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A LABORATORY STUDY OF THE PERCEIVED BENEFIT OF ADDITIONAL NOISE ATTENUATION BY HOUSES

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SUMMARY

Two experiments were conducted to investigate the perceived benefit of additional house attenuation against aircraft flyover noise. First, subjects made annoyance judgments in a simulated living room environment. External loudspeakers reproduced a range of aircraft flyover noise levels while the windows were manipulated in full view of the subjects. The window conditions were: open, closed, closed plus a dummy storm window, and closed plus a real storm window.

Second, subjects made annoyance judgments in an anechoic audiometric test chamber of frequency shaped noise signals having spectra closely matched in one-third-octave-bands to the spectra of the aircraft flyover noises reproduced in the first experiment. These stimuli represented the aircraft flyover noises in levels and spectra but without the situational and visual cues present in the simulated living room.

Perceptual constancy theory implies that annoyance judgments indoors would tend to remain constant despite reductions in noise level due to additional attenuation of which the subjects are fully aware. This theory was supported when account was taken for a reported annoyance overestimation for the closed and closed plus real storm window spectra and when account was taken for a simulated condition cue overreaction. The overestimation was observed in the second experiment and was equivalent to 3.3 dB for A-weighted sound pressure level. The simulated condition cue overreaction was determined by using the dummy storm window in the first experiment.

INTRODUCTION

Community exposure to aircraft flyover noise can be reduced by; first, engineering noise control or changed operational procedures to reduce sound power output at source; second, controlling flight paths and land use to increase the distances between aircraft and communities; and third, providing additional noise insulation at dwellings. Whenever a decision has to be made to implement one or more of these methods it is necessary to compare their relative cost-effectiveness, in terms of the likely annoyance reductions to be achieved. However, it has not been proven that noise level reduction measured in decibels is an adequate predictor of annoyance reduction. Perceptual constancy might reduce the perceived benefit of additional house attenuation, from that otherwise expected on the basis of noise level reductions alone. Such a reduction could affect any comparison between additional house attenuation and other methods of reducing community exposure to aircraft flyover noise.

Perceptual constancy describes that tendency towards forming a constant perception of the nature of an object despite variations in sensory stimulation due to intervening variables, such as distance or insulation. Thouless (ref. 1) described it as "phenomenal regression to the real object" and Brunswick (ref. 2) emphasized the "distal focussing" of perceptual achievement. The theory suggests that perception of an aircraft flyover noise could tend to remain constant despite noise level reductions caused by additional attenuation, providing that people are aware that the additional attenuation has been applied. (With the obvious caveat that if too much additional attenuation is applied, the aircraft flyover noise could become inaudible). The theory is particularly relevant to the observation by Kryter (ref. 3) that "people apparently require a noise environment within their home that is 20 dB (Perceived Noise Level) or so lower than that which they find to be acceptable when heard outdoors." Kryter attributed this phenomenon to indoor activities being more sensitive to noise interference.

Robinson et al (refs. 4 and 5) described a "projection effect" which could have been due to perceptual constancy. Any given aircraft flyover noise would be judged nearly as noisy when heard at a considerable distance as when heard at a much smaller distance. Further, aircraft flyover noise was judged more noisy indoors than outdoors for corresponding noise levels at the subject's position. However, the indoor increase in annoyance was not as great as the outdoor to indoor attenuation would imply. Bishop (ref. 6) also found that aircraft flyover noises were judged more annoying indoors than outdoors for corresponding noise levels at the subject's position. Bishop attributed this difference to his experimental subject's supposed preference to listen to moderate levels of noise. Kryter (ref. 7) found that aircraft flyover noises were judged less noisy indoors than outdoors for corresponding outdoor measured noise levels. This is a similar result to those of Robinson et al and Bishop, allowing for outdoor to indoor attenuation.

Flindell (ref. 8) compared exposure-response relationships between a field study using outdoor measurements of road traffic noise and a laboratory study using recordings of the same road traffic noise. The respondents in the field study were also the subjects in the laboratory study. Good correspondence was obtained between the field and laboratory exposure-response relationships. The appropriate outdoor to indoor attenuation adjustment was 18 dB which is less than the typical outdoor to indoor attenuation of the dwellings in the sample. It appears that people were partially compensating for assumed outdoor and indoor attenuation when making laboratory annoyance judgments.

Aylor and Marks (ref. 9) studied the effects of different visible noise barriers on the perceived loudness of white noise signals reproduced by loudspeakers behind the barriers. They observed an increase in perceived loudness when the loudspeakers were shielded from view, but the noise level at the subject's position was held constant. This result implies that their subjects were allowing for an assumed attenuation due to the barrier and were attempting to judge distal properties of the noise sources rather than noise level at the subject's positions.

