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NASA
National Aeronautics
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Scientific and Technical Information Branch

SUMMARY

The effects of aircraft flyover noise on annoyance were compared for face-to-face conversation, reverie, and television viewing. Eighteen 5-minute sessions, each composed of three flyovers, were presented on each of 2 days to subjects in a simulated living room. Twelve pairs of females and 12 pairs of males were tested, once before and once after work. Flyovers varied in peak noise level from 53 to 83 dB, A-weighted. On each day, subjects engaged in 18 sessions; six of conversation, six of television viewing, and six of reverie. The subjects completed subjective ratings following every session. The ratings concerned the annoyance of the noise and the acceptability of the noise for each activity.

Of the predictors investigated, noise level was found to be the most important predictor of annoyance. Both annoyance and unacceptability judgments were significantly higher for the activity of television viewing compared to conversation or reverie. There was no difference between judgments during the latter two activities. A noise level of 68 dB (A-weighted) was found to be unacceptable for television viewing by 50 percent of the subjects. Judgments compared on the basis of "fatigue" (before/after work) or sex of the subject showed no differences.

INTRODUCTION

Community aircraft-noise annoyance has been thought to be modulated by the activities in which one is engaged (refs. 1 to 3). Activities that have been found to influence aircraft-noise annoyance include communication activities such as television viewing and conversation (refs. 4 to 6).

In a previous study (ref. 7), no difference was found in aircraft-noise annoyance over a range of noise levels between reverie (sitting quietly) and face-to-face conversation conditions for the same subjects. However, an interaction between activity and noise level was found in reference 5 for reverie and the passive communication activities of telephone listening and television watching. In this latter experiment, different groups received different flyover noise levels and were engaged in different activities. As a consequence, differences in annoyance judgments between these groups are tenuous. Also, monetary bonuses were provided for only the telephone listening conditions and may account for some of the observed interaction effects.

In a similar study, reported in reference 1, closer agreement than that in reference 5 was found for acceptability ratings of four different activities. The activities were reverie, simulated radio, television, and telephone listening. The investigators interpreted this agreement to mean that "a listener tends to judge an aircraft noise presented in the absence of speech in terms of the potential effect this noise might have on speech communication."

The present study was performed to test the hypothesis of reference 1 by allowing comparisons of active (face-to-face conversation) and passive (television viewing) speech communication as well as a reverie condition. Specific objectives of the study were

(1) To compare the noise-annoyance judgments made while engaged in each of three activities: face-to-face conversation, television viewing, and reverie

(2) To determine the influence on these annoyance judgments of possible fatigue associated with an average 8-hour day

(3) To determine the influence of the sex of the subject on annoyance judgments

The details of the experimental design and results of the experiment relevant to these objectives are reported herein.

SYMBOLS AND ABBREVIATIONS

D	dummy variable for television viewing in regression analysis
EPNL	effective perceived noise level, dB
F	ratio of variances
k	number of levels of a variable
L_A	A-weighted sound pressure level, dB
n	number of observations in a group
PNLT	perceived noise level, tone-corrected, dB
Q	weighted ratio of sums of squares
R	Pearson product-moment multiple correlation coefficient
SIL	speech interference level, dB
SPL	sound pressure level, dB
SS	sum of squares
Y_1	predicted annoyance, in regression equation
Y_2	predicted acceptability, in regression equation
β_i	unstandardized regression coefficient (i = 0, 1, 2, 3, 4, 5)

EXPERIMENTAL METHOD

Test Facility

The interior effects room in the Langley Aircraft Noise Reduction Laboratory (fig. 1) was used in the present experiment. This room is designed to resemble a typical living room and to allow controlled acoustical environments to be presented to subjects. The construction of the test room is typical of modern single-family dwellings.

The loudspeaker systems used to produce the airplane-noise stimuli were located outside the test room to provide a realistic simulation of residential airplane noise. Reference 8 presents an additional description of the facility and the results of acoustic measurements which indicate that airplane noises presented to test subjects in this facility are representative of those measured inside typical dwellings.

Noise Stimuli

A tape recording made approximately 1.6 km from touchdown of a Boeing 707 landing, reproduced at various levels, comprised the noise stimuli presented in these tests. The noise-level time history and representative one-third octave spectrum as measured in each subject seat (fig. 1) are reproduced in figures 2 and 3. The spectrum in each figure is the energy-averaged SPL over all 0.5-second intervals of the flyover for each one-third octave band. The flyovers had durations of approximately 50 seconds.

The noise stimuli were presented at six levels in 6-dB increments. These levels were approximately 83, 77, 71, 65, 59, and 53 dB, A-weighted peak, when averaged across the two seats. These levels are listed by seat in table I for some widely used noise metrics. The differences in noise level between the left and right seat were typically less than 1 dB. A computer-controlled tape recorder system was used to play back the proper flyover stimulus at the appropriate level and number of times during each session. During portions of the experiment, subjects watched video tapes of two popular television shows ("M.A.S.H." and "The Muppets"). The sound level of the television was set for an A-weighted level of approximately 60 dB at the subjects' seats.

Design

A $2 \times 2 \times 3 \times 6$ split-plot factorial repeated-measures design was selected for the study. The subjects were grouped by sex for two "fatigue" levels, before and after 8 hours of work; three activities, reverie, conversation, and television viewing; and six noise levels as described earlier. Reverie was any quiet seated activity such as reading, and conversation was casual face-to-face conversation. Each subject participated twice, 1 day before work and 1 day after work, and saw a different television show each time. The orders of all conditions, counterbalanced in a Latin square, are presented in table II. Each session, employing one of the six noise levels, consisted of three 50-second flyovers of that noise level with 30-second interflyover intervals. Six sessions, constituting a period, were presented for each of the three activities, so that in total each pair of subjects received 18 different 5-minute sessions during each of the two visits to the laboratory.

Dependent Measures

Dependent measures were the subjects' questionnaire responses. These responses were recorded after each 5-minute session. They consisted of rating, on a scale of 0 to 10, the annoyance due to the noise and yes/no responses for the acceptability of the noise for the respective activities. The questions are reproduced in the appendix.

