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THE NOISINESS OF LOW-FREQUENCY ONE-THIRD OCTAVE BANDS OF NOISE

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16. Abstract

This study examined the relative noisiness of low-frequency one-third octave bands of noise bounded by the bands centered at 25 Hz and 200 Hz, with intensities ranging from 50-dB sound pressure level (SPL) to 95-dB SPL. Thirty-two subjects used a method-of-adjustment technique, producing comparison-band intensities as noisy as standard bands centered at 100 Hz and 200 Hz, with each band at 60-dB SPL and 72-dB SPL.

The work resulted in four contours of equal noisiness for one-third octave bands, extending down to 25 Hz and ranging in intensity from approximately 58-dB SPL to 86-dB SPL. These curves were compared with the contours of equal noisiness of Kryter and Pearsons. In the region of overlap (between 50 Hz and 200 Hz) the agreement was good.

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SUMMARY

This study examined the relative noisiness of low-frequency one-third octave bands of noise bounded by the bands centered at 25 Hz and 200 Hz, with intensities ranging from 50-dB sound pressure level (SPL) to 95-dB SPL. Thirty-two subjects used a method-of-adjustment technique, producing comparison-band intensities as noisy as standard bands centered at 100 Hz and 200 Hz, with each band at 60-dB SPL and 72-dB SPL.

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INTRODUCTION

Perceived Noise Level (PNL) has been developed as a computed rating scale used to quantify human disturbance caused by aircraft noise. (See refs. 1 to 6.) This scale is a measure of that quality of aircraft noise described as "noisy," "unwanted," "objectionable," or "disturbing." The sound pressure levels (SPL) of the frequency bands between 50 Hz and 10 kHz are weighted with respect to noisiness and are combined to give a single number rating-scale value. Since PNL does not account for noise bands which occur below 50 Hz, this unit may become increasingly inaccurate for quantifying the noise associated with aircraft such as short takeoff and landing (STOL) vehicles and wide body jets which have major noise bands below 50 Hz. For example, in references 7 and 8 the subjective response to STOL noise is considered. The authors of reference 7 suggest: "The noise contained in these very low frequencies may be specially important since the perceived-noise-level calculation procedures do not consider any energy below 50 Hz in the calculation process. Should the low-frequency energy be significant in the

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responses of people to STOL noise, there may be a need to modify the present PN dB as a unit of measure or to develop a new measuring unit."

Throughout the development and current application of the PNL concept, relatively little attention has been given to the frequency bands below 150 Hz. The major effort in past work has focused on the subjectively more objectionable higher frequencies (above approximately 500 Hz). The original work with equal noisiness contours, which weight the frequency bands, dealt with octave bands and bands of unspecified width. In the low-frequency region the final contours of reference 5 were based upon individual adjustments of a band of noise centered at 70 Hz. From this point, the reference contours were extended by visual fit to 50 Hz, a preferred one-third octave-band center frequency.

Recently there has been renewed interest in the actual shape of the equal noisiness or noy contours used in PNL calculations, particularly for the low-frequency bands. Ollerhead (ref. 9) describes two experiments conducted in part to determine equal noisiness contours for narrow bands of noise down to the 31.5-Hz one-third octave band. The resulting contour of the two experiments is shown in figure 1. For comparison, a contour is also shown from reference 5. Ollerhead also reports (refs. 10 and 11) the relative noisiness of bands of noise at intensities up to 120 dB. (Throughout this report, dB are referenced to 20 $\mu N/m^2$.) The envelope of the contours, collapsed relative to the 1-kHz octave band, is also presented in figure 1 for comparison with a noy contour from reference 5. All of these studies by Ollerhead show a flattening of the contours in the

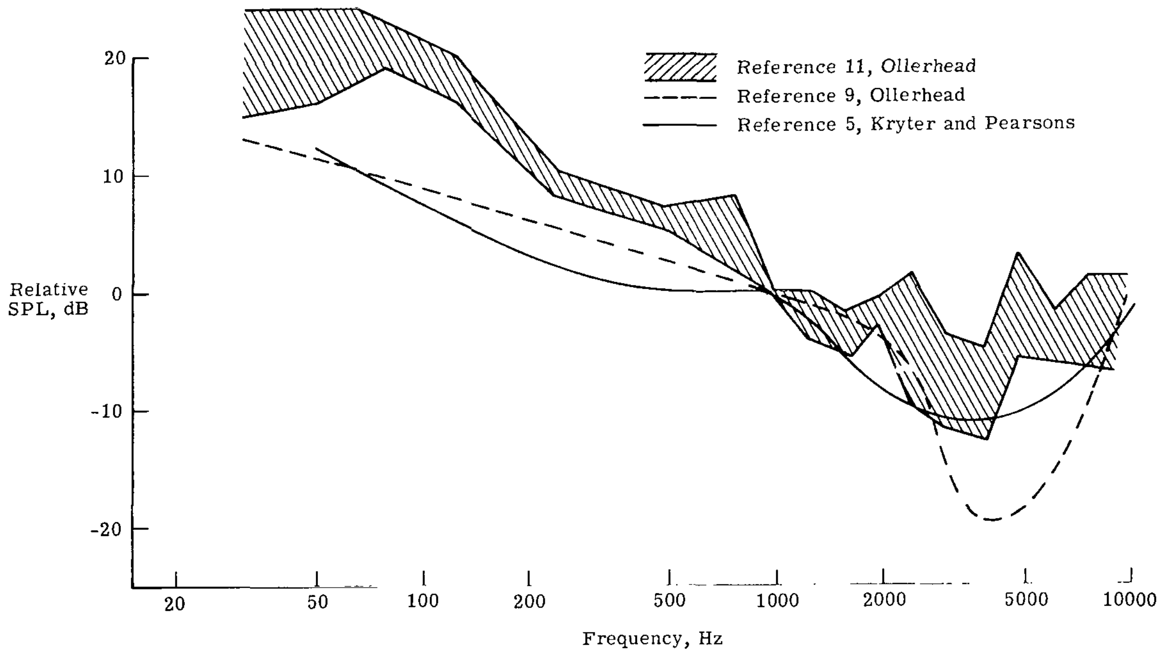


Figure 1.- Comparison of equal noisiness contours from Ollerhead and from Kryter and Pearsons.

low-frequency region. However, the relationships of these contours to the 1963 contours of Kryter and Pearsons indicate both more and less noisiness at a given SPL value. The experiment described in this report is specifically aimed toward a resolution of this discrepancy in the low-frequency region.

The scarcity of noisiness data below 50 Hz represents a gap in the knowledge of human perception of and reaction to noise. With this consideration in mind, the object of the research reported herein was to investigate the relative noisiness of low-frequency one-third octave bands of noise. The frequency range investigated was bounded by the bands centered at 25 Hz and 200 Hz, inclusive. The band intensities ranged between 50 dB and 95 dB. It is believed that the results of this study will improve the ability of the PNL concept to explain or predict subjective response to noises with components below 50 Hz.

EXPERIMENTAL DESIGN

The experimental method used in this study was the method of adjustment. This procedure involved providing a subject with an auditory stimulus termed "comparison stimulus," which was adjusted by the subject to be equal in noisiness to another stimulus, termed "standard stimulus." The two stimuli provided were different from each other with respect to perceived noisiness as defined in reference 12.

The comparison and standard stimuli were chosen to be the one-third octave bands centered at:

Comparison bands, Hz	Standard bands, Hz
25	100
31.5	200
40	
50	
63	
80	
100	
200	

Each of the eight comparison bands was presented with each of the two standard bands, making a total of 16 standard-comparison frequency pairs.

There were three stimulus presentation conditions considered in the design of the experiment. First, to minimize the possibility of a time-order error, each presentation-pair member (either standard or comparison) was heard first in the pair an equal number of times throughout the experiment. That is, for any frequency pair the standard and comparison bands had equal probability of being the first stimulus heard. Second, the initial presentation of the comparison bands was, in turn, with equal probability more or less noisy than the standard. Thus, the subject had to adjust the comparison noisiness either up or down. Finally, to allow for some generalization of the results, the levels of the standard stimuli were fixed at two values: 60 dB and 72 dB. Thus, the final results in the form of curves of equal noisiness would cover a wide, useful intensity range.

In summary, there were three stimulus presentation conditions which were considered: (a) order (standard heard first or comparison heard first); (b) initial noisiness of comparison stimulus (more or less noisy than standard); and (c) intensity of standard (60 dB or 72 dB). Each of these conditions had two alternatives. Thus, there were eight combinations of these conditions (S, standard, C, comparison):

S(=60 dB) > C	C < S(=60 dB)
S(=60 dB) < C	C > S(=60 dB)
S(=72 dB) > C	C < S(=72 dB)
S(=72 dB) < C	C > S(=72 dB)

The experimental variables to be considered were the sixteen frequency pairs and the eight presentation conditions. In order to allocate the pairs and conditions among the subjects and places in the order of presentation, a balance alphanumeric matrix was constructed. This matrix consisted of 32 rows representing the stimuli presentations to be heard by each of 32 subjects, and 20 columns representing the order of presentation of the stimuli. Of the 20 presentations for each subject, the first two were dummies or practice adjustments and the last two were within-subject repeatability adjustments.

Table I presents the 32-row × 20-column experimental matrix. In the matrix, the numbers represent the 16 frequency pairs; the letters represent the 8 presentation conditions. The pairs and conditions were randomly assigned among the numbers and letters; these assignments are listed in table II.