Griffiths et al (ref. 10) conducted repeated interview surveys of response to road traffic noise. They drew attention to the possible role of perceptual constancy in causing reported dissatisfaction to remain constant seasonally despite higher noise levels indoors due to open windows in warmer weather and more exposure outdoors in warmer weather. They further noted that whereas perceptual constancy might result in reduced perceived benefit from additional attenuation, perceptual constancy would not affect the perceived benefit of reductions in noise source sound power output.

The purpose of the present study was to investigate the extent to which perceptual constancy might reduce the perceived benefit of additional house attenuation. Subjects seated in a simulated living room environment made annoyance judgments of a number of sessions of recorded aircraft flyover noises representing a range of noise source sound power outputs. Additional house attenuation was represented by either (a) closing the window or (b) closing the window and adding a storm window. In both cases, reported annoyance was compared with reported annoyance with the window open. Loudspeakers were mounted outside the room so that noise levels inside would be affected by the window condition. The windows were manipulated in full view of the subjects.

A subsidiary experiment was conducted in an adjoining anechoic audiometric test chamber using the same subjects. The purpose of this experiment was to investigate the correspondence between different noise level measures and annoyance judgments over the range of spectra introduced by the different window conditions. Subjects made annoyance judgments of frequency shaped noise signals having spectra matched in one-third-octave-bands to the spectra of the aircraft flyover noises.

Detailed designs, results and conclusions are reported below. In addition to the investigations of possible perceptual constancies, and possible particular noise measure inaccuracies, three annoyance scales were compared and a successive intervals scale transform (ref. 11) was investigated.

NOISE MEASURES, SYMBOLS AND ABBREVIATIONS

Noise Measures

L_A	A-weighted sound pressure level, dB
L_B	B-weighted sound pressure level, dB
L_C	C-weighted sound pressure level, dB
L_D	D-weighted sound pressure level, dB
L_E	E-weighted sound pressure level, dB
L_{eq}	Equivalent continuous sound level, dB
LL	Loudness level (Stevens Mark VI procedure), phons
LL_Z	Zwicker's loudness level, phons
OASPL	Overall Sound Pressure Level, dB
PL	Perceived level (Stevens Mark VII procedure), phons
PNL	Perceived noise level, dB

A more detailed description of the noise measures used in this report can be found in references 12 and 13.

Symbols and Abbreviations

ANRL	Aircraft Noise Reduction Laboratory
AR	Anechoic Room - Audiometric test chamber
IER	Interior Effects Room - Simulated living room environment

EXPERIMENTAL METHOD

Test Facilities

The primary experiment was conducted in the Interior Effects Room (IER) (see fig. 1) at the Langley Aircraft Noise Reduction Laboratory (ANRL). The interior of the IER is furnished as a simulated living room and the construction of the room is typical of modern single family dwellings. The aircraft flyover noise recordings were reproduced through high quality loudspeakers mounted outside the IER, to either side of, and slightly above the window. Sheer drapes were fitted inside the window in order to prevent subjects being able to differentiate between a glazed storm window and an unglazed dummy storm window frame by means of double reflections. Pastel blue cloth was hung vertically about 3 feet outside the windows and illuminated from above. This was in order to conceal the loudspeakers from view and yet encourage the subjects to focus their attention on events outside the room, such as the simulated aircraft flyovers and the window manipulations.

The subsidiary experiment was conducted in an anechoic audiometric test chamber (AR) (see fig. 2) located adjacent to the IER. The frequency shaped noise signals were reproduced through a combination of high and low frequency loudspeaker units. The high frequency unit is a standard high fidelity type of loudspeaker and the low frequency unit is a special subwoofer having a flat response down to 30 Hz (± 1 dB).

Further details of both test facilities are given by Hubbard and Powell (ref. 14).

Noise Stimuli and Window Conditions

IER Experiment.- The noise stimuli used in the IER experiment were recordings of aircraft take-offs. They were selected not only from the point of view of high fidelity but also in that they sounded as if they had been originally recorded at a range of source-to-receiver distances. Since apparent source to receiver distance is one of the variables involved in perceptual constancy then it was important to vary this realistically with noise level. Of course, apparent distance in this context is extremely difficult to judge and therefore exact matching was not required. Table I gives aircraft types and recording locations relative to the runway.

The window conditions used in the IER experiment were the following; open window; closed window; closed window with a dummy storm window; and closed window with a real storm window. A standard wooden window frame was used, approximately 5 feet high and 6 feet wide. It had two vertically sliding sashes on each side of a central mullion. For the open window condition both upper sashes were pushed completely down so as to cover the lower sashes, and leave an opening of approximately 12 square feet.