Subjects

The subjects were 48 paid volunteers, 24 females and 24 males, screened for normal hearing. They were obtained from the local community. The subjects were tested in pairs of like sex, and in most cases knew each other prior to the experiment. Ages ranged between 18 and 62 years, with an overall mean age of 31.7 years and a median age of 30 years.

Procedure

Upon arrival at the laboratory, the subject pair were seated approximately 1.4 m apart in the interior effects room and were given a set of instructions and questionnaires. A copy of the instructions is provided in the appendix. The subjects read the instructions and completed a consent form required of all participants in subjective experiments in this laboratory. The test conductor reviewed the instructions and questionnaires and answered any questions that the subjects had.

For the six conversation sessions, the subjects were instructed to converse as they would at home. For the six reverie sessions, the subjects were instructed not to talk but to read or do some other quiet activity, such as needlework. During the six television sessions, the subjects were asked to watch the television and not to read or converse. For all sessions, subjects were instructed to respond to the questionnaire after the end of each session. The intersession interval was 1 minute. The subjects had a 15-minute break at the end of either the first or second six sessions.

RESULTS AND DISCUSSION

Annoyance

Annoyance was rated, on an 11 point (0-10) unipolar scale, at the end of each 5-minute session. Various analyses of variance were performed on these data.

Grouping factors.- The first analyses assessed the effects of the grouping factors; sex, subject pair, and seat position. The analysis of variance results with sex as the grouping factor are summarized in table III. Because of the repeated-measures design, the error term for each item in the analysis is the interaction of that term with individual subjects. Similar analyses for the other grouping factors, subject pair, and seat position also indicated that only activity, noise level, and the interaction between activity and noise level were significant factors. Therefore, in the following results, all subject scores were collapsed across sex, subject pair, and seat position.

Main factors.- The summary of the analysis of variance performed on the pooled data is presented in table IV. The before/after work condition was not significant, which may be explained by a lack of sufficient experimental control. "Work" constituted 8 hours of a person's normal activity whether at home, job, or school. The types of "work" were not controlled. Thus, wide variation in work demands and the resulting fatigue between subjects and between test days may have obscured any annoyance effects due to before/after work. On the other hand, of interest is the fact that a representative random sample across both sexes and several different daily work experiences showed no evidence that annoyance varied between the start and end of a typical 8-hour day (or night).

The main effects of activity and noise level and the interaction of activity and noise level are signficant factors. By partitioning the variance, these factors accounted for 6 percent, 30 percent, and 2 percent of the total variance, respectively. The relationship between the mean annoyance scores and the factors of activity and noise level is illustrated in figure 4. An increased divergence between annoyance during television viewing and the other two activities as the peak level of flyover noise increased is depicted in the figure. However, this interaction between activity and noise level is thought to be due to range effects of the annoyance scale and is discussed later.

The effect of activities on the mean scores was also examined by tests of orthogonal contrasts between the total sums of squares associated with each activity. No difference was found between annoyance scores for reverie and conversation. However, the television scores were found to be significantly greater than the combined averaged scores of reverie and conversation.

Regression analyses.- Multiple regression analyses were computed with only the significant terms of the analysis of variance. A series of stepwise regressions were performed using the individual scores. Various models were progressively tested to choose the most appropriate model. Subject activity was treated as a dummy variable. The best linear model, which accounted for 41.7 percent of the variance, considered only noise level, television viewing, and the interaction of noise level and television viewing.

After examination of the plotted data in figure 4, a slight deviation from linearity was noticed. Therefore, the decision was made to test quadratic and cubic versions of the best linear model found above. The cubic model accounted for 42.6 percent of the variance, while the quadratic model accounted for 42.3 percent of the variance. The slight difference in accounted-for variance of the latter two versions is not practically significant. Therefore, only the quadratic model was chosen for further evaluation.

The difference in the slopes of the activities depicted in figure 4 was thought to be due to range effects. Had the noise levels not been truncated at an L_A value of 83 dB, the slopes may have eventually been the same although shifted by approximately 10 dB. Therefore, the significant interaction of noise level and activity may be due to this range effect. To calculate the shift while incorporating the quadratic effect, another regression model was tested

$$Y_1 = \beta_0 + \beta_1(L_A + \Delta D) + \beta_2(L_A + \Delta D)^2$$

where D is the dummy variable for television viewing. When this model is expanded, the shift Δ for television could be calculated.

This model was run and was found to account for 42.9 percent of the variance. Noise level, A-weighted, accounted for 34.7 percent of the variance; whereas, television and the combined quadratic terms accounted for 5.8 percent and 2.3 percent, respectively. These results are summarized in table V. The shift was calculated to be 8.9 dB for television. This value closely fits the difference between the slope of television and the combined slope of conversation and reverie as seen by visual examination of figure 4.

Acceptability

The second question answered by the subjects at the end of each session required a "yes" or "no" response about the acceptability of the flyover noise for the particular activity in which the subjects were engaged. These responses were scored as "1" or "0," respectively, and were averaged across the subjects. As was found for annoyance, only the main effects of activity and noise level, and the interaction of activity and noise level were found to be significant for acceptability in the analysis of the variance summary presented in table VI.

The Q values listed in table VI were computed, according to the method of reference 9, to test the sums of squares of the dichotomous acceptability data. The dichotomous responses allowed the mean ratings to be viewed in terms of unacceptability of the noise for each activity by percent of subjects, as illustrated in figure 5. Unacceptability of noise for each activity increased monotonically with noise level. These data appear to closely parallel the annoyance data. Although not statistically tested, no appreciable difference between conversation and reverie conditions is indicated in figure 5. By interpolation, 50 percent of the subjects rated an L_A value of 68 dB as unacceptable for television viewing but rated an L_A value of 78 dB as unacceptable for conversation or reverie.

A regression analysis was performed with the same expanded quadratic model used for the annoyance responses. Presented in table VII, these results closely parallel those of the annoyance responses, as expected. The model accounted for 40.0 percent of the variance. Noise level, A-weighted, accounted for 32.5 percent of the variance, whereas television and the combined quadratic terms accounted for 5.2 percent and 2.4 percent, respectively. The shift for television was 5.4 dB.