Male and female subjects participated in the experiment. This sex variable required that the two sexes be allocated among the rows in a balanced manner. This allocation was done by assigning male subjects to perform rows 1, 3, 5, . . ., 13, 15, 18, 20, . . ., 30, and 32, and assigning the females to perform rows 2, 4, 6, . . ., 14, 16, 17, 19, . . ., 29, and 31. Arranged in this manner, both sexes performed each matrix permutation, both forward and backward to avoid carry-over effects. The listing of subject sex is also to be found in table I.

EXPERIMENTAL EQUIPMENT AND PROCEDURE

Facility

The experiment was conducted in an anechoic chamber of volume 34.44 m^3 (5.30 m × 2.28 m × 2.85 m). All surfaces of the chamber were covered with open-cell polyurethane foam wedges 0.3 m deep. The dimensions of the wedges were too small to suppress significantly reflections in the frequency range of the stimuli. Therefore, the chamber was essentially a pressure chamber for this experiment.

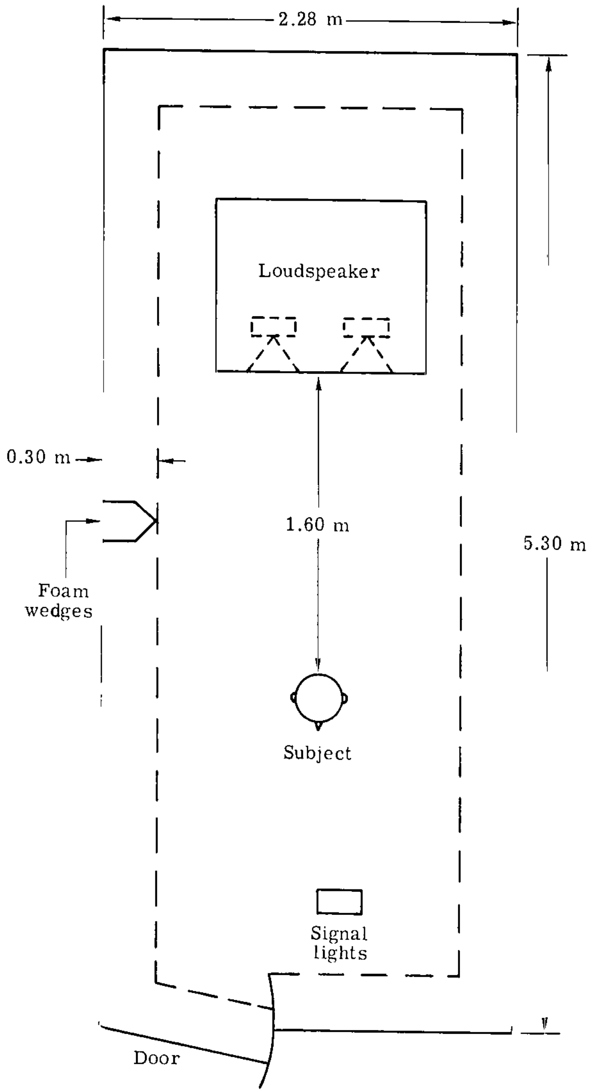
The frequency-pair stimuli were presented to individual subjects in the chamber using a loudspeaker specially constructed for this experiment. Four commercially available bass loudspeaker units with diaphragm dimensions of 0.40 m × 0.30 m were mounted in a rigid, airtight box weighing approximately 225 kg and having an internal volume of 1.30 m^3.

The subject was seated in a hard chair with his head 1.6 m from the front surface of the loudspeaker. Figures 2(a) and 2(b) illustrate the orientation of the loudspeaker and subject within the chamber. The subject sat with his back to the loudspeaker because the long travel of the speaker diaphragms was visible from the subject's chair and it was felt that this motion would distract the subject from his adjustment task. Such a seating arrangement is of little consequence; the absence of head diffraction effects and difficulty in localizing low-frequency sounds make the configuration of the sound field unimportant in relation to the sensation it produces.

Experimental Equipment

The electronic equipment for generation of the stimuli, control of the experiment, and acquisition of data is shown in figure 3. The general functions of the subsystems are indicated on the diagram.

The standard stimulus signals were reproduced from magnetic recording tape loops. The comparison-stimulus signals, on the other hand, were generated real-time and were under the control of the subjects. The comparison signal passed into the chamber to the subject's "control box," a 60-dB attenuator. This attenuator had three knobs: one labeled as a "fine" adjustment giving a total of 5-dB attenuation in 5 steps; another labeled as a "coarse" adjustment giving 25 db in 5 steps; and the third labeled as an "abort" switch giving 30 dB in one step. For each frequency-pair adjustment the subject was given instructions via an intercom system to turn the coarse and fine knobs of his attenuator to their maximum or minimum positions. This manipulation made the comparison band more or less noisy than the standard band, fulfilling the initial magnitude of comparison presentation condition explained in the "Experimental Design" section of this paper.



(a) Sketch (roughly to scale).

(b) Photograph (courtesy of Institute of Sound and Vibration Research, University of Southampton).

Figure 2.- Orientation of loudspeaker and subject within chamber.

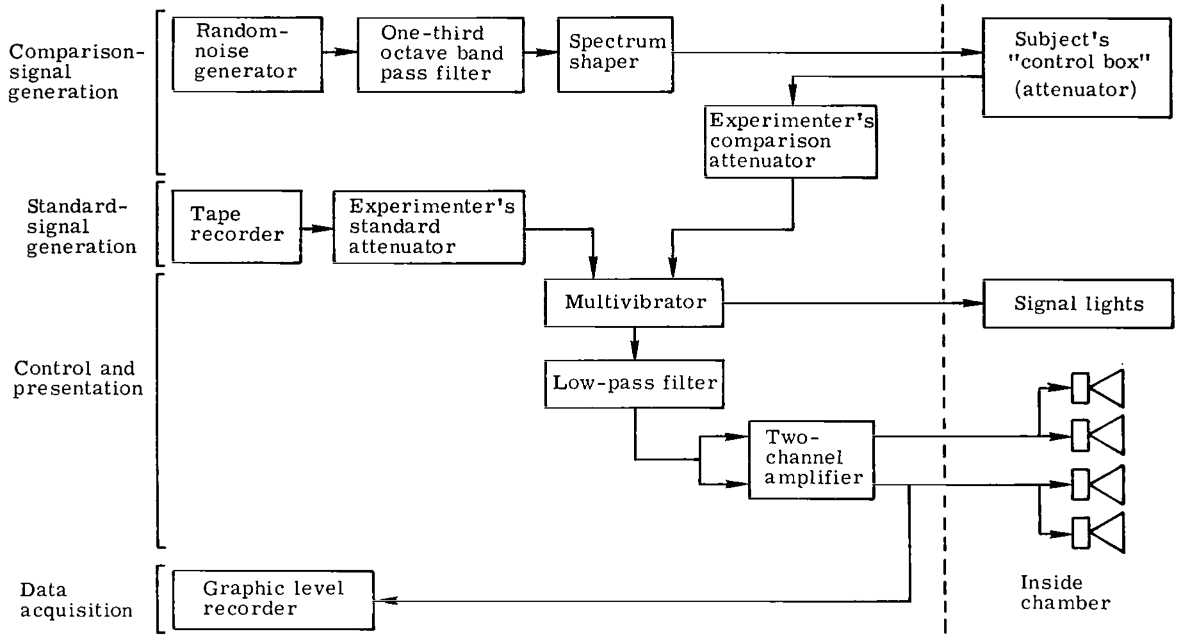


Figure 3.- Diagram of electronic system for generating, controlling, and presenting noise stimuli and recording data during the experiment.

The presentation of the two signals was controlled by a multivibrator. This electronic device alternated the two signals every 5 seconds. The multivibrator also operated two signal lights which identified the two stimuli for the subject. A red light indicated the standard frequency; a green indicated the comparison frequency.

Stimuli

The comparison and standard stimuli were one-third octave bands with center frequencies as listed in the "Experimental Design" section. Figure 4 shows the general frequency-intensity region covered by the comparison and standard bands; figure 5 shows a one-third octave band analysis of a typical stimulus band (all bands had the same analysis ±1 dB). The standard and comparison bands were alternated by the multivibrator so that each band lasted 5 seconds. The frequency pairs were repeated for as long as the subject required to adjust the comparison noisiness to match that of the standard. Figures 6(a) to 6(h) present representative time histories of adjustments for each of the stimulus-presentation conditions listed in the "Experimental Design" section. For clarity, the figure presents SPL, whereas the graphic-level recorder measured the voltage to the loudspeaker; it was necessary to calibrate the system for volts to dB SPL at the subject's head.

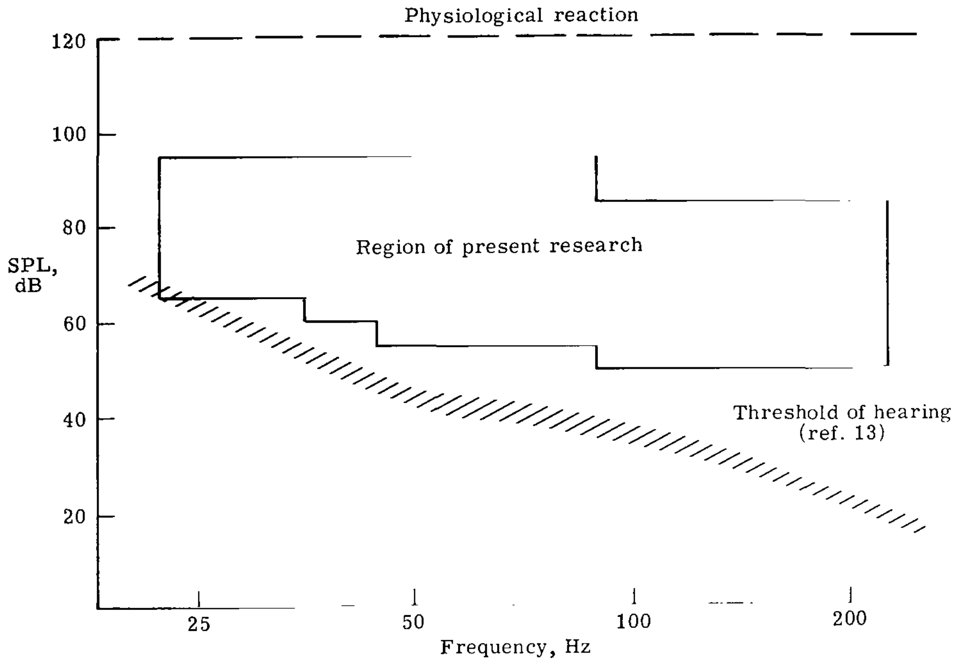


Figure 4.- Frequency-intensity region of present research.