Two storm window frames were provided, both running in sliding tracks mounted on the outside wall so that either frame could be slid across the window or retracted from view. The "real" storm window frame was glazed with 0.25 inch acrylic sheet (for safety reasons) and the dummy storm window frame was not glazed. The dummy was weighted so that it made the same sound as the real storm window when being slid across the track. The subjects were able to see the vertical members of the frames moving across.

Figure 3 shows the attenuation of the closed window and closed plus real storm window conditions as compared with the open window condition. The dummy storm window added no attenuation to that of the closed window. An extra 5 dB of electrical attenuation was applied to the closed plus real storm window condition. There was no roof between the loudspeakers and the ceiling of the IER. Flanking transmission through the ceiling reduced the attenuation of the closed plus real storm window condition below representative levels. The electrical attenuation was added in order to make the condition representative. Careful listening tests established that the contribution to the sound levels inside the IER made by sound propagated through the ceiling did not materially affect the realism of the simulations.

AR Experiment.-The noise stimuli used in the AR experiment were frequency shaped noise signals having spectra matched in one-third-octave-bands to the spectra of the aircraft flyover noises. The stimuli were recorded such that a close match was obtained between spectra measured in the IER and the AR at the subject's head position. Cascaded graphic equalizers and a one-third-octave-band real time analyzer were used. The aircraft flyover noise spectra were measured using a maximum hold function and a 1 second averaging time. Then average spectra were calculated from the spectra of the two aircraft flyovers in each treatment session. These average spectra were used as models for the AR experiment stimuli.

Design

IER Experiment.-There were 3 aircraft noise levels and 4 window conditions. A 3 x 4 repeated measures factorial design was adopted using 12 groups of 4 subjects such that each subject judged every treatment combination according to a Latin Square. Each treatment occurred once per order position across the 12 subject groups and once after every other treatment. Each treatment was a 5 minute session during which two aircraft flyovers were presented. The two aircraft flyovers in each session were always different recordings but chosen as having closely matched noise levels. They were reproduced after 30 seconds and after 180 seconds. The presentation order is given in Table II. Two retest treatments were added as orders 13 and 14.

AR Experiment.-There were 12 frequency shaped noise signals. Nine of these corresponded to the 9 combinations of aircraft noise level and window conditions having different spectra as used in the IER experiment. (The closed plus dummy storm window conditions were acoustically indistinguishable from the closed window conditions in the IER experiment). The last 3 AR experiment stimuli were matched to the spectra of the IER open window treatment sessions and to the noise levels (L_A) of the IER closed plus real storm window treatment sessions. Each stimulus was reproduced for 5 seconds with a 15 second interstimulus interval for annoyance judgments. Three warning tones were presented at the beginning, middle and end of the test. Each tone was a 2 second burst of 500 Hz at 62 dB (L_A). A 3 x 4 repeated measures factorial design was adopted using 24 groups of 2 subjects and one major replication such that every subject judged every treatment combination twice according to a Latin Square based design. The presentation order is given at Table III.

Subjects.-The 48 subjects (divided in 12 groups of 4 for the IER experiment and into 24 groups of 2 for the AR experiment) were all paid volunteers from the general population of Hampton, Newport News, and York County, Virginia. Approximately half of the subjects had previous experience in psychological judgment tests. All subjects were audiometrically screened to ensure normal hearing ability.

Procedure

Subject instruction sheets and questionnaires are given in the appendix. On arrival each subject was given Part I of the instructions and a sample questionnaire Form 1 for the IER experiment. The annoyance response scales were verbally reinforced, and questions were solicited and answered. The 0 to 9 numerical category annoyance scale has been used in many similar studies. The 5 point verbal category annoyance scale was included for comparison purposes. This scale was taken from a recent national road traffic survey (ref. 15).

Subjects were then escorted to the IER and randomly assigned seats. Two experimenters consecutively pointed out the window while a third experimenter operated the window and the real storm window frame from outside the room. The subjects were told that they would be able to hear the storm window being slid across on its' tracks. The subjects could see whether the upper window sashes were up or down, but had to remember whether or not a storm window frame (real or dummy) had been slid across the window from outside. The subjects were never told about the dummy storm window. After each 5 minute treatment session one experimenter returned with fresh questionnaire forms for immediate completion while a second experimenter passed through the IER in order to manipulate the window for the next treatment session. If either storm window frame was in position across the window the experimenter always slid it back out of the way at the end of the treatment session even if the presentation order called for it to be immediately replaced. This was in order to prevent subjects being given any clue that two storm window frames were provided.