Comparison With Previous Studies

The hypothesis of reference 1 that aircraft noise in the absence of speech is judged in terms of the potential effect on speech communication was not confirmed by the results of the present study. Judgments made during passive speech communication were different from those made during reverie. Furthermore, no difference was found between active conversation and reverie. The latter finding agrees with the results of reference 7, which found that people who are in control of their conversations can either increase their voices or stop talking momentarily when an aircraft flyover occurs. Conversely, unless one has a remote control, a person is not likely to increase the television volume for each flyover. Therefore, unlike repeatable conversation, the verbal message from the television can be lost. This may explain the increased annoyance during television viewing.

The acceptability ratings are also in general agreement with a previous study. The results of the present study agree with those of reference 7 for conversation and reverie. An L_A value of 78 dB was rated unacceptable by 50 percent of the subjects in the present study compared to 77 dB in reference 7.

For television viewing, direct comparisons are not possible with previous studies because of the differences in rating scales used, six points versus two in the present study. However, the noise levels are within a range of comparison. The range of L_A levels for judgments from barely acceptable to unacceptable were 75-85 dB (refs. 1, 5, and 10) compared to an L_A value of 68 dB for unacceptability found in the present study. (The latter is based upon ratings by 50 percent of the subjects. The former values were based on overall averages.)

Therefore, for active speech communication, in the form of casual face-to-face conversation, aircraft flyover noise does not appear to be more annoying than when engaged in reverie. However, when engaged in passive speech communication, in this case television viewing, aircraft noise is more annoying. The latter finding, which differs from previous studies, is probably due to differences in compensation or control between active and passive speech communication.

CONCLUSIONS

This experiment was conducted to assess differences in annoyance and acceptability effects of aircraft flyovers for three activities. In the experiment, sessions of flyovers varying in noise level were presented to subjects while engaged in conversation, television viewing, and reverie. Listed below are conclusions from this experiment.

1. Annoyance and unacceptability judgments were significantly higher when made while engaged in television viewing compared to face-to-face conversation or reverie. There was no difference between judgments during the latter two activities.

2. An A-weighted sound pressure level of 68 dB was found to be unacceptable for television viewing by 50 percent of the subjects.

3. No effect of "fatigue" (before/after work) was found.

4. No differences in the judgments were found between the sexes.

5. Noise level was found to be the most important predictor of annoyance and acceptability of community aircraft flyover noise.

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September 25, 1981

APPENDIX

INSTRUCTIONS AND QUESTIONNAIRES

Instructions

The experiment in which you are participating today is to help us understand the reactions of people to various aircraft noise environments. There will be three sessions of aircraft noises, each session lasting about 30 minutes. There will be a break after two of the sessions. There will be a separate session for conversation, television, and quiet.

For the conversation session, we would like you to talk to each other as much as possible. You may also do any craft work that you may have brought with you, however, please keep conversing whether or not you work.

A list of conversation topics will be shown to you to help you think of something to talk about, should you need some suggestions. The only restricted topic is that of the present experiment. Other than that, you may talk about anything you wish. The subject matter is of no interest to us.

During the quiet session, we request that you do not talk nor express any emotion which might influence the response of the other person in the room. During this session, we would like you to relax and read or quietly do any craft work you may have brought with you.

Another session will be spent watching television. During this session, we ask that you <u>do not</u> carry on a conversation, read, or do any craft work. This is because we would like your judgments for each activity separately. During this session, we would like you to relax and watch the taped television show. Please do not attempt to adjust the volume controls on the television. (If you have any problems with respect to the color or <u>quality</u> of sound during the television show, please use the intercom system in the room.)

You will be told the type of activity before each session. During each session there will be six different periods of aircraft noise lasting 4 minutes each. There will be two short "beeps" at the <u>beginning</u>, and a single "beep" at the <u>end</u> of each period. At the end of every period, we would like you to make two judgments on the noises that you just heard.

A score sheet will be given out at the start of each session. Please be sure that you record your judgments on the appropriate part of this sheet for the period concerned--each period number will be displayed on a counter in the room for its duration.

The scoring sheet will have one scale numbered "0 to 10," for each period. The end points are labeled "NOT ANNOYING AT ALL" and "EXTREMELY ANNOYING." Your judgment in all cases should be indicated by circling one of the numbers on the scale. For example, if you judge the noise to be very annoying, then you should circle a number closer to the "EXTREMELY ANNOYING" end of the scale. Similarly, if you judge the noise to be only slightly annoying, you should circle a number closer to the "NOT ANNOYING AT ALL" end of the scale. For the second question, you should just put a check in the box beside the answer with which you most closely agree. An example of these scoring sheets is on the final page of this instruction sheet.

APPENDIX

There are no correct answers; we just want a measure of your own personal reaction to the noises in each session. For this reason, we request that you do not talk about the noise, especially while responding to questions on the scoring sheet, and do not attempt to compare judgments.

Thank you for participating in this investigation.

APPENDIX

Questionnaire

Subject no./Group no. _____ Time _____

Seat _____ Session _____

Code _____ Date _____

PERIOD

1

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for sitting in quiet? (check one)

( ) Yes ( ) No

2

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for sitting in quiet? (check one)

( ) Yes ( ) No

3

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for sitting in quiet? (check one)

( ) Yes ( ) No

4

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for sitting in quiet? (check one)

( ) Yes ( ) No

5

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for sitting in quiet? (check one)

( ) Yes ( ) No

6

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for sitting in quiet? (check one)

( ) Yes ( ) No

APPENDIX

Subject no./Group no. _____ Time _____

Seat _____ Session _____

Code _____ Date _____

PERIOD

1 (1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for conversation? (check one)

( ) Yes ( ) No

---

2 (1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for conversation? (check one)

( ) Yes ( ) No

---

3 (1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for conversation? (check one)

( ) Yes ( ) No

---

4 (1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for conversation? (check one)

( ) Yes ( ) No

---

5 (1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for conversation? (check one)

( ) Yes ( ) No

---

6 (1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for conversation?