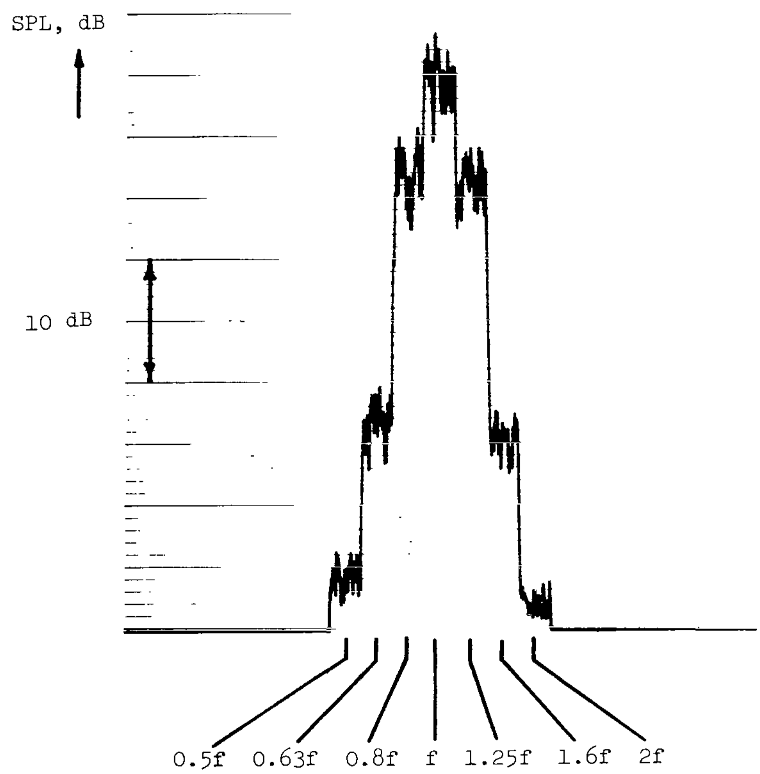
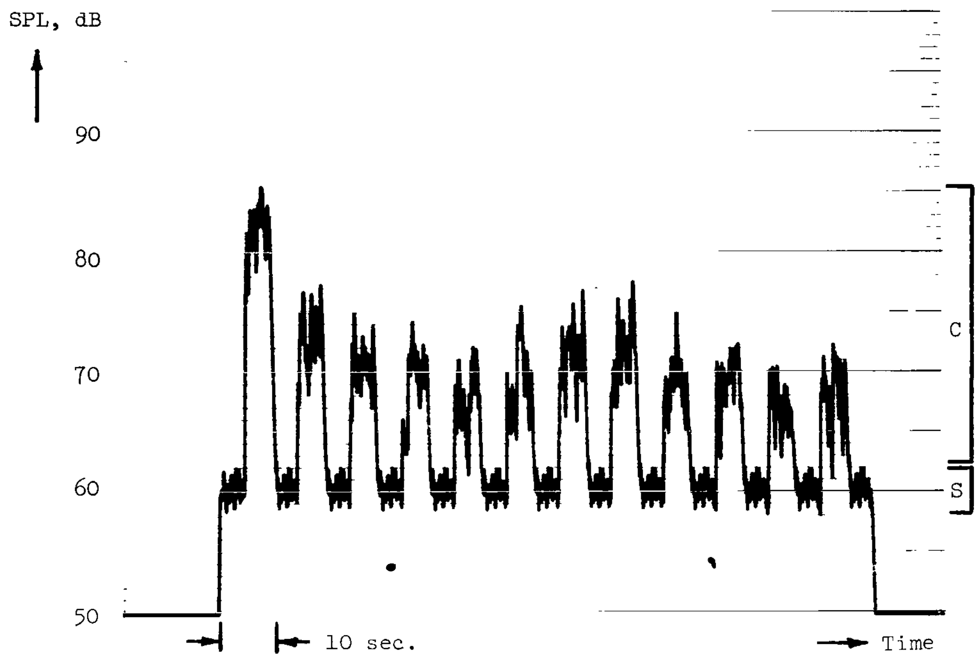
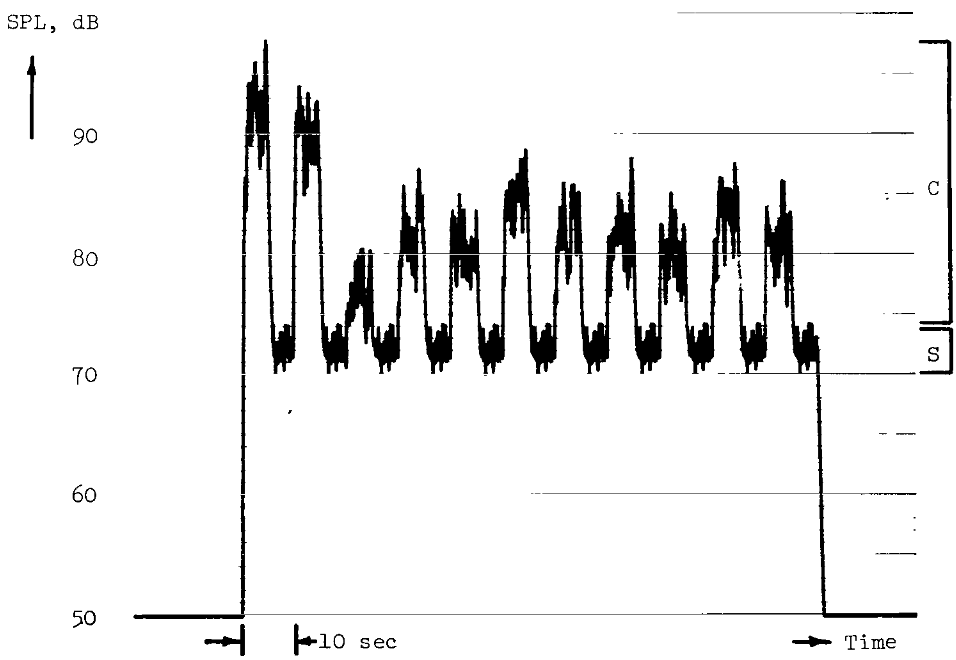


Figure 5.- One-third octave-band analysis of a representative stimulus band with center frequency f; adjacent bands have center frequencies 0.5f, 0.63f, 0.8f, 1.25f, 1.6f, and 2.0f.

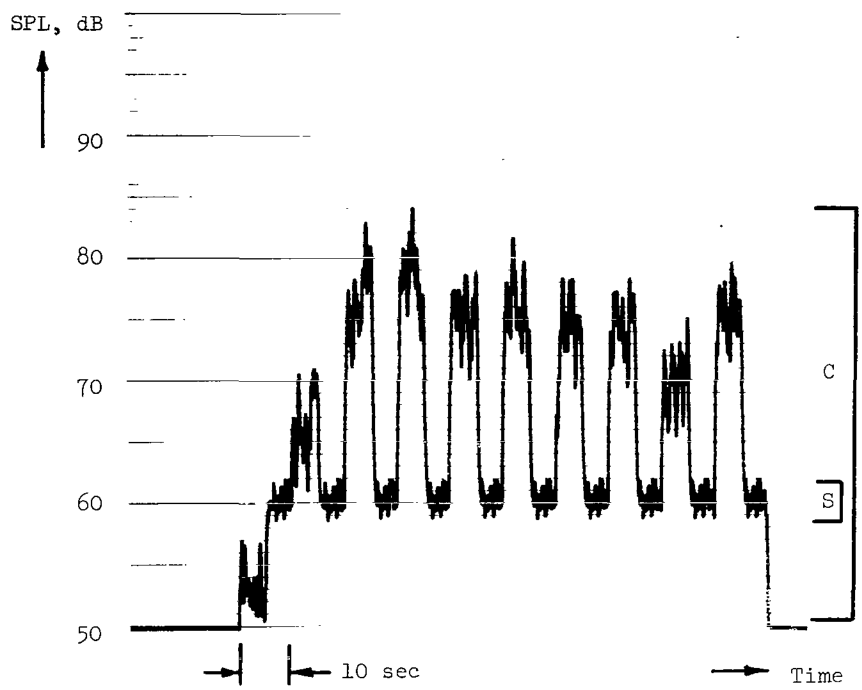


(a) Presentation condition A, S(=60 dB) < C.