After making annoyance judgments of the 14 IER treatment sessions, the subjects then completed questionnaire Form 2. The percentages "highly annoyed" can be derived by scaling the 0 to 9 annoyance judgments as 0, 0.5, or 1 depending on whether they are less than, the same as, or greater than, the subjects reported "highly annoyed" threshold. Subjects then returned to the briefing room where they were given Part II of the instructions and a sample questionnaire Form 3 for the AR experiment. Subjects were divided into groups of 2 to take part in the AR experiment. Two tests were repeated because subjects lost their places when filling out the questionnaire. Each group of 4 subjects completed both experiments within 2 1/4 hours.

ANALYSIS OF RESULTS

Noise Measurements

IER Experiment.- Acoustic measurements in terms of 19 commonly used measures are given in Table IV. These figures represent the average of the measurements for the two aircraft flyovers in each treatment session. The differences between noise levels measured at each of the 4 subjects' head positions were generally less than 1 dB and thus not significant. Care was taken to position the subjects' chairs in a broad arc centered on the window such that the effect of closing the windows would be similar at each chair. Subjects were sufficiently far apart that their questionnaires could not be read easily by their adjacent neighbors. The range of noise exposures was representative of typical community noise exposures in the vicinity of major airports.

The duration correction used in the measurements was identical to that used in the effective perceived noise level procedure defined in the Federal Aviation Administration FAR 36 regulation (ref. 16).

AR Experiment.- Acoustic measurements in terms of 10 commonly used measures are given in Table V. Duration corrections were not applied because the duration was always 5 seconds for all stimuli. There were no measurable differences between noise levels at the 2 subjects' head positions.

Comparison of AR and IER Noise Levels.-There were no difficulties in matching the AR and IER spectra, except at very low frequencies where different low frequency resonances hampered matching in certain one-third-octave-bands. This meant that perfect agreement between noise levels in the AR and IER could not be obtained over all the noise measures used. However, regression of AR noise levels with IER noise levels over 9 different spectra and 10 noise measures applied in common gave the following result:

AR noise level = 1.013 (IER noise level) - 0.821 - (1)

The correlation coefficient of the regression was 0.996.

AR Experiment

Although the IER experiment was in each case conducted before the AR experiment, the results of the AR experiment were used in the analysis of the IER experiment and therefore, are discussed first.

Analysis of Variance

An analysis of variance summary table is given in Table VI. Block-error is within subject error associated with the major replication. There was a significant interaction between window condition and aircraft level. This is shown in figure 4 and appears to result from scale compression at the lower end, or reduced sensitivity to differences in noise level at the lower noise levels. A successive intervals scale analysis to further examine this apparent scale compression is described below. The mean squares for the main effects are sufficiently large in comparison with either the block error mean square or the window condition X aircraft level interaction mean square to enable those variables to be considered as significant sources of variation in reported annoyance.

Regression Analyses

Table VII gives a summary of 10 regression analyses conducted to determine the strengths of relationship between reported annoyance and the 10 noise measures. There were no significant differences between the sizes of the correlation coefficients. The ubiquitous A-weighting (L_A) gave the highest correlation with reported annoyance of the different frequency weightings but not of all the more complex loudness summation procedures. L_A was adopted for further analysis in view of its simplicity and almost universal use and the slight differences between the correlation coefficient for L_A and the highest correlation coefficients.

Successive Intervals Scale Analysis

In view of the interaction apparent in figure 4 it was decided to investigate whether a successive intervals scale transform would linearize the data. Diederich, Messick, and Tucker's (ref. 11) method was used to transform the 0 to 9 numerical scale category boundaries. Then a polynomial regression was carried out to fit the derived successive interval scale to the original 0 to 9 numerical scale. Figure 5 shows that the relationship between the two scales does not depart far from linearity. Figure 6 shows the mean 0 to 9 numerical responses plotted against L_A, and figure 7 shows the mean successive interval scale transformed response plotted against L_A. There is a negligible difference between the two figures showing that the 0 to 9 numerical scale categories were not far from linear in terms of the successive intervals scale transform. Thus the interaction in figure 4 was probably due to a lack of discrimination between the treatments at the lower noise levels. There were no significant differences between the results of further analyses using the successive intervals scale and the results of further analyses using the original scales.

Dummy Variable Regression for Window Effect

Figure 6 shows that the data points for closed and closed plus real storm window spectra generally lie below the data points for open window spectra. Individual multiple linear regressions were carried out on each subject's data in order to determine the ratio between the coefficient for noise level and the coefficient for a dummy variable set to 0 for open window spectra and 1 for closed and closed plus real storm window spectra. This ratio represents the equivalent effect of changing from an open window spectra to a closed or closed plus real storm window spectra in terms of an increase in L_A.

