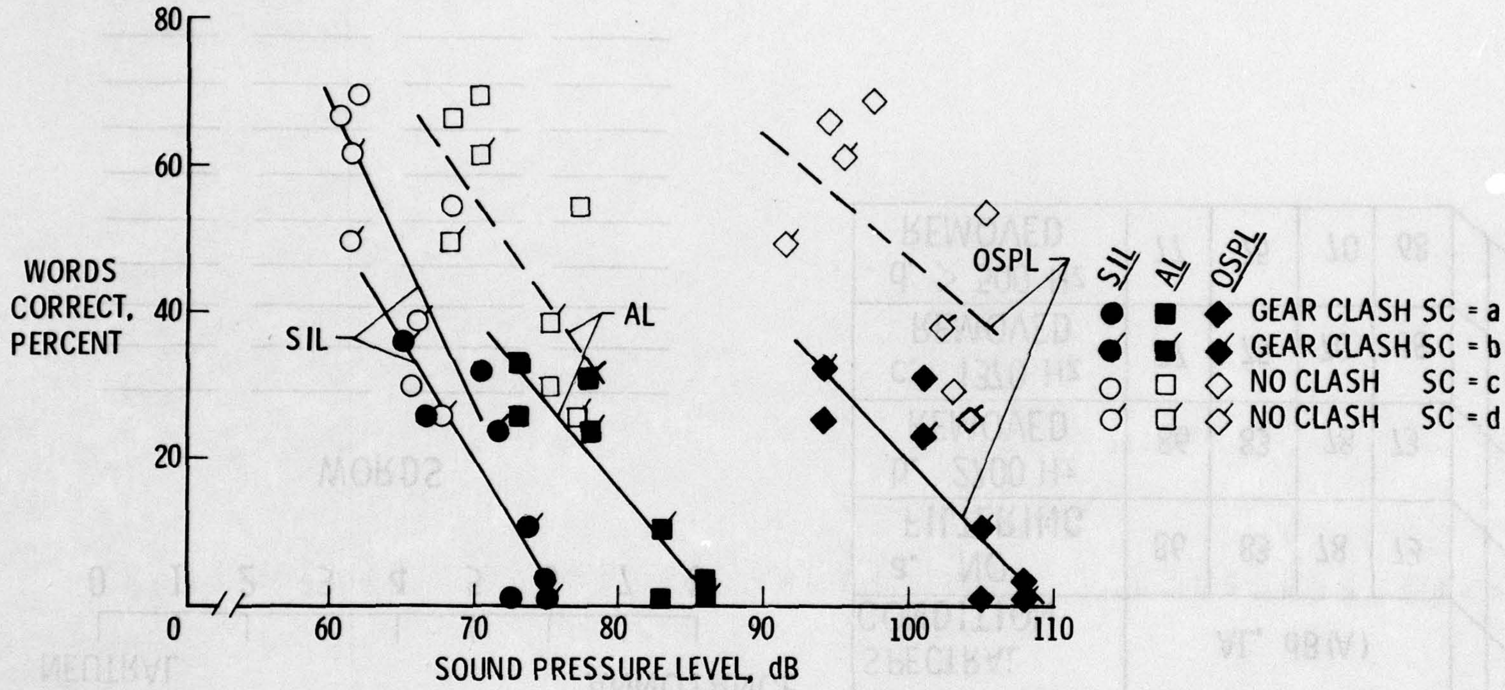


Figure 6.- Performance (words correct) as function of noise level for three descriptors: SIL, AL, and OSPL.