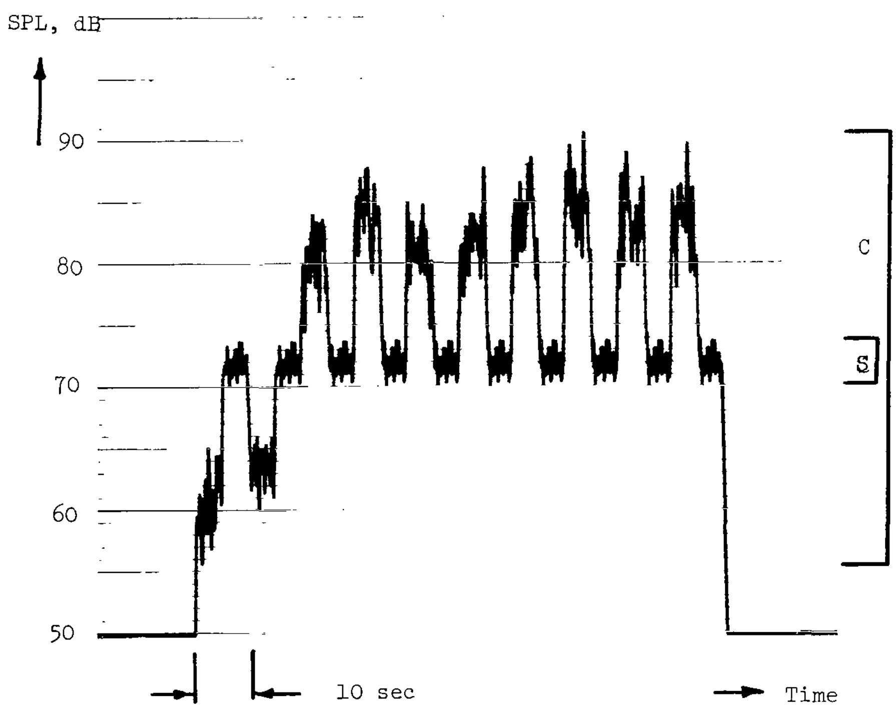


(b) Presentation condition B, C > S(=72 dB).

Figure 6.- Sample time histories of adjustments for each of the eight presentation conditions (S, standard, C, comparison).

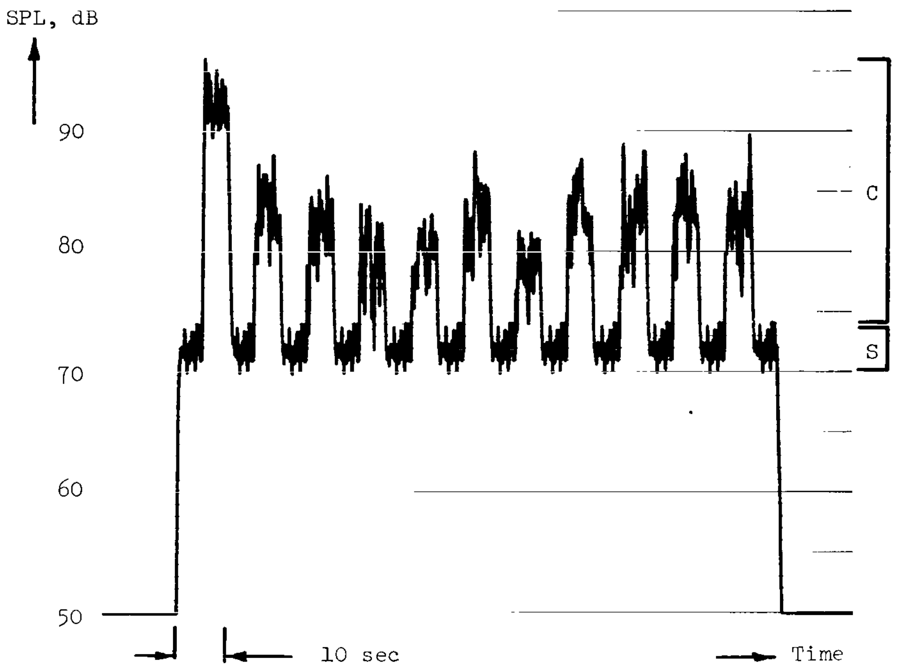


(c) Presentation condition C, C < S(=60 dB).

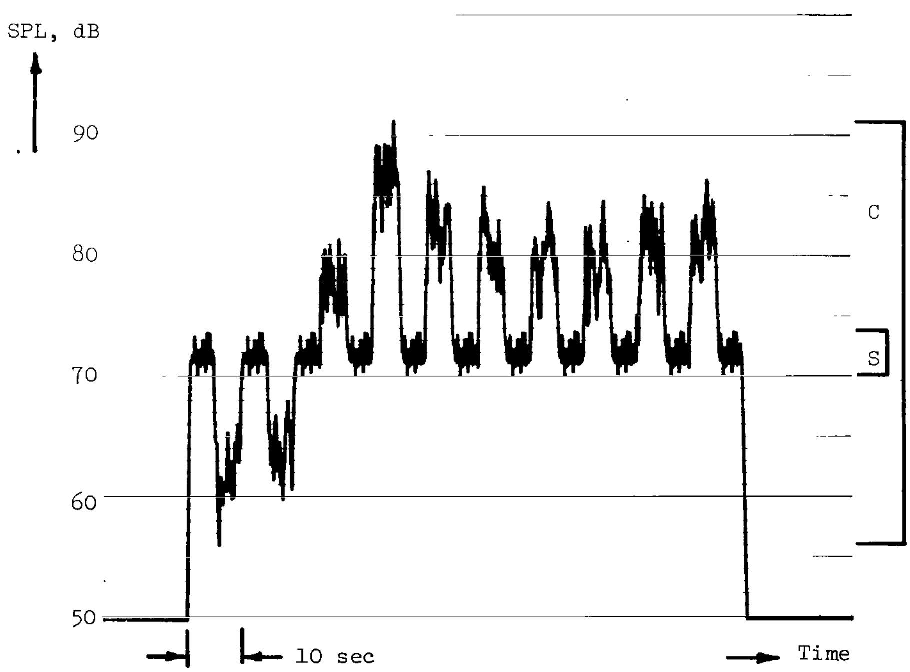


(d) Presentation condition D, C < S(=72 dB).

Figure 6.- Continued.

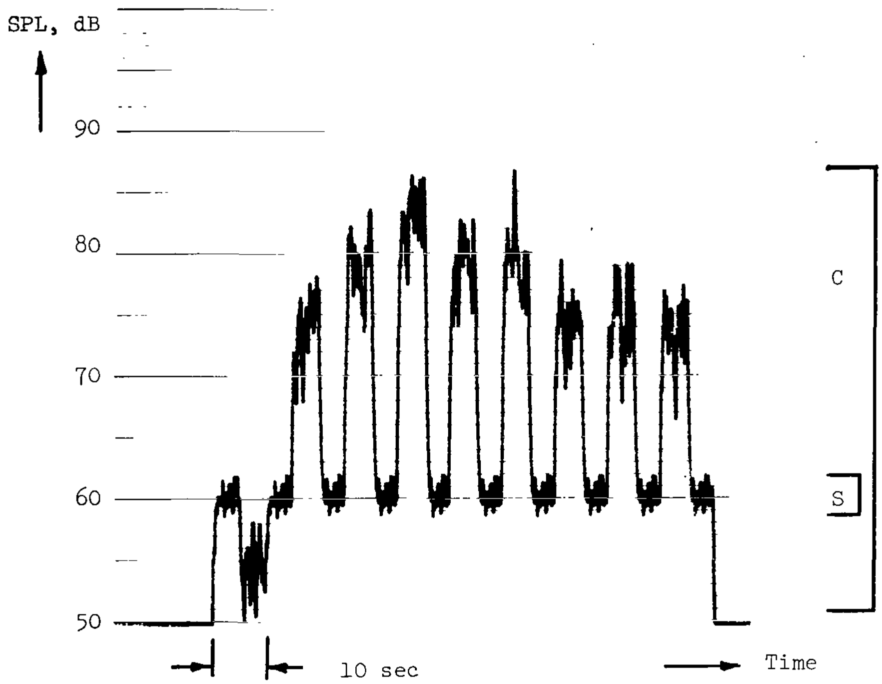


(e) Presentation condition E, S(= 72 dB) < C.

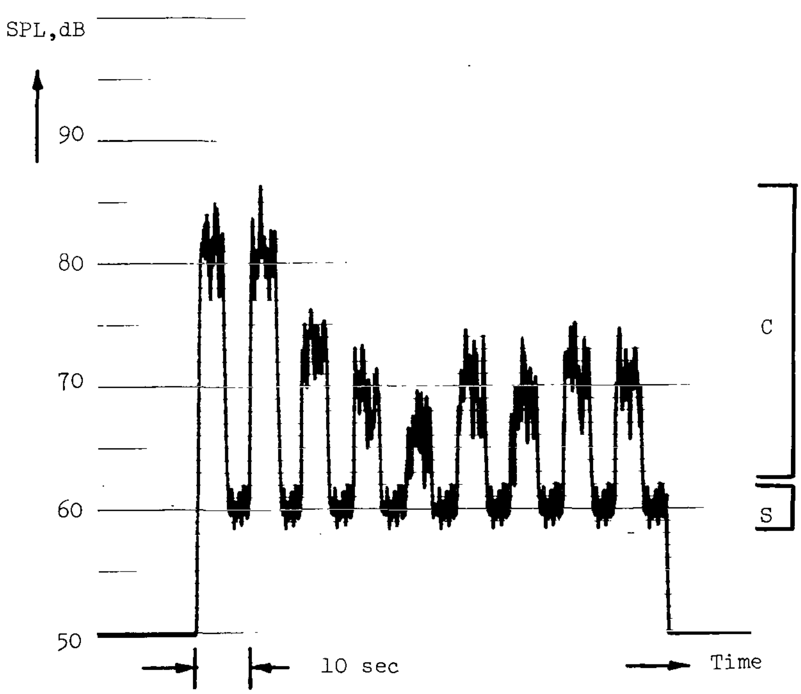


(f) Presentation condition F, S(=72 dB) > C.

Figure 6.- Continued.