Assuming a regression model of reported annoyance, Y, on window condition W (dummy variable), and noise level L:

$$Y = B_0 + B_1W + B_2L + \epsilon$$

where B_0, B_1, B_2 are regression coefficients and ϵ is a random error term. Then the decibel equivalent window effect is given by B_1/B_2.

The mean ratio B_1/B_2 across the subjects was 3.3 dB with 95% confidence intervals of ± 1.0 dB, calculated directly from the sampling distribution of B_1/B_2 ratios. Figure 8 shows mean 0 to 9 annoyance responses plotted against L_A adjusted for the decibel equivalent window effect of 3.3 dB. Although differences between the data points plotted in figure 6 and figure 8 are small they are nevertheless of practical significance when considering this decibel equivalent window effect.

This effect implies that L_A overestimated the reported annoyance of closed and closed plus real storm window spectra in comparison with open window spectra. This is most probably due to the A-weighting network responding too strongly to the increased low frequency content of the closed and closed plus real storm window spectra, with the implication that under these circumstances, the weighting for low frequencies should be even lower.

Examination of the decibel equivalent window effect was continued by making further plots of mean reported annoyance against the other 9 noise measures. These plots are not reproduced here for reasons of space. However, in all cases except for LL_Z the plots were compatible, on an eye-inspection basis, with decibel equivalent window effects of from 2 to 6 dB. Figure 9 shows mean reported annoyance against LL_Z.

IER Experiment

Analyses of Variance

An analysis of variance summary table is given in Table VIII. The window condition and aircraft level interaction was not a significant source of variation in reported annoyance. Both window condition and aircraft level were significant sources of variation in reported annoyance, both in the 0 to 9 numerical scale and in the 5 point verbal scale used.

Regression Analyses

Table IX gives a summary of regression analyses between 0 to 9 numerical scale responses and 19 noise level measures. There were no significant differences between the sizes of the correlation coefficients. As in the AR experiment the A-weighting (L_A) gave the highest correlation with reported annoyance of the different frequency weightings but not of all the more complex loudness summation procedures. L_A was adopted for further analysis in view of its simplicity and almost universal use and because of the slight differences between the correlation coefficient for L_A and the highest correlation coefficients. The duration correction was adopted because of current trends towards integrated energy type measures despite the (insignificantly) lower correlation coefficient.

Successive Intervals Scale Analysis

As in the AR experiment, Diederich, Messick and Tucker's method (ref. 11) was used to transform both the 0 to 9 numerical scale and the 5 point verbal scale category boundaries. Polynomial regressions were carried out to fit the derived successive interval scales to the original scales. Figure 10 shows that the relationship between the 0 to 9 numerical scale and the derived successive interval scale transform does not depart far from linearity, except at the upper extreme. The departure from linearity at the upper extreme is curious but of no consequence. Figure 11 shows that the relationship between the 5 point verbal scale and its derived successive interval scale transform has a distinct S-shape although it is still not far from linear. There were no significant differences between the results of further analyses using the successive intervals scales and the results of further analyses using the original scales.

Perceptual Constancy

Figures 12, 13 and 14 show that the data points for closed and closed plus real storm window conditions do not, in general, lie above or below the data points for open window conditions when the noise measure is duration corrected L_A. However, figure 15 shows that when the noise measure is LL_Z the data points for closed window and closed plus real storm window conditions generally lie above the data points for open window conditions. (The 5 point verbal scale and derived percent highly annoyed scale are not plotted against LL_Z due to space considerations). In Figure 15 the data points for closed plus real storm window conditions have been adjusted to take account of an assumed simulated condition cue overreaction discussed below.

Figures 12, 13 and 14 all show a trend for the data points for closed plus dummy storm window conditions to lie below the data points for closed window conditions. This trend represents a tendency for subjects to reduce their reported annoyance in response to the purely situational differences between the closed window and closed plus dummy storm window conditions. Of course, the dummy storm window has no acoustic effect. A possible explanation for this reported annoyance reduction is that the subjects reason that if a storm window (in this case a dummy) has been fitted then the noise level ought to have dropped and therefore reported annoyance should be reduced. In the laboratory, subjects may be quite likely to behave in this fashion as they usually attempt to fulfill whatever they perceive as the experimenter's requirements, rather than express their own opinions. However, in the field (or in a different type of laboratory experiment) a dummy storm window that has no effect on noise levels would probably be perceived as being ineffective and would therefore not influence reported annoyance. Therefore, it has been assumed that the reported annoyance reduction is a simulated condition cue overreaction, and an artifact of the laboratory paradigm. As an artifact, adjustments for it are valid, though it should be noted that it does not affect the conclusions relating to perceptual constancy in the case of the open to closed window comparison, only in relation to the open to closed plus real storm window comparison.