( ) Yes ( ) No

APPENDIX

Subject no./Group no. _____ Time _____

Seat _____ Session _____

Code _____ Date _____

PERIOD

1

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for watching television? (check one)

( ) Yes ( ) No

2

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for watching television? (check one)

( ) Yes ( ) No

3

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for watching television? (check one)

( ) Yes ( ) No

4

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for watching television? (check one)

( ) Yes ( ) No

5

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for watching television? (check one)

( ) Yes ( ) No

6

(1) How annoying was the noise in the period? (circle a number)

NOT ANNOYING AT ALL 0 1 2 3 4 5 6 7 8 9 10 EXTREMELY ANNOYING

(2) Was the noise in the period acceptable for watching television? (check one)

( ) Yes ( ) No

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TABLE I.- MEASURED NOISE LEVELS

Metric	Measured noise level, dB		
	Left seat	Right seat	Average
L_A	53.0	51.7	52.4
	59.0	58.1	58.5
	65.0	64.4	64.7
	71.0	70.8	70.9
	77.0	77.1	77.1
	83.0	83.5	83.3
SIL	43.8	41.5	42.7
	49.6	47.7	48.7
	55.5	54.0	54.7
	61.3	60.2	60.8
	67.2	66.5	66.8
	73.0	72.7	72.9
PNLT	71.1	69.3	70.2
	77.0	75.6	76.3
	82.8	81.9	82.4
	88.7	88.3	88.5
	94.5	94.6	94.6
	100.4	100.9	100.6
EPNL	65.4	65.9	65.7
	71.6	72.1	71.8
	77.8	78.2	78.0
	83.9	84.4	84.2
	90.1	90.5	90.3
	96.3	96.7	96.5

TABLE II.- PRESENTATION ORDER OF ACTIVITY-NOISE LEVEL CONDITIONS BY TEST DAY FOR EACH SUBJECT PAIR[a]

Subject pair	Work condition	Stimuli for period		
		1	2	3
First test day				
1	Before	R1	C2	T3
2		C6	T1	R4
3		T5	R6	C1
4		T4	C3	R6
5		R3	T5	C2
6		C2	R4	T5
7	After	T2	C4	R5
8		R3	T5	C2
9		C4	R3	T6
10		R5	C6	T1
11		C6	T1	R4
12		T1	R2	C3
Second test day				
1	After	T4	C5	R6
2		R5	T3	C2
3		C2	R4	T3
4		R1	C2	T5
5		C6	T1	R4
6		T3	R6	C1
7	Before	C3	T6	R1
8		T6	R1	C4
9		R1	C2	T5
10		R2	T4	C3
11		C5	R3	T2
12		T4	C5	R6

[a]This ordering was the same for both sexes.

Stimuli key	
Activity	Order of average noise levels, L_A, dB
R = Reverie C = Conversation T = Television	1 = 58, 68, 78, 63, 73, 83 2 = 63, 83, 68, 78, 58, 73 3 = 83, 58, 78, 63, 73, 68 4 = 68, 63, 58, 78, 83, 73 5 = 78, 83, 68, 73, 58, 63 6 = 73, 63, 78, 83, 68, 58

TABLE III.- SUMMARY OF ANALYSIS OF VARIANCE: ANNOYANCE OF NOISE GROUPED BY SEX

Source	Degrees of freedom	Sum of squares	Mean square	F-ratio (a)
Between subjects				
Sex	1	26.26	26.26	0.31^{ns}
Error	46	3912.06	85.04	
Within subjects				
Work	1	3.80	3.80	0.39^{ns}
Work × sex	1	<0.01	<0.01	$<0.01^{ns}$
Error	46	443.95	9.65	
Activity	2	647.64	323.82	56.02*
Activity × sex	2	12.96	6.48	1.12^{ns}
Error	92	531.84	5.78	
Work × activity	2	5.13	2.56	0.53^{ns}
Work × activity × sex	2	7.06	3.53	0.74^{ns}
Error	92	441.48	4.80	
Level	5	3960.54	792.11	188.06*
Level × sex	5	11.89	2.38	0.56^{ns}
Error	230	968.76	4.21	
Work × level	5	4.26	0.85	0.53^{ns}
Work × level × sex	5	6.18	1.24	0.77^{ns}
Error	230	369.65	1.61	
Activity × level	10	175.74	17.57	10.65*
Activity × level × sex	10	11.63	1.16	0.70^{ns}
Error	460	759.19	1.65	
Work × activity × level	10	11.48	1.15	0.78^{ns}
Work × activity × level × sex	10	20.17	2.02	1.38^{ns}
Error	460	674.35	1.47	

[a]Superscript ns indicates not significant, and * indicates significant at 0.01 level.

TABLE IV.- SUMMARY OF ANALYSIS OF VARIANCE: ANNOYANCE OF NOISE-POOLED DATA

Source	Degrees of freedom	Sum of squares	Mean square	F-ratio (a)
Between subjects	47	3938.32	83.79	
Within subjects				
Work	1	3.80	3.80	0.40^{ns}
Error	47	443.95	9.45	
Activity	2	647.64	323.82	55.87*
Error	94	544.80	5.80	
Work × activity	2	5.13	2.56	0.54^{ns}
Error	94	448.54	4.77	
Level	5	3960.54	792.11	189.82*
Error	235	980.66	4.17	
Work × level	5	4.26	0.85	0.53^{ns}
Error	235	375.83	1.60	
Activity × level	10	175.74	17.57	10.72*
Error	470	770.81	1.64	
Work × activity × level.....	10	11.48	1.15	0.78^{ns}
Error	470	694.52	1.48	

[a]Superscript ns indicates not significant, and * indicates significant at 0.01 level.