(g) Presentation condition G, S(=60 dB) > C.



(h) Presentation condition H, C > S(=60 dB).

Figure 6.- Concluded.

Subjects

Thirty-two paid volunteer subjects participated in the experiment; the number included 16 males and 16 females. The male subjects were university lecturers, technicians, and under- and post-graduate students, whose ages ranged from 19 to 33 years with median age of 24 years. The female subjects were secondary-school teachers and students, housewives, secretaries, university research employees, and under- and post-graduate students, whose ages ranged from 17 to 36 years with median age of 25. For all subjects the ages ranged from 17 to 36 years and median age was 24 years.

Procedure

Upon reporting for duty in the experiment, each potential subject went through a screening procedure. A potential subject was shown the list of contraindications presented in appendix A. (Low-frequency noise exposure was thought to be possibly hazardous to people with any of the conditions listed.) If the potential subject reported that none of the contraindications applied, a pure-tone screening audiogram from 250 to 10 kHz was taken. If the person's hearing was found to be better than 10-dB hearing level (International Organization for Standardization (ISO) 1964) for audiometric test frequencies less than 1 kHz and better than 20-dB hearing level for higher frequencies, the person was allowed to continue the subject-selection procedures.

The potential subject was then asked to complete the consent form presented in appendix B. When the consent form was completed, the person's hearing was tested for minimum audible-field pure tones of 31.5-, 63-, and 100-Hz frequency. Persons whose low-frequency hearing threshold differed more than 10 dB from the threshold curves of reference 13 were dismissed.

A person who had completed the four parts of the screening process was accepted as a subject. Each subject was then given the instructions to read. The instructions are contained in appendix C. (The definition of perceived noisiness was taken from reference 12.) When the subject had read the instructions, he was taken into the experimental chamber, seated, and given verbal instructions concerning the control box and the signal lights used to identify the comparison and standard bands. When the subject was confident in his knowledge of his task and the controls, he was left alone in the chamber and the test was begun.

The adjustments appropriate to the first ten cells of the subject's matrix row were performed. The first two adjustments were subject-blind dummies, for practice only, and the remaining eight were for data-analysis purposes. After the first ten adjustments the subject was given the opportunity to leave the chamber for a short rest, usually lasting less than five minutes.

When the test was resumed, the subject performed the remaining ten adjustments of his matrix row. Eight of these adjustments were for data analysis and the last two were subject-blind repeats, for within-subject repeatability.

When the subject completed the last adjustment, it was necessary to test for a low-frequency threshold shift. Hearing thresholds were redetermined at 31.5 Hz, 63 Hz, and 100 Hz. After the post-exposure low-frequency threshold measurements, the individual subjects were paid and dismissed.

RESULTS AND DISCUSSION

The data collected during the experiment were the comparison-band SPL's when the comparison band was adjusted to be as noisy as the standard band. Each subject performed 20 adjustments, of which 16 were in the main body of the experimental matrix for the relative-noisiness analysis, and 2 were for test-retest repeatability analysis. In all, there were 512 adjustments for the relative-noisiness analysis and 64 data points consisting of two adjustments for the test-retest analysis.

Relative-Noisiness Analysis

The 512 data points collected from the relative-noisiness adjustments contained not only the effects of the comparison-band frequency, but also the effects of the presentation conditions explained in the "Experimental Design" section. Two analyses of variance calculations were performed: a nested 5-way classification model and a 4-way classification model. The nested 5-way model examined the following sources of variation: (a) sex of the subjects; (b) different subjects within each sex classification; (c) presentation order; (d) level of the standard band; and (e) initial level of the comparison band. The 4-way model combined sources (a) and (b) into a single source of variation (subjects) and treated the remaining three sources as in the 5-way model. The results of the analysis of variance calculations for both models are presented in table III. These results were expected; different subjects are normally treated as sources of unexplained variation in any human response to noise investigation. The other significant variable, standard level, contained a 12-dB variation which was reflected in the comparison-band data, regardless of standard-band frequency. The significance of these variables was expected. However, it was still necessary to extract their variances in order that the residual or error variance be as small as possible so that the calculations for the other sources of variation would be accurate. The remaining sources were found to be not significant at the 0.05 level. This conclusion permitted the pooling of all the data at each comparison-band frequency.

The adjustment data for all subjects were combined to give means and standard deviations for each comparison band. These means and standard deviations were separated by the frequency and level of the standard bands. These statistics are presented in table IV. The data from the table are shown graphically in figure 7, which presents the means, and in figures 8 and 9, which present the standard deviation. In figure 7, the means are connected to form curves of equal noisiness which exhibit expected trends. In a similar manner to the threshold of audibility curve of reference 13 (see fig. 4), the equal-noisiness curves fall from the highest SPL values at the lowest frequency band.

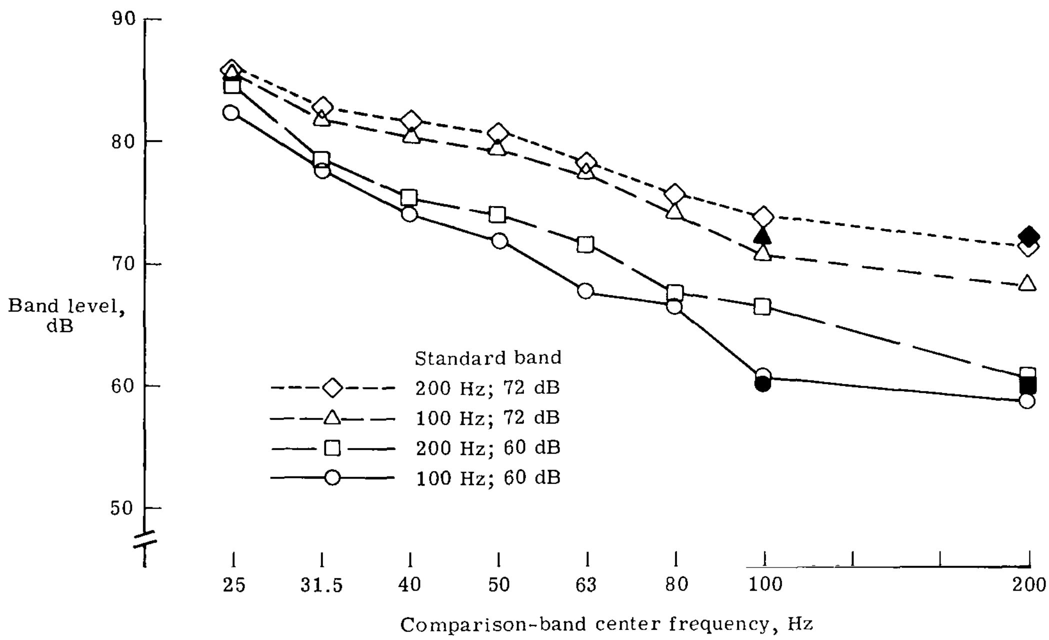


Figure 7.- Means of the comparison-band adjustments separated according to standard-band frequency and level.

The data points of the curves of figure 7 were tested to discover whether each curve was significantly separated from the nearest neighboring curve. Two tests were performed, using the t test for paired data (ref. 14, pp. 143-150). For these tests the data of the two 60-dB curves (represented by the squares and circles in fig. 7) were tested against each other. The same tests were applied to the 72-dB data points (diamonds and triangles). The null hypothesis for each test was that the mean separation between adjacent curves was zero. In both cases this hypothesis was rejected:

60-dB curves	72-dB curves
$t = 4.05$ 7 degrees of freedom $P < 0.005$	$t = 4.33$ 7 degrees of freedom $P < 0.005$

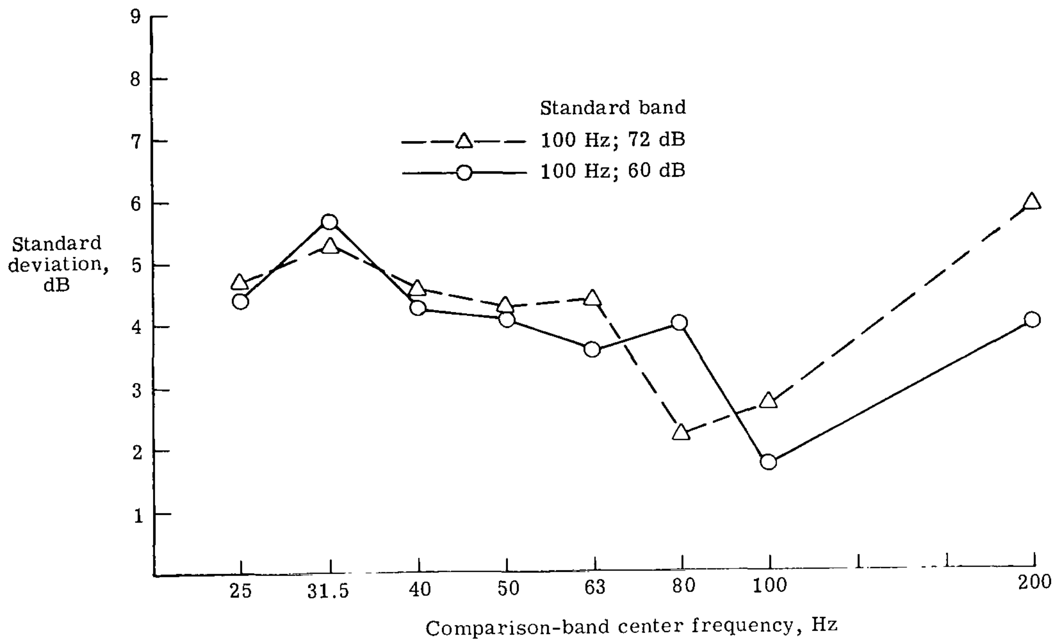


Figure 8.- Standard deviations of the comparison-band adjustments to the 100-Hz standard bands.