In addition, the results of the AR experiment implied that L_A overestimated the reported annoyance of closed and closed plus real storm window spectra in comparison with open window spectra but that LL_Z did not. Figures 16, 17 and 18 show that the data points for closed and closed plus real storm window conditions, in general, lie above the data points for open window conditions when the noise measure is duration corrected L_A, adjusted for the decibel equivalent window effect, and the annoyance response for the closed plus real storm window conditions are adjusted for the simulated condition cue overreaction. These figures illustrate that, in general, reducing the outside aircraft flyover noise level, but keeping the window open, has a greater effect on reported annoyance than a similar reduction in noise level caused by closing the window or by closing the window and adding a real storm window. This result is consistent with a certain degree of perceptual constancy in that aircraft noisiness tends towards remaining constant despite the introduction of attenuation due to windows.

Figure 15 shows the same result but without adjusting for decibel equivalent window effect as such an adjustment was not appropriate for LL_Z.

There are further comparisons which could have been made, i.e., between the closed window and closed plus real storm window conditions and between the closed plus dummy storm window and closed plus real storm window conditions. These comparisons will be dealt with in future pulications which are planned for submission to scientific journals.

Dummy Variable Regression for Perceptual Constancy

Dummy variable regressions for each individual's data set were carried out to determine the mean perceived benefits of closing the window and closing the window with a real storm window added, both in comparison with the open window, in terms of equivalent reductions in L_A. These analyses were carried out as in the AR experiment, by setting the dummy variable to 0 for open window and 1 for closed window or closed plus real storm window, and then calculating the mean B_1/B_2 ratio over all subjects. As in the AR experiment, the 95% confidence intervals were determined directly from the sampling distribution of B_1/B_2 ratios. Thus mean B_1/B_2 ratios were obtained for two comparisons; open to closed window; and open to closed plus real storm window; and for two annoyance scales; 0 to 9 numerical category and 5 point verbal category. In these cases the B_1/B_2 ratio represents the extent to which the data points for the open window conditions lie to the right of the data points for the closed and closed plus real storm window conditions when plotted at figures 16 and 17. Thus, the B_1/B_2 ratios represent the extent to which the perceived benefit of closing the window and closing the window with a real storm window added, fall short of the perceived benefit of corresponding reductions in noise level at the loudspeakers with the window remaining open. These shortfalls were then subtracted from the actual attenuations measured when closing the window and closing the window with a real storm window added in order to determine the perceived benefit as a per centage of the corresponding perceived benefit from corresponding noise level reductions at the loudspeakers with the window remaining open. These percentages were obtained as follows:

Comparison	0 to 9 numerical scale	5 point verbal scale
open window to closed window	55% (± 13%, 95% intervals)	66% (± 18%, 95% intervals)
open window to closed plus real storm window	71% (± 21%, 95% intervals)	97% (± 28%, 95% intervals)

It is worth noting that greater reliance should be placed on the estimates obtained using the 0 to 9 numerical scale than the 5 point verbal scale as the confidence intervals are narrower, and the successive intervals scale transform showed superior linearity (see figs. 10 and 11).

No similar analysis was conducted for the percent highly annoyed data plotted at figure 18 as confidence intervals could not be determined with the same precision. (Individual B_1/B_2 ratios cannot be obtained from percentage data of this type because of the grouping). However, figure 18 is illustrative of the same effects, i.e., data points for open window conditions, in general, lie to the right of data points for closed window and closed plus real storm window conditions.

DISCUSSION

In general, there are two possible interpretations of the results of the IER experiment. The first is that by taking account of a decibel equivalent window effect, as measured in the AR experiment, then a certain degree of perceptual constancy was evident in going from open window to closed window conditions. Further, by also taking account of an assumed simulated condition cue overreaction, a certain degree of perceptual constancy was evident in going from open window to closed plus real storm window conditions.

The second interpretation is that, disregarding these adjustments, measurements in terms of L_A gave reasonable predictions of the perceived benefit of closed and closed plus real storm window conditions, without perceptual constancy being evident. However, the AR experiment established that LL_Z appeared to be the only noise measure tested that did not suggest a decibel equivalent window effect to adjust for presumed errors in taking account of different spectra. Perceptual constancy was apparent in a plot of mean reported annoyance (adjusted for simulated condition cue overreaction) against LL_Z in the IER experiment (fig. 15). Therefore it seems that the fact that L_A gives reasonable predictions without adjustments may be merely fortuitous, in that spectral accounting errors approximately compensate for the effects of perceptual constancy.