TABLE V.- MULTIPLE REGRESSION OF ANNOYANCE ON NOISE LEVEL AND TELEVISION VIEWING[a]

Variable entered	Coefficient	F to enter regression equation	R^2	Change in R^2
Level (L_A)	-0.265	458.878	0.347	
Television (D)	-2.353	84.092	.405	0.058
L_A^2	.003	17.481	.417	.012
L_AD	.054	17.201	.429	.012
Constant	8.505			

[a]Expanded regression equation:

$$Y_1 = \beta_0 + \beta_1 L_A + \beta_2 D + \beta_3 L_A^2 + \beta_4 (L_A D) + \beta_5 D^2$$

TABLE VI.- SUMMARY OF ANALYSIS OF VARIANCE: ACCEPTABILITY OF NOISE FOR ACTIVITY

Source	Degrees of freedom	Sum of squares	Q-ratio (a)
Between subjects.....	47	60.37	
Within subjects			
Work	1	0.08	$<0.01^{ns}$
Error	47	12.64	
Activity	2	16.39	33.81*
Error	94	23.27	
Level	5	107.35	538.84*
Error	235	47.81	
Work × activity	2	0.10	0.28^{ns}
Error	94	16.68	
Work × level	5	0.28	2.99^{ns}
Error	235	22.33	
Activity × level	10	7.84	73.11*
Error	470	51.49	
Work × activity × level	10	0.42	4.30^{ns}
Error	470	46.47	

[a]Superscript ns indicates not significant; * indicates significant at 0.05 level; and $Q = \frac{n(k - 1)SS_{source}}{SS_{error}}$.

TABLE VII.- MULTIPLE REGRESSION OF ACCEPTABILITY ON NOISE LEVEL[a]

Variable entered	Coefficient	F to enter regression equation	R^2	Change in R^2
Level (L_A)	0.056	414.07	0.324	
Television (D)	.302	71.97	.377	0.053
L_A^2	-.006	22.66	.393	.016
L_AD	-.008	11.19	.400	.007
Constant	-.415			

[a]Expanded regression equation:

$$Y_2 = \beta_0 + \beta_1 L_A + \beta_2 D + \beta_3 L_A^2 + \beta_4 (L_A D) + \beta_5 D^2$$

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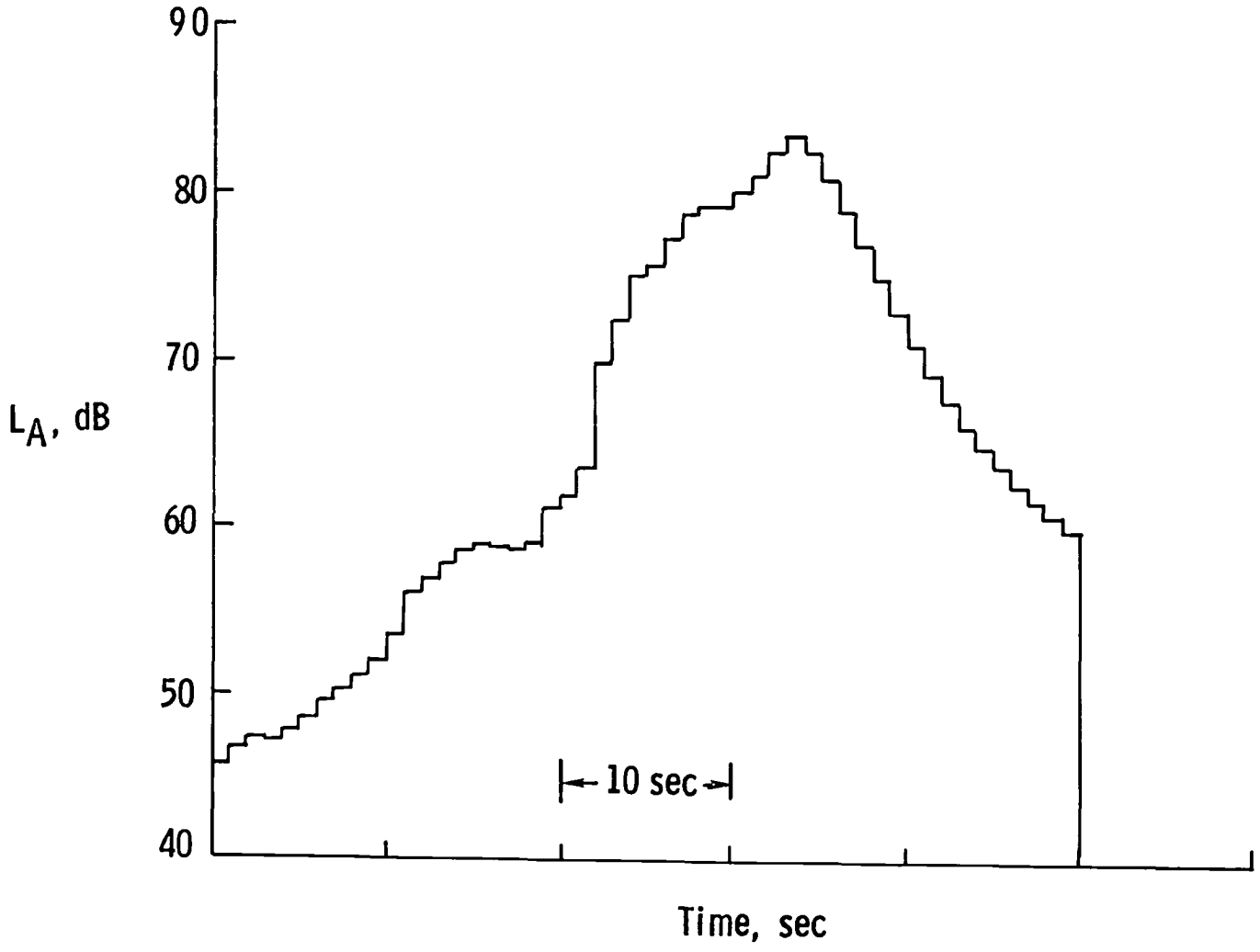
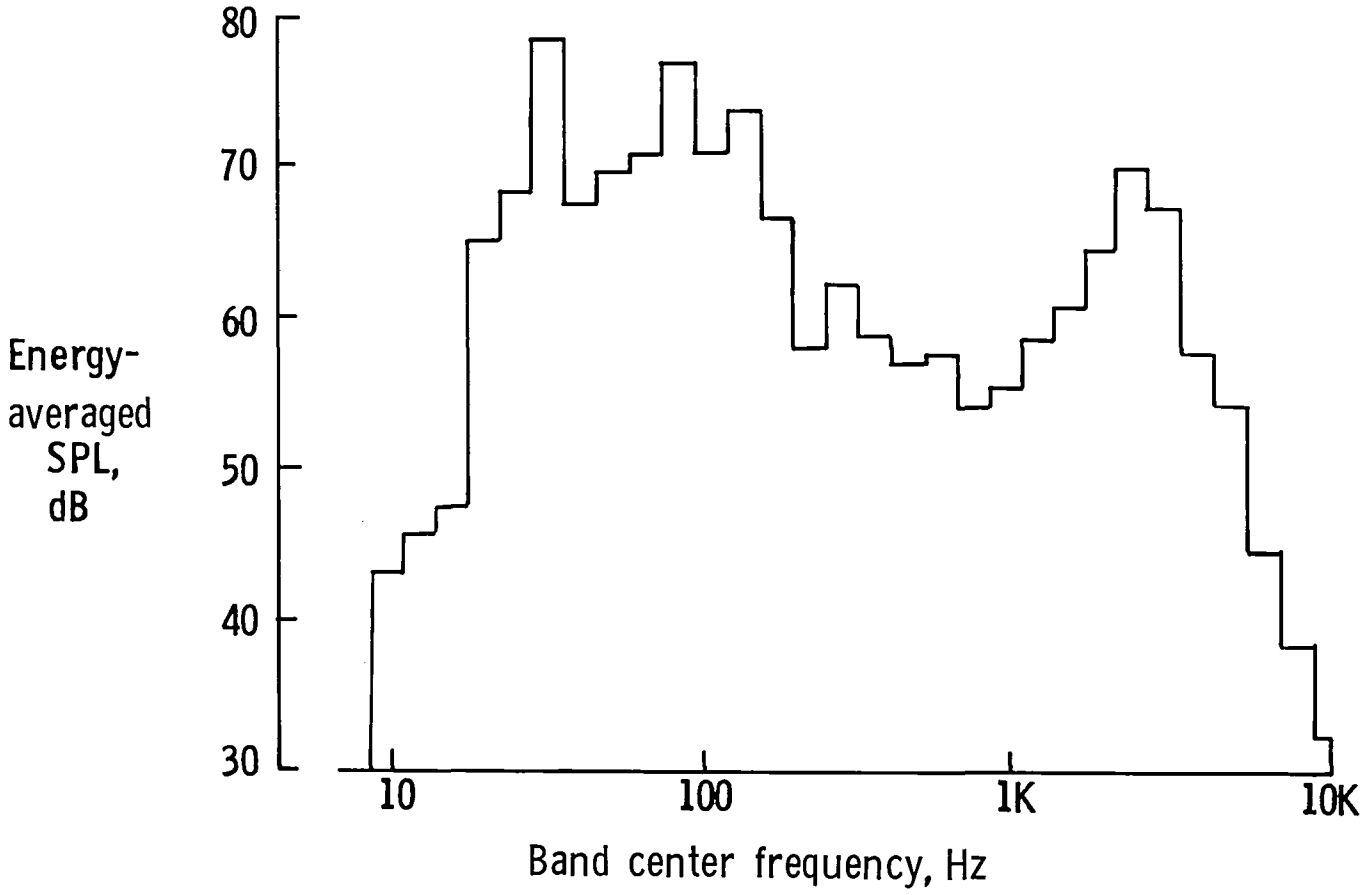
Figure 1.- Subjects in the interior effects room.