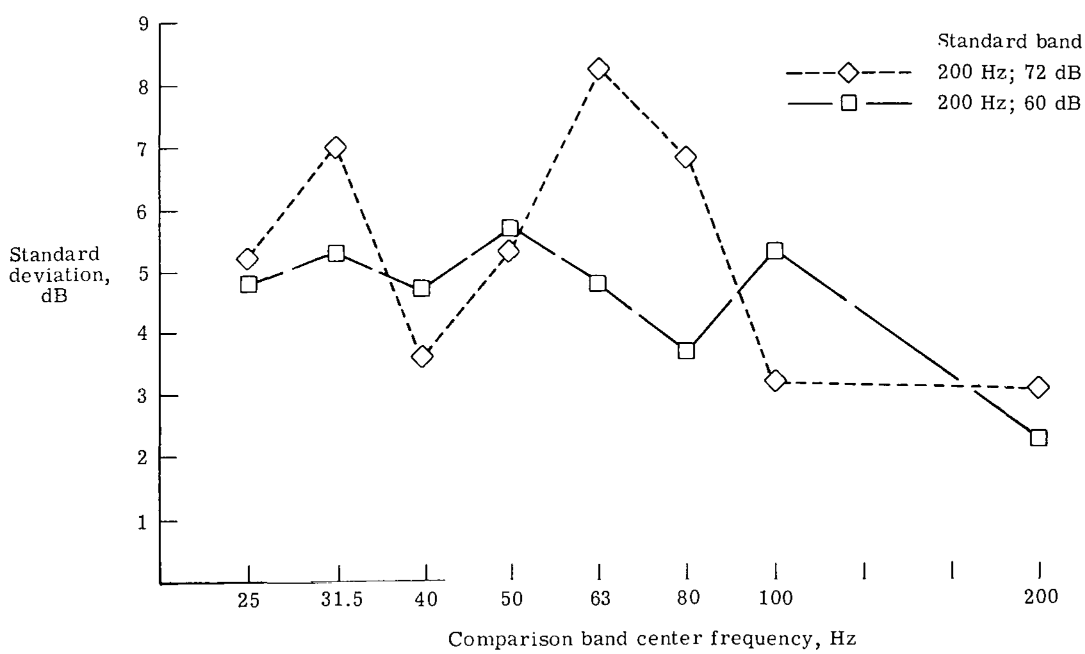


Figure 9.- Standard deviations of the comparison-band adjustments to the 200-Hz standard bands.

In other words, the 60-dB curves are significantly different from each other, as are the 72-dB curves. The larger separations between the 100-Hz curves and between the 200-Hz curves are also significant. Thus, each curve of figure 7 is significantly distinct.

As illustrated in figures 8 and 9, expected trends are seen in the standard-deviation data. As the frequency difference between comparison and standard bands increased, the noisiness-balance task became more difficult for the subjects, causing increasing variation in the adjustments. The data associated with each standard-band frequency (100 Hz and 200 Hz) were tested for homogeneity of variances using Bartlett's test (ref. 14, pp. 160-162). The null hypothesis of identical variances was rejected at the 0.05 significance level for the 100 Hz, 200 Hz, and combined cases. This result was not surprising considering the low variances for the identical comparison-standard frequency cases.

The present study has resulted in extended knowledge of the subjective noisiness reaction to one-third octave bands of noise over a very limited intensity range. The present data were analyzed to produce curves which show equal noisiness. In a manner similar to the threshold of audibility curves, the general shape of each curve falls from high SPL values at the lowest frequencies tested. (See ref. 13.) The present curves of equal noisiness do not fall so steeply with increasing frequency, but as seen in figure 7, the curves tend to be closer together at the lower frequencies. This trend was borne out by a linear-regression analysis (not included here) through each set of mean adjustments. The slopes of the line increased from the top to bottom curve. That is, the bottom curve (for the 100-Hz, 60-dB standard) has the greatest negative slope. This decreased spacing between the curves at lower frequencies indicates that the growth of noisiness is more rapid at lower frequencies. In addition to these considerations, the curves of equal noisiness preserve among themselves, without crossing, the same ordinal relationship of noy values as their associated standards.

Test-Retest Repeatability

As explained in the section headed "Procedure," each subject was required to repeat the last two adjustments of his row of the experimental matrix. This requirement was made to assess the precision of the subjects' adjustments. The test-retest data are shown in figure 10. The horizontal axis is the SPL produced for an adjustment within the main body of the experimental matrix. The vertical axis is the SPL produced for the same adjustment when repeated. The figure also shows the first order regression line and its equation in the form $y = ax + b$, and the Pearson product moment correlation coefficient r of the data points. The equation of the regression line, with a slope very close to 1.00, and the high correlation coefficient indicate that the subjects' repeatability

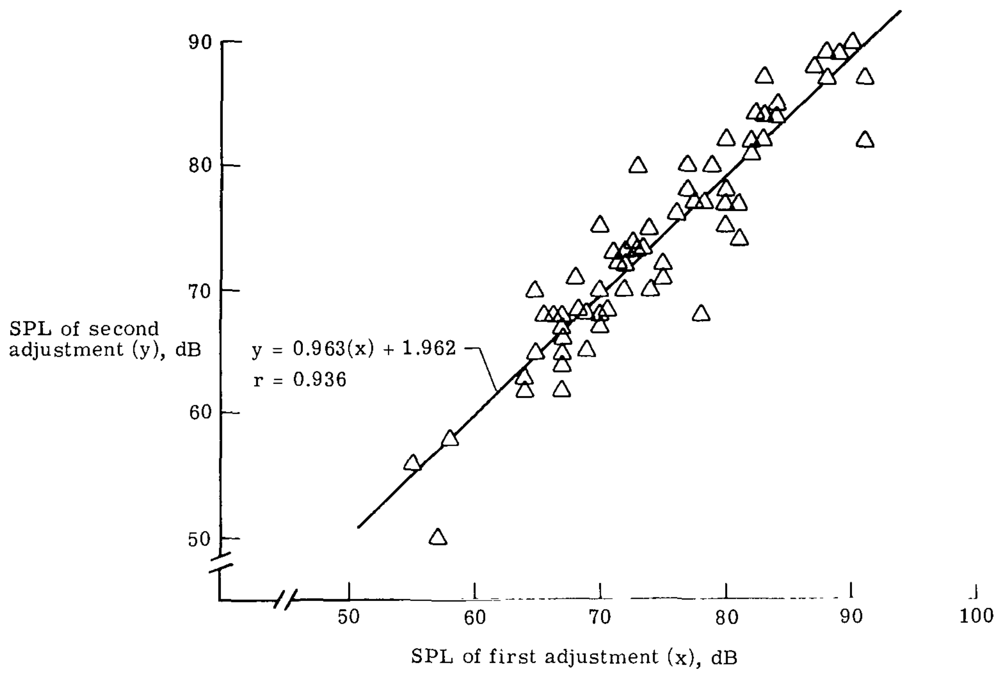


Figure 10.- Test-retest data with first-order regression and correlation coefficient.

was satisfactory. That is, the subjects understood the instructions and were able to perform the noisiness-balance adjustment task with relatively high precision.

Comparison With Previous Work

The adjustment means were compared to the noy values from reference 5. In figures 11 and 12 the appropriate noy contours from reference 5 are shown (up to 400 Hz) with the adjustment means of the present study. In the region of overlap between the 50-Hz and 200-Hz bands, the present and reference values were tested for each noy case. Each adjustment mean was compared with its matching reference value using a normal z test. The null hypothesis tested was that the present data are a sample drawn from the population represented by the reference value. This null hypothesis was rejected at the 0.05 significance level for a majority of the points constituting the 100-Hz, 60-dB line and the 200-Hz, 72-dB line. For these two lines, a majority of the present adjustment means were significantly displaced from the reference decibel values. For the other two curves of the present data, the null hypotheses were not rejected at the 0.05 level.

Additionally, linear regressions were performed in the region of overlap for each of the present and reference values. The slopes of the present curves and the appropriate reference values were tested for significant differences in slopes. In each of the four tests of slopes, the null hypotheses of identical slopes were not rejected at the 0.05 level.

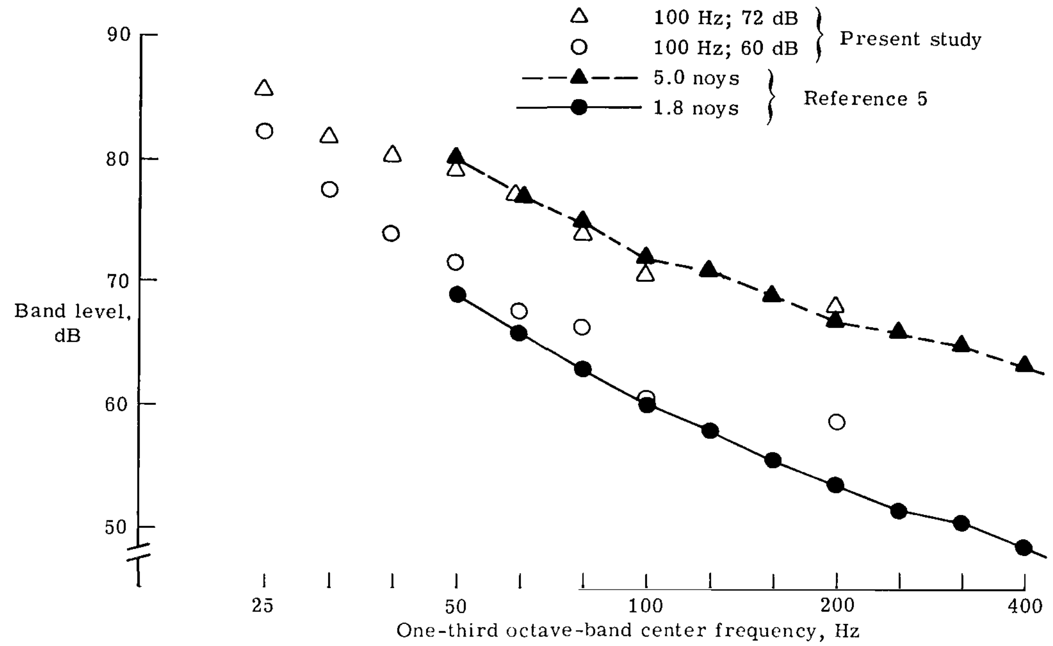


Figure 11.- Comparison of the 100-Hz standard-mean adjustments with the reference noy values appropriate to the standard levels.