There are two caveats that might affect the results of any future experiments on this topic. The first is that while an assumed simulated condition cue overreaction occurred in respect of response to the storm windows, a similar overreaction could have occurred in respect of just the closed window. Since it was not possible to construct a dummy closed window that would have been undetectable to the subjects in the same way that the dummy storm window frame was undetectable, it was not possible to separate out this possible effect.

Second, in the field, most subjects have much more limited experience of the additional noise attenuation attributable to real storm windows than the noise attenuation attributable to ordinary closed windows. The actual attenuation achieved by the additional real storm window in the IER was very small, owing to flanking transmission as discussed earlier. Subjects could have been expecting the additional attenuation to be greater and this might have influenced their responses.

The results imply that the perceived benefits of additional house attenuation are likely to be less than the perceived benefits of source sound power reductions having similar effects on noise levels indoors. It should be borne in mind that the perceived benefits of additional house attenuation are likely to be even smaller in the field than in this laboratory study for two reasons. First, annoyance response in the field is likely to be affected by outdoor exposure which is not reduced by additional house attenuation. Second, on many occasions additional house attenuation may be rendered ineffective by a desire for ventilation.

One last implication of these results is that annoyance response can be influenced by parameters associated with the noise exposure which are not subsumed by measurements of noise levels at the subject's listening position. This is an important finding as it casts doubt on the widely held view that noise annoyance response is merely a direct result of certain activity interferences which are adequately described by noise level measurements at the subject's listening position. The perceptual basis of noise annoyance response is presumably more subtle than commonly believed, even without taking account of the many attitudinal factors which have been found in many previous studies.

CONCLUSIONS

Experimental subjects made annoyance judgments of recorded aircraft flyover noises while listening in a simulated living room environment (IER), and of frequency shaped noise signals having spectra closely matched to those of the aircraft flyover noises, while listening in an anechoic audiometric test chamber (AR). A range of aircraft noise levels was reproduced by loudspeakers outside the simulated living room environment while a range of window conditions was applied to variously attenuate the aircraft noise. The window conditions were; open, closed, closed plus a dummy storm window, and closed plus a real storm window. The stimuli in the anechoic audiometric test chamber thus varied in level and spectrum, but without the situational and visual cues available to the subjects when in the simulated living room environment.

1. In both experiments, there were only very small differences in the annoyance predictive ability of the various noise measures examined.

2. In the anechoic audiometric test chamber experiment there was a significant difference between the exposure response relationships for the open window spectra and the closed and closed plus storm window spectra. This decibel equivalent window effect was in the range of 2 to 6 dB depending on the noise measure used, except for Zwicker loudness level, where it was not apparent. Thus, all the noise measures examined, except for Zwicker loudness level, overestimate the reported annoyance of closed and closed plus storm window spectra in comparison with open window spectra.

3. In the simulated living room experiment, the closed plus dummy storm window conditions were judged less annoying than the closed window conditions despite there being no differences in noise level. This effect was opposite to any perceptual constancy effect and was assumed to be a simulated condition cue overreaction, i.e., a laboratory paradigm artifact. This effect only applied to the open window with closed plus real storm window comparison.

4. Some degree of perceptual constancy was evident in the results of the simulated living room experiment. This was apparent either by plotting mean annoyance response adjusted for simulated condition cue overreaction against duration corrected L_A adjusted for decibel equivalent window effect, or by plotting mean annoyance response adjusted for simulated condition cue overreaction against Zwicker loudness level. The meaning of the results is that the perceived benefit of closed and closed plus real storm windows was less than

implied by the actual reductions in noise levels, i.e., there was a tendency for reported annoyance to remain constant despite reductions in noise level due to the window attenuation.

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APPENDIX

INSTRUCTIONS (PART I)

Please imagine yourself sitting comfortably and relaxed at home. You can reduce the amount of noise coming in from outside by closing a window. Adding a storm window will further reduce the amount of noise coming in from outside. Today, we would like to measure the reduction in aircraft noise annoyance caused by adding a storm window or closing a window.

There will be fourteen sessions of aircraft noise, each lasting five minutes, with two flyovers per session. The aircraft flyovers vary [illegible] ise level. From time-to-time a technician will open or close the window [illegible] open or close a storm window. The storm window is fitted to a sliding track [illegible] de. We would like you to judge whether or not there is an effect on aircr[illegible] oise annoyance. Afterwards, there will be a second, much shorter, experiment in another room.