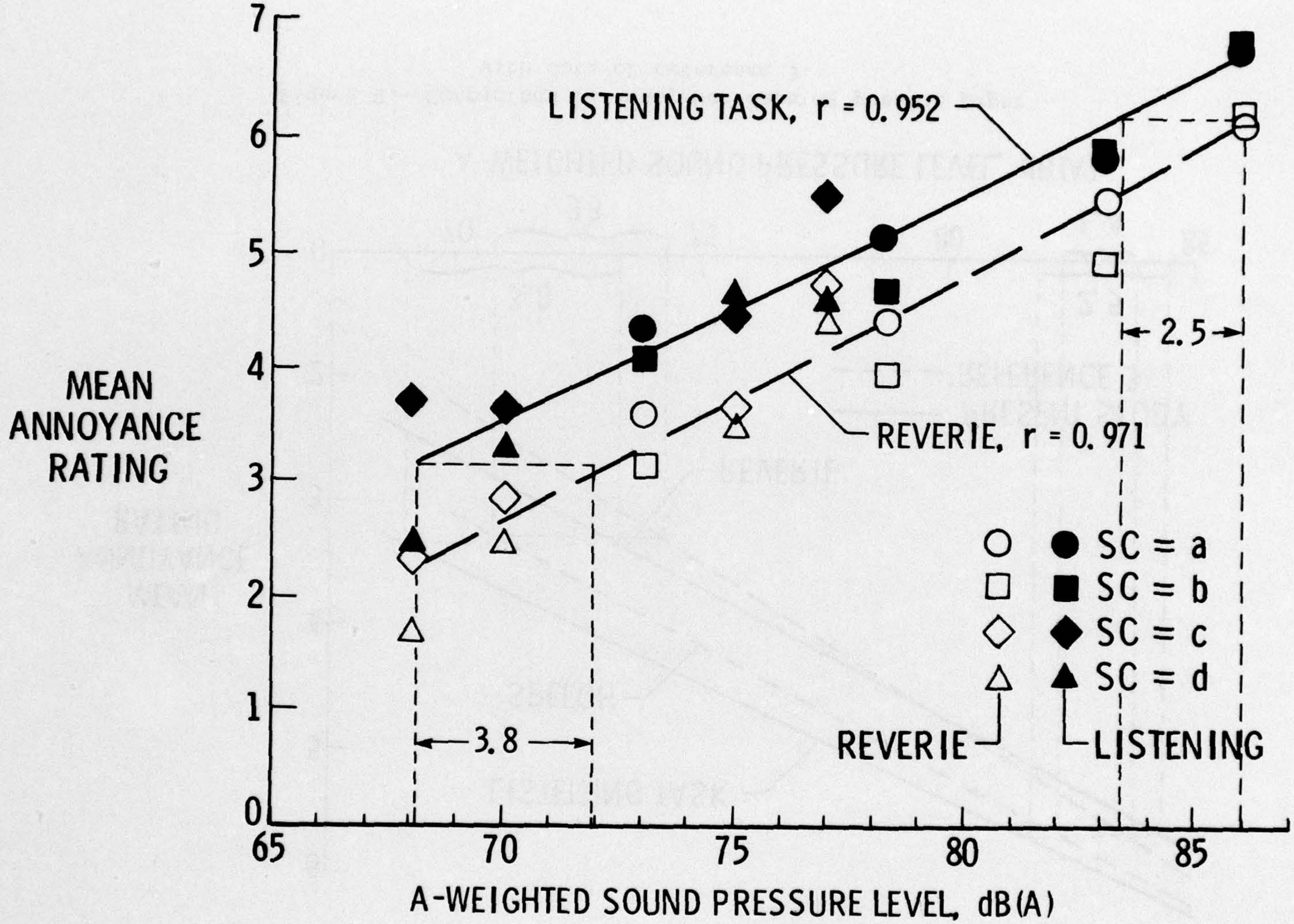


Figure 7.- Comparison of annoyance for various spectal conditions.
r = correlation coefficient.