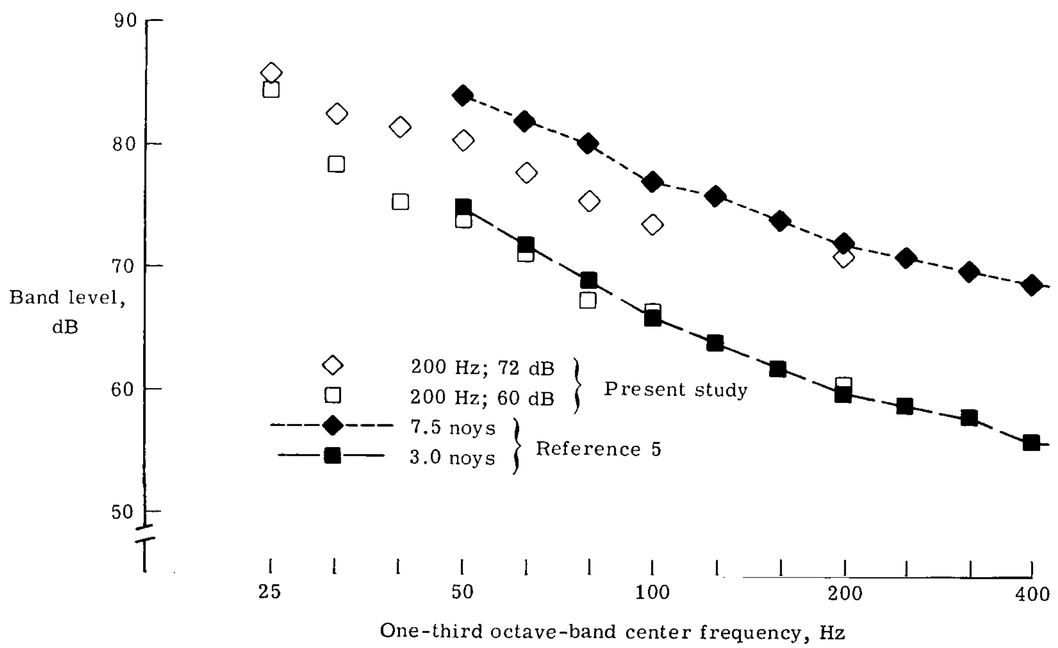


Figure 12.- Comparison of the 200-Hz standard-mean adjustments with the reference noy values appropriate to the standard levels.

The results of these statistical tests of the present and reference values indicate that the agreement is generally good. In the region of overlap of the two sets of values, two of the four curves of the present data were significantly displaced from their appropriate noy contours, and all lines of the present data had slopes identical to the reference noy contours. Figure 13 shows an overall comparison of the present results and the noy contours of Kryter and Pearsons.

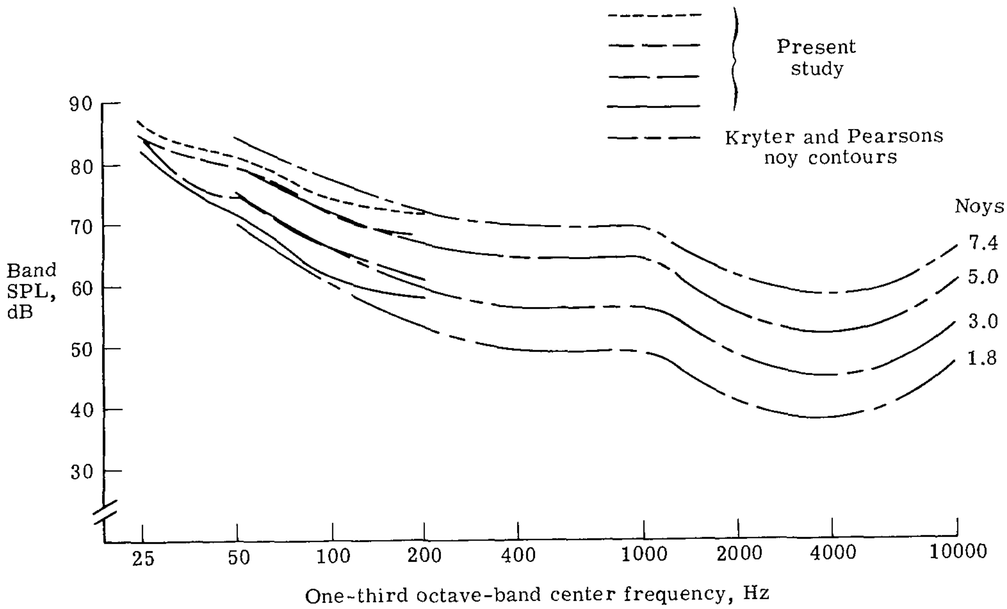


Figure 13.- Comparison of present results with noy contours from reference 5.

CONCLUDING REMARKS

The purpose of the study was to examine the relative noisiness of one-third octave bands of noise bounded by the bands centered at 25 Hz and 200 Hz, with intensities ranging from 50-dB to 95-dB sound pressure level (SPL). Thirty-two subjects used a method-of-adjustment technique to produce comparison bands equal in noisiness to 100-Hz and 200-Hz standard bands at 60 dB and 72 dB.

The data were analyzed to yield four contours of equal noisiness for one-third octave bands, ranging in intensity over the approximate range 58-dB to 86-dB SPL. The curves fall wtih increasing frequency, like the threshold of audibility, but have decreasing negative slopes with increasing intensity. That is, the curves are closer together at the lower frequencies. This trend in the data suggests that the growth of noisiness is more rapid at lower frequencies.

The present contours of equal noisiness were compared with the contours of equal noisiness of Kryter and Pearsons. In the region of overlap between 50 Hz and 200 Hz the agreement was good. This agreement suggests that the present contours may be used to extend the current equal-noisiness contours, at least in the frequency-intensity region tested, to enlarge the perceived-noise-level (PNL) concept to account for low-frequency acoustic energy.

Langley Research Center
National Aeronautics and Space Administration
Hampton, Va. 23665
September 5, 1975

APPENDIX A

LIST OF MEDICAL CONTRAINDICATIONS

Persons with any of the following conditions are considered unfit for the present experiment involving whole-body exposure to low-frequency noise:

infectious disease or fever;
cold or ear infection;
deafness or history of ear surgery;
blindness, glaucoma, or history of eye surgery;
history of coughing up, vomiting, or passing blood;
history of blood pressure disorder or heart disease;
any internal prosthetic device;
surgical operation within the past 6 months;
pregnancy;
mental defect or disorder;
neurological disorder;
history of suicide attempt.

APPENDIX B

CONSENT FORM COMPLETED BY ALL SUBJECTS

UNIVERSITY OF SOUTHAMPTON INSTITUTE OF SOUND & VIBRATION RESEARCH

Operational Acoustics & Audiology Group

Consent form to be completed by a subject volunteering to undergo an experiment for research purposes before the experiment commences.

I, ... of . . . .
consent to take part in . . . .
to be conducted by . . . .
during the period . . . . to . . . . 197 .

The purpose and nature of this experiment have been explained to me.

I understand that the investigation is to be carried out solely for the purpose of research and I am willing to act as a volunteer for that purpose on the understanding that I shall be entitled to withdraw this consent at any time, without giving any reasons for withdrawal. I further certify that I have seen the list of questions concerning medical fitness for this experiment and confirm that to the best of my knowledge I do not suffer from any of the conditions listed.

Date . . . . Signed . . . .

I confirm that I have explained to the subject the purpose and nature of the investigation which has been approved by the Safety and Ethics Committee.

Date . . . . Signed . . . .

APPENDIX C

INSTRUCTIONS EXPLAINING THE GENERAL NATURE OF THE EXPERIMENT AND THE ADJUSTMENT TASK

Instructions

The purpose of this experiment is to discover the relative noisiness of low-frequency noises. Your job is to adjust the noisiness of one noise to match another. Please read the following definition:

"The subjective impression of the unwantedness of a not unexpected, non-pain or fear-provoking sound as part of one's environment is defined as the attribute of perceived noisiness." Noisiness means the same thing as "unwantedness," "unacceptableness," or "objectionableness."

When the experiment starts, you will hear two noises separated by a short interval; this pair of noises will be repeated. One of the noises will be at a fixed noisiness; this noise is called the fixed standard. You can control the noisiness of the other noise, called the variable comparison. The signal lights will tell you when to adjust the noisiness of the variable comparison, using the control box. When signal is red, do not adjust. When the signal is green, you may adjust the noisiness of the variable comparison.

Your job is to adjust the noisiness of the variable comparison until it is as noisy as the fixed standard. Each pair of noises will be repeated for as long as you need to make your adjustments. When you have completed your adjustments for each pair of noises, please tell me so over the intercom system.