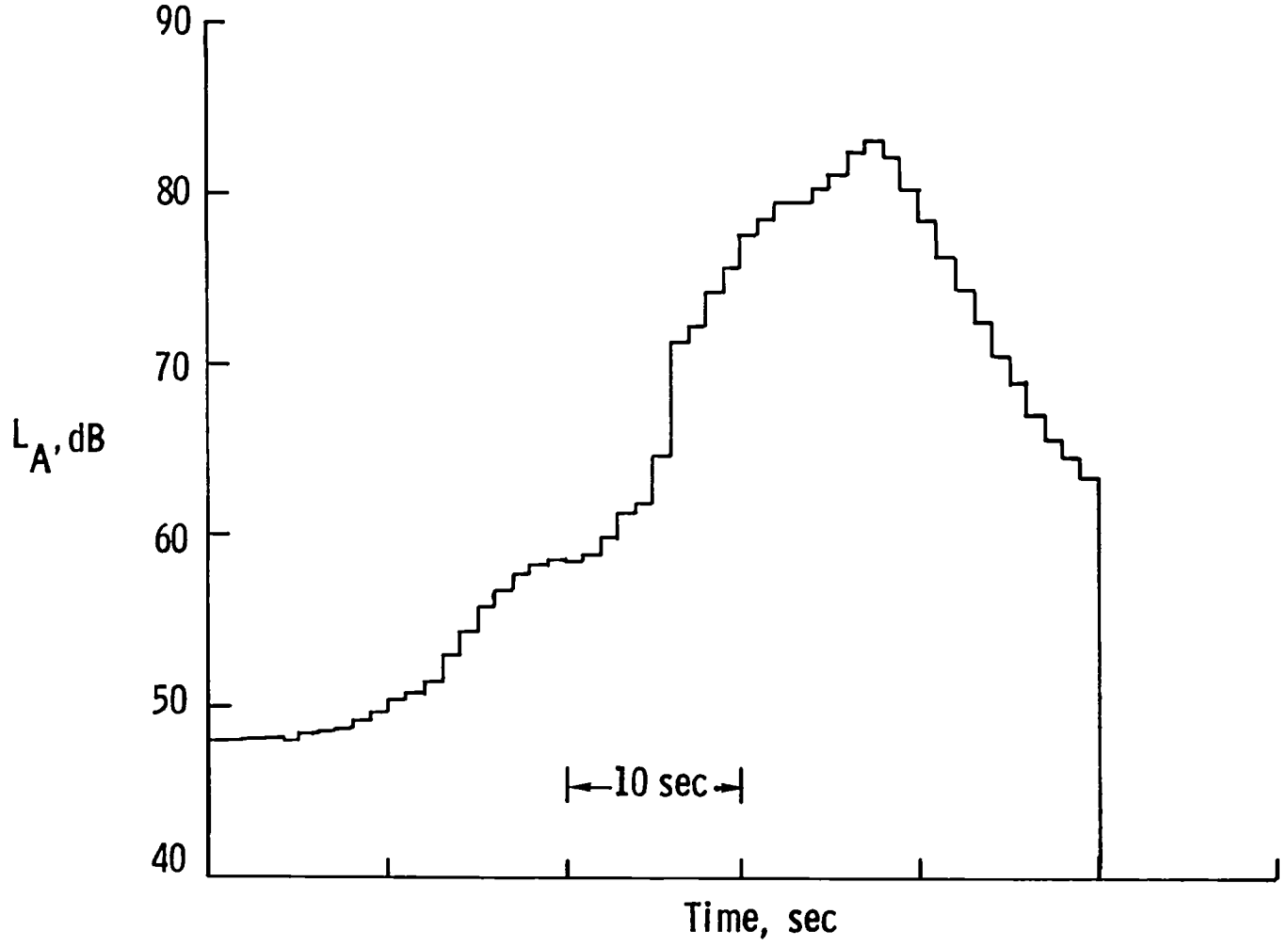
(a) Time history.