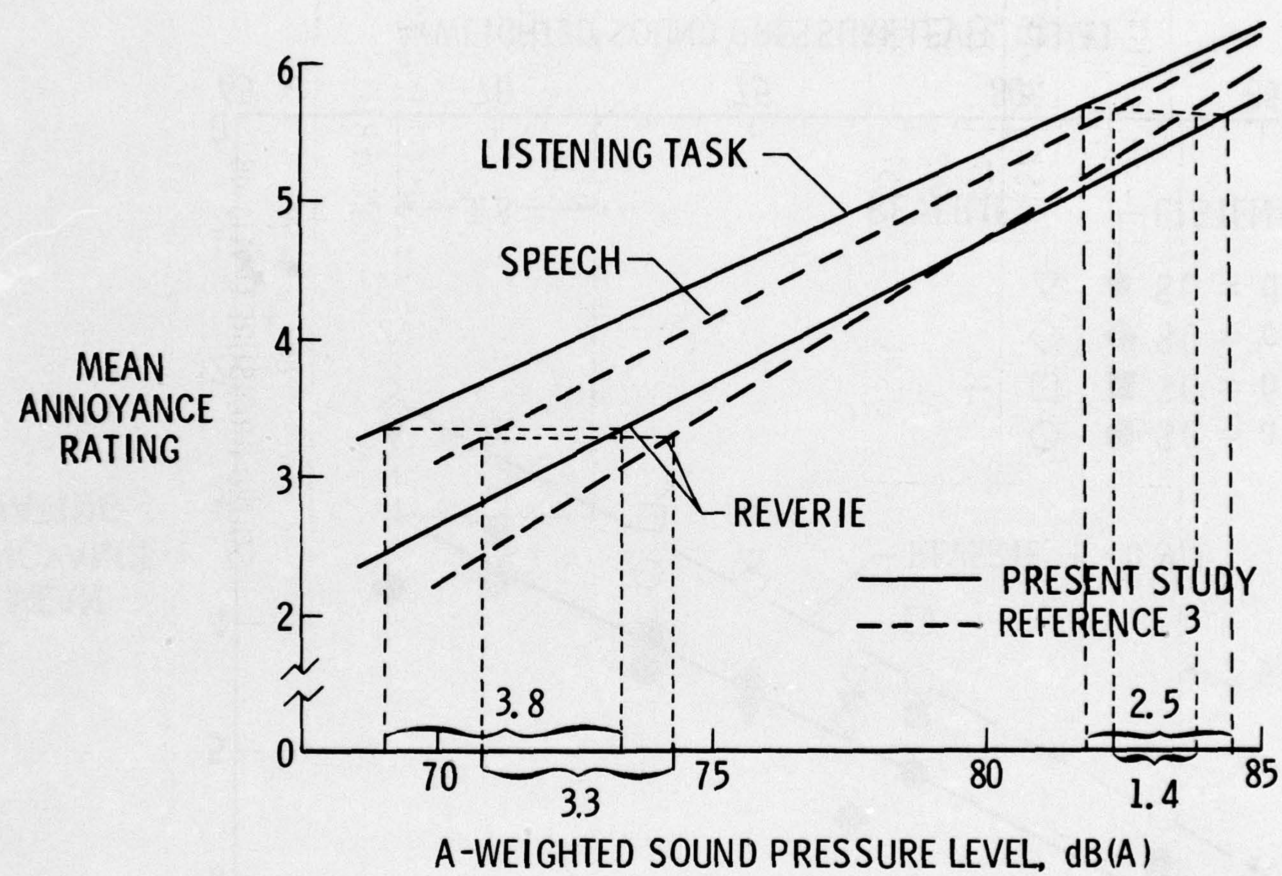


Figure 8.- Comparison of annoyance data of present paper with data of reference 3.

DESCRIPTOR	CORRELATION COEFFICIENT	
	TASK	REVERIE
SIL	0.917	0.933
AL	.952	.971
OSPL	.851	.889

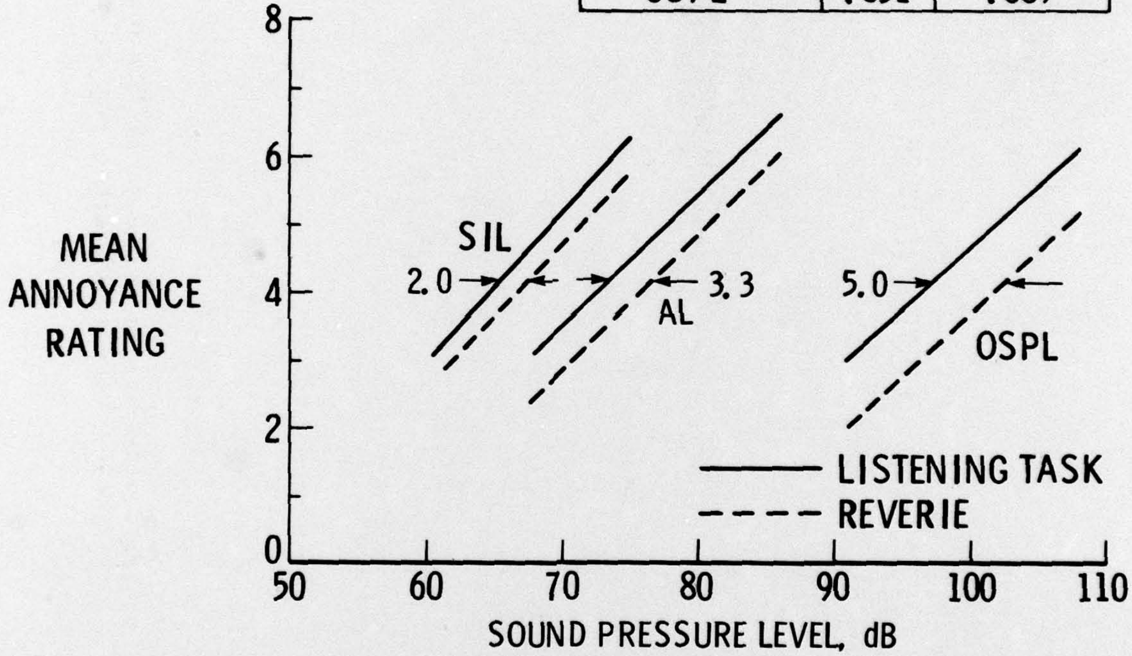


Figure 9.- Comparison of annoyance rating for various descriptors both during reverie and during listening task.

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16. Abstract

A laboratory study was conducted to determine the effects of helicopter interior noise on passenger annoyance. Both reverie and listening situations were studied as well as the relative effectiveness of several descriptors (i.e., overall sound pressure level, A-weighted sound pressure level, and speech interference level) for quantifying annoyance response for these situations. The noise stimuli were based upon recordings of the interior noise of the NASA Civil Helicopter Research Aircraft. These noises were presented at levels ranging from approximately 68 to 86 dB(A) with various gear clash tones selectively attenuated to give a range of spectra. The listening task required the subjects to listen to and record phonetically balanced words presented within the various noise environments. Results indicate that annoyance during a listening condition is generally higher than annoyance during a reverie condition for corresponding interior noise environments. Attenuation of the planetary gear clash tone results in increases in listening performance but has negligible effect upon annoyance for a given noise level. The noise descriptor most effective for estimating annoyance response under conditions of reverie and listening situations is shown to be the A-weighted sound pressure level.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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80