You are free to withdraw from the experiment at any time. Also, you may stop the noise, if you feel it necessary, by using the "abort" switch on your control box.

Any questions?

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TABLE I.- EXPERIMENTAL MATRIX OF STIMULUS PRESENTATIONS FOR EACH SUBJECT

Subject	Sex	Dummies		Experimental conditions																Within subject repeatability adjustments	
1	M	15 A	16 B	1 A	2 B	16 A	3 C	15 B	4 D	14 C	5 E	13 D	6 F	12 E	7 G	11 F	8 H	10 G	9 H	10 G	9 H
2	F	15 A	16 B	2 A	3 A	1 B	4 B	16 C	5 C	15 D	6 D	14 E	7 E	13 F	8 F	12 G	9 G	11 H	10 H	11 H	10 H
3	M	15 A	16 B	3 B	4 A	2 C	5 A	1 D	6 B	16 E	7 C	15 F	8 D	14 G	9 E	13 H	10 F	12 H	11 G	12 H	11 G
4	F	15 A	16 B	4 C	5 B	3 D	6 A	2 E	7 A	1 F	8 B	16 G	9 C	15 H	10 D	14 H	11 E	13 G	12 F	13 G	12 F
5	M	15 A	16 B	5 D	6 C	4 E	7 B	3 F	8 A	2 G	9 A	1 H	10 B	16 H	11 C	15 G	12 D	14 F	13 E	14 F	13 E
6	F	15 A	16 B	6 E	7 D	5 F	8 C	4 G	9 B	3 H	10 A	2 H	11 A	1 G	12 B	16 F	13 C	15 E	14 D	15 E	14 D
7	M	15 A	16 B	7 F	8 E	6 G	9 D	5 H	10 C	4 H	11 B	3 G	12 A	2 F	13 A	1 E	14 B	16 D	15 C	16 D	15 C
8	F	15 A	16 B	8 G	9 F	7 H	10 E	6 H	11 D	5 G	12 C	4 F	13 B	3 E	14 A	2 D	15 A	1 C	16 B	1 C	16 B
9	M	15 A	16 B	9 H	10 G	8 H	11 E	7 G	12 E	6 F	13 D	5 E	14 C	4 D	15 B	3 C	16 A	2 B	1 A	2 B	1 A
10	F	15 A	16 B	10 H	11 H	9 G	12 G	8 F	13 F	7 E	14 E	6 D	15 D	5 C	16 C	4 B	1 B	3 A	2 A	3 A	2 A
11	M	15 A	16 B	11 G	12 H	10 F	13 H	9 E	14 G	8 D	15 F	7 C	16 E	6 B	1 D	5 A	2 C	4 A	3 B	4 A	3 B
12	F	15 A	16 B	12 F	13 G	11 E	14 H	10 D	15 H	9 C	16 G	8 B	1 F	7 A	2 E	6 A	3 D	5 B	4 C	5 B	4 C
13	M	15 A	16 B	13 E	14 F	12 D	15 G	11 C	16 H	10 B	1 H	9 A	2 G	8 A	3 F	7 B	4 E	6 C	5 D	6 C	5 D
14	F	15 A	16 B	14 D	15 E	13 C	16 F	12 B	1 G	11 A	2 H	10 A	3 H	9 B	4 G	8 C	5 F	7 D	6 E	7 D	6 E
15	M	15 A	16 B	15 C	16 D	14 B	1 E	13 A	2 F	12 A	3 G	11 B	4 H	10 C	5 H	9 D	6 G	8 E	7 F	8 E	7 F
16	F	15 A	16 B	16 B	1 C	15 A	2 D	14 A	3 E	13 B	4 F	12 C	5 G	11 D	6 H	10 E	7 H	9 F	8 G	9 F	8 G
17	F	15 A	16 B	9 H	10 G	8 H	11 F	7 G	12 E	6 F	13 D	5 E	14 C	4 D	15 B	3 C	16 A	2 B	1 A	2 B	1 A
18	M	15 A	16 B	10 H	11 H	9 G	12 G	8 F	13 F	7 E	14 E	6 D	15 D	5 C	16 C	4 B	1 B	3 A	2 A	3 A	2 A
19	F	15 A	16 B	11 G	12 H	10 F	13 H	9 E	14 G	8 D	15 F	7 C	16 E	6 B	1 D	5 A	2 C	4 A	3 B	4 A	3 B
20	M	15 A	16 B	12 F	13 G	11 E	14 H	10 D	15 H	9 C	16 G	8 B	1 F	7 A	2 E	6 A	3 D	5 B	4 C	5 B	4 C
21	F	15 A	16 B	13 E	14 F	12 D	15 G	11 C	16 H	10 B	1 H	9 A	2 G	8 A	3 F	7 B	4 E	6 C	5 D	6 C	5 D
22	M	15 A	16 B	14 D	15 E	13 C	16 F	12 B	1 G	11 A	2 H	10 A	3 H	9 B	4 G	8 C	5 F	7 D	6 E	7 D	6 E
23	F	15 A	16 B	15 C	16 D	14 B	1 E	13 A	2 F	12 A	3 G	11 B	4 H	10 C	5 H	9 D	6 G	8 E	7 F	8 E	7 F
24	M	15 A	16 B	16 B	1 C	15 A	2 D	14 A	3 E	13 B	4 F	12 C	5 G	11 D	6 H	10 E	7 H	9 F	8 G	9 F	8 G
25	F	15 A	16 B	1 A	2 B	16 A	3 C	15 B	4 D	14 C	5 E	13 D	6 F	12 E	7 F	11 F	8 H	10 G	9 H	10 G	9 H
26	M	15 A	16 B	2 A	3 A	1 B	4 B	16 C	5 C	15 D	6 D	14 E	7 E	13 F	8 F	12 G	9 G	11 H	10 H	11 H	10 H
27	F	15 A	16 B	3 B	4 A	2 C	5 A	1 D	6 B	16 E	7 C	15 F	8 D	14 G	9 E	13 H	10 F	12 H	11 G	12 H	11 G
28	M	15 A	16 B	4 C	5 B	3 D	6 A	2 E	7 A	1 F	8 B	16 G	9 C	15 H	10 D	14 H	11 E	13 G	12 F	13 G	12 F
29	F	15 A	16 B	5 D	6 C	4 E	7 B	3 F	8 A	2 G	9 A	1 H	10 B	16 H	11 C	15 G	12 D	14 F	13 E	14 F	13 E
30	M	15 A	16 B	6 E	7 E	5 F	8 C	4 G	9 B	3 H	10 A	2 H	11 A	1 G	12 B	16 F	13 C	15 E	14 D	15 E	14 D
31	F	15 A	16 B	7 F	8 E	6 G	9 D	5 H	10 C	4 H	11 B	3 G	12 A	2 F	13 A	1 E	14 B	16 D	15 C	16 D	15 C
32	M	15 A	16 B	8 G	9 F	7 H	10 E	6 H	11 D	5 G	12 C	4 F	13 B	3 E	14 A	2 D	15 A	1 C	16 B	1 C	16 B

TABLE II. - ASSIGNMENTS OF FREQUENCY PAIRS AND PRESENTATION CONDITIONS TO THE NUMBERS AND LETTERS OF THE EXPERIMENTAL MATRIX

Number	Standard band, Hz	Comparison band, Hz
1	100	25
2	200	50
3	200	25
4	100	80
5	200	200
6	100	63
7	200	40
8	200	31.5
9	100	200
10	100	40
11	200	80
12	200	63
13	200	100
14	100	100
15	100	50
16	100	31.5

Letter	Experimental condition
A	S(=60 dB) < C
B	C > S(=72 dB)
C	C < S(=60 dB)
D	C < S(=72 dB)
E	S(=72 dB) < C
F	S(=72 dB) > C
G	S(=60 dB) > C
H	C > S(=60 dB)

TABLE III. - ANALYSIS-OF-VARIANCE TABLE, COMBINING RESULTS OF THE NESTED 5-WAY CLASSIFICATION, AND THE 4-WAY CLASSIFICATION

Source	Degrees of freedom	Sum of squares	Mean square	F ratio
Between sex	1	187.70	187.70	3.34 NS[b]
Between subjects within sex	30	4 472.23	149.07	[a]2.65
Between subjects	31	4 659.93	150.32	[a]2.68
Between presentation orders	1	46.32	46.32	.82 NS[b]
Between standard levels	1	5 778.12	5778.12	[a]102.85
Between initial comparison levels	1	118.20	118.20	2.10 NS[b]
Residual	477	26 797.23	56.18	
Total	511	37 399.80		

[a]Significant at the 0.001 level.

[b]NS = Not significant.

TABLE IV. - MEANS AND STANDARD DEVIATIONS OF THE COMPARISON-BAND ADJUSTMENTS, IN dB

[First value denotes the mean whereas second value is the standard deviation]

Standard-band center frequency, Hz	Standard-band center level, dB	Comparison-band center frequencies, Hz, of –							
		25	31.5	40	50	63	80	100	200
100	60	82.1	77.7	74.0	71.9	67.8	66.5	60.4	58.8
		4.4	5.7	4.3	4.1	3.6	4.0	1.7	4.0
200	60	84.8	78.4	75.4	74.0	71.4	67.6	66.3	60.6
		4.8	5.3	4.7	5.7	4.8	3.7	5.3	2.3
100	72	85.6	81.9	80.2	79.1	77.1	74.0	70.7	68.2
		4.7	5.3	4.6	4.3	4.4	2.2	2.7	5.9
200	72	85.9	82.6	81.6	80.6	78.0	75.4	73.8	71.1
		5.2	7.0	3.6	5.3	8.2	6.8	3.2	3.1