Figure 2.- Noise characteristics of Boeing 707 landing, 1.6 km from touchdown, as measured in the right subject seat of the interior effects room.



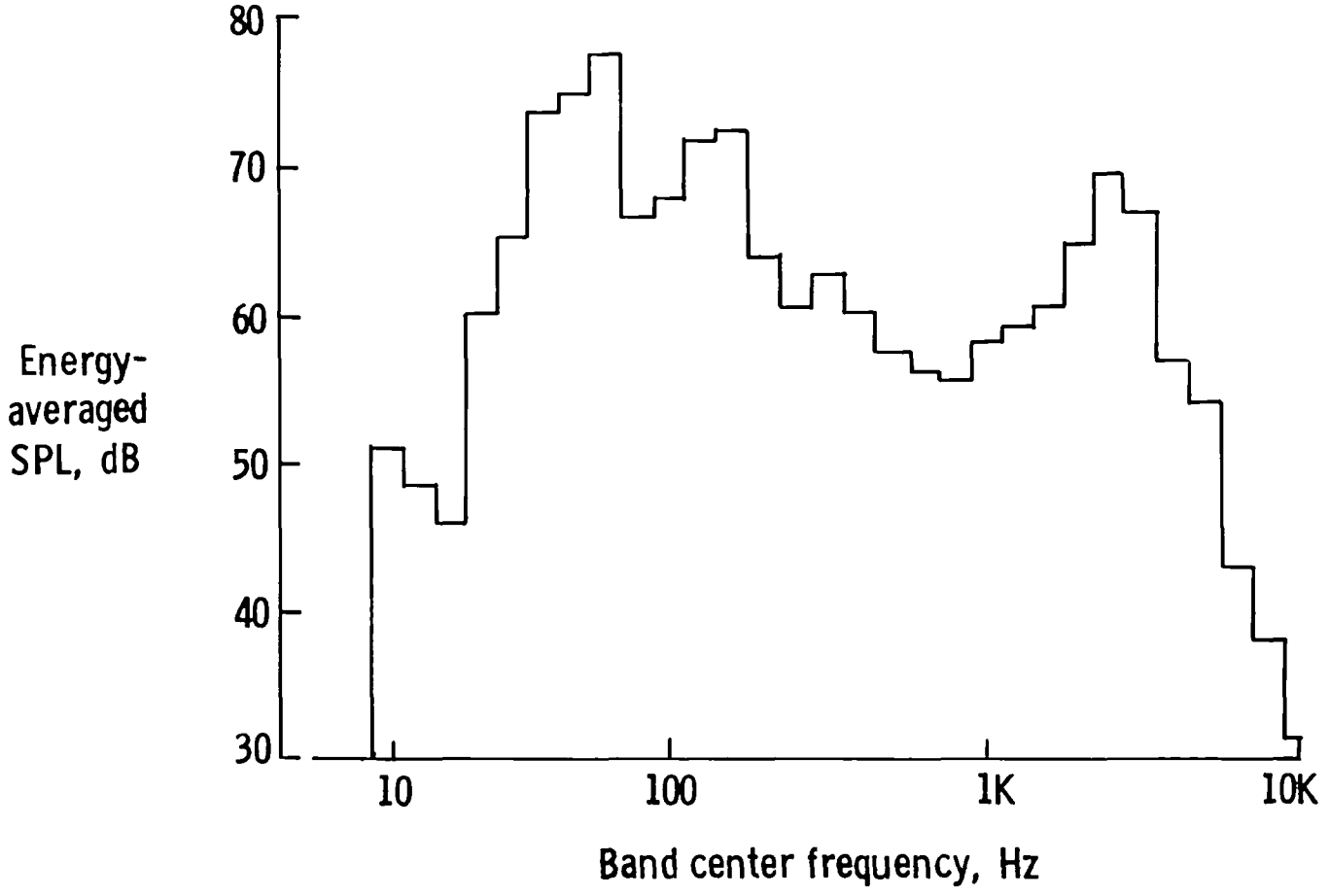
(b) One-third octave band center frequency spectrum.

Figure 2.- Concluded.



(a) Time history.

Figure 3.- Noise characteristics of Boeing 707 landing, 1.6 km from touchdown, as measured in the left subject seat of the interior effects room.



(b) One-third octave band center frequency spectrum.

Figure 3.- Concluded.

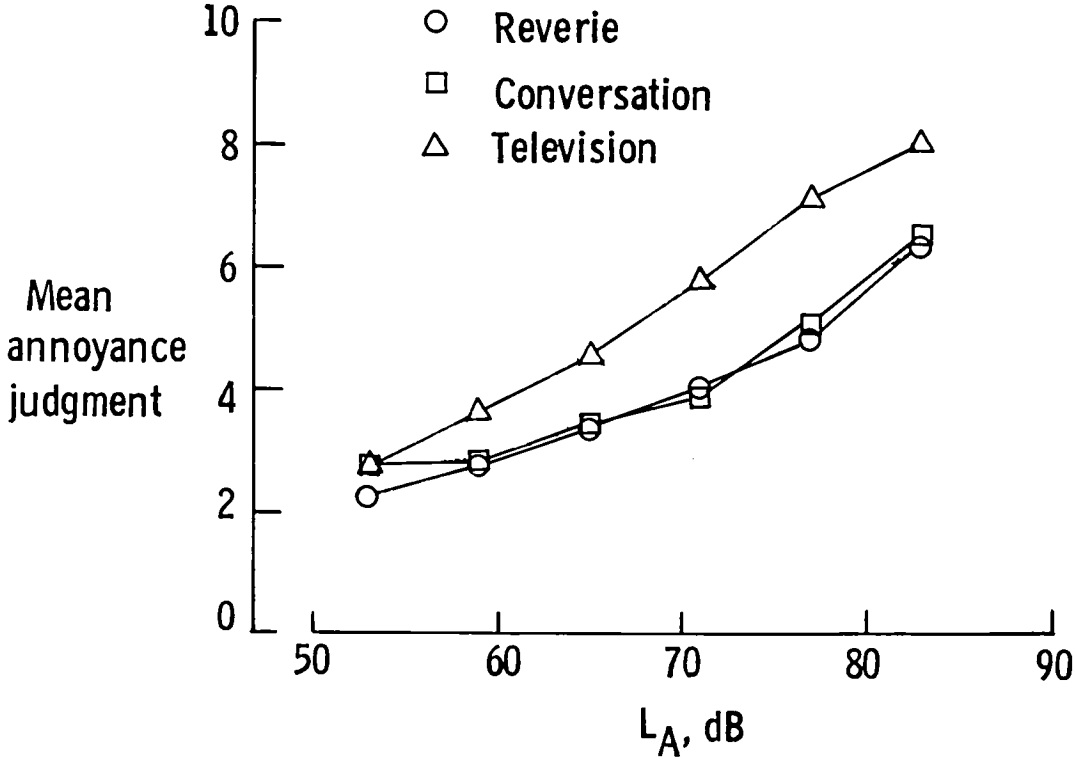


Figure 4.- Effects of noise level L_A on annoyance, indicating activity difference.

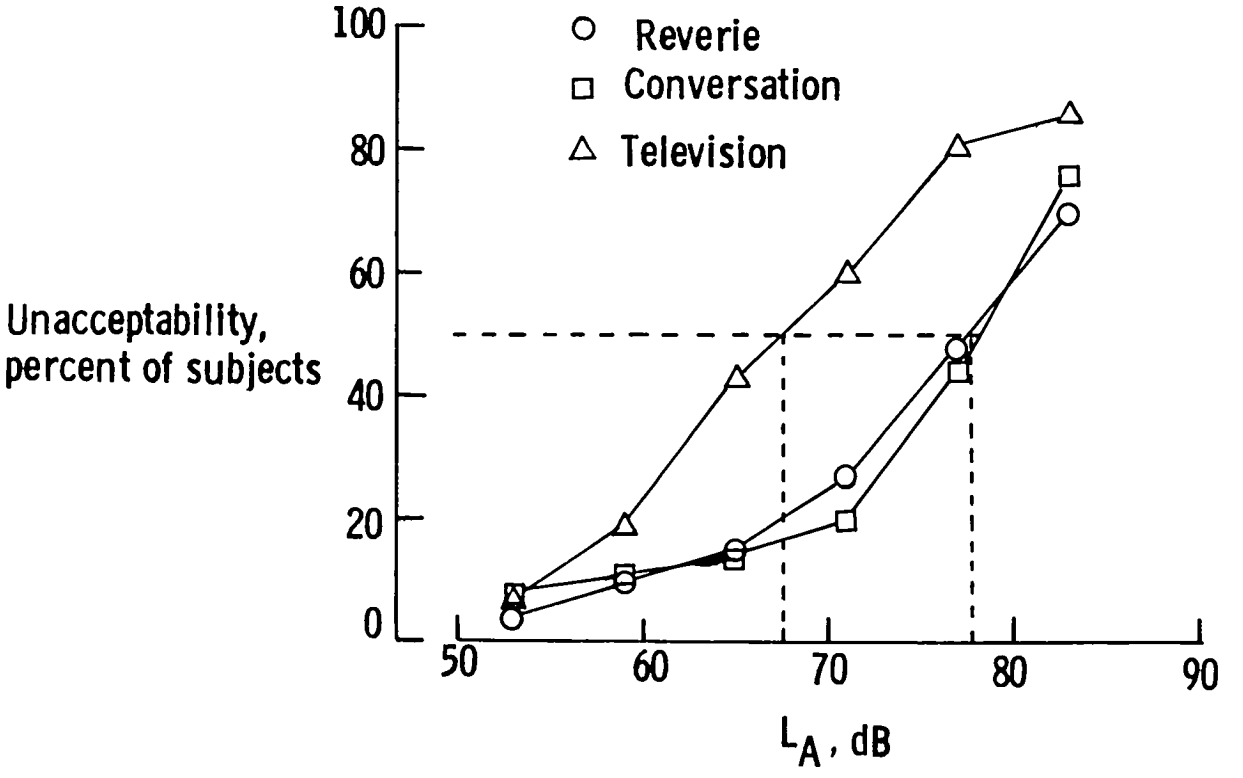


Figure 5.- Effect of noise level on unacceptability of noise.

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15. Supplementary Notes

16. Abstract

The effects of aircraft flyover noise on annoyance were compared for face-to-face conversation, reverie, and television viewing. Eighteen 5-minute sessions, each composed of three flyovers, were presented on each of 2 days to subjects in a simulated living room. Twelve pairs of females and 12 pairs of males were tested, once before and once after work. Flyovers varied in peak noise level from 53 to 83 dB, A-weighted. On each day, subjects engaged in 18 sessions; six of conversation, six of television viewing, and six of reverie. The subjects completed subjective ratings of annoyance and acceptability following every session. Annoyance and unacceptability rating scores were significantly higher for the activity of television viewing compared to conversation or reverie. There was no difference between judgments during the latter two activities. No differences were found in the judgments when compared on the basis of "fatigue" (before/after work) or sex of the subject.

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