We would like you to make an annoyance judgment at the end of each five minute session by completing a short questionnaire. Each questionnaire has two items: a 0 to 9 scale going from "Not Annoying at All" to "Extremely Annoying"; and a five point verbal scale of annoyance.

For the first item, circle a number on the 0 to 9 scale that best corresponds to the aircraft noise annoyance. If you felt the aircraft noise was very annoying, then choose a number nearer to the "Extremely Annoying" end of the scale. On the other hand, if you felt the aircraft noise was not very annoying, then choose a number nearer to the "Not Annoying at All" end of the scale.

For the second item, select a descriptor from the five point verbal scale that comes closest to the aircraft noise annoyance.

We would like you to respond according to your personal opinion at the time you complete each questionnaire. Therefore, there are no right or wrong answers. Please do nothing that could influence the opinion of the other people in the room with you.

APPENDIX

QUESTIONNAIRE (FORM 1)

How annoying were the noises in the last session?

A. Not Annoying at All 0 1 2 3 4 5 6 7 8 9 Extremely Annoying

B. Not at all------------- ☐

Slightly--------------- ☐

Moderately------------- ☐

Very------------------- ☐

Extremely-------------- ☐

SUBJECT ID ____________________

CHAIR ____________________

DATE ____________________

SESSION ____________________

APPENDIX

QUESTIONNAIRE (FORM 2)

At what point on the 0 to 9 scale of annoyance would you become highly annoyed? That is, you would feel like wanting to do something about the noise, such as start looking for somewhere else to live, or complain to authorities.

Not Annoying at All 0 1 2 3 4 5 6 7 8 9 Extremely Annoying

SUBJECT ID ____________________

CHAIR ____________________

DATE ____________________

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APPENDIX

INSTRUCTIONS (PART II)

This experiment takes less than ten minutes. We would like you to record your annoyance reactions to twenty-four short noises. Each noise lasts for five seconds only. You will have about fifteen seconds after each noise to record your annoyance reaction on the questionnaire.

You will hear a short tone at the start. This is to prepare you for the noises. You will hear a second short tone after the first twelve noises and a third short tone at the end. It is very important that you record an annoyance judgment on your questionnaire for each and every noise. If you should inadvertently lose your place we can easily repeat the test.

As before, there are no right or wrong answers. Please respond according to your personal opinion at the time. Again, please do nothing that could influence the opinion of the other people in the room with you.

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APPENDIX

QUESTIONNAIRE (FORM 3)

1. Warning tone. - do not make an annoyance judgment.

Noise 1	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 2	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 3	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 4	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 5	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 6	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 7	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 8	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 9	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 10	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 11	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 12	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying

2. Warning tone. - Half-way through. - do not make an annoyance judgment.

Noise 13	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 14	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 15	Not Annoying at all	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 16	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 17	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 18	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 19	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 20	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 21	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 22	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 23	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying
Noise 24	Not Annoying at All	0 1 2 3 4 5 6 7 8 9	Extremely Annoying

3. Warning tone. - The end of the experiment. - do not make an annoyance judgment.

SUBJECT ____________________

CHAIR ____________________

DATE ____________________

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TABLE I.- AIRCRAFT RECORDINGS USED IN IER EXPERIMENT

AIRCRAFT LEVEL	AIRCRAFT TYPE	RECORDING LOCATION*
HIGH	DC-8 B707	3 MILE CENTERLINE 3 MILE CENTERLINE
MEDIUM	B707 B720	3 MILE CENTERLINE 3 MILE SIDELINE
LOW	DC-8 DC-8	3 MILE SIDELINE 5 MILE CENTERLINE

*Distances are from brake release on take-off.
Centerline is under the flight path.
Sideline is 1/4 mile off the flight path.

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TABLE II.- PRESENTATION ORDER OF EXPERIMENTAL TREATMENTS TO TEST SUBJECT GROUPS IN IER EXPERIMENT

SUBJECT GROUP	ORDER OF EXPERIMENTAL TREATMENTS 1	2	3	4	5	6	7	8	9	10	11	12	RETESTS 1	2
1	I	G	J	E	K	F	H	C	A	L	B	D	I	G
2	J	I	K	G	H	F	A	F	B	C	D	L	J	I
3	K	J	H	I	A	G	B	E	D	F	L	C	K	J
4	H	K	A	J	B	I	D	G	L	E	C	F	H	K
5	A	H	B	K	D	J	L	I	C	G	F	E	A	H
6	B	A	D	H	L	K	C	J	F	I	E	G	B	A
7	D	B	L	A	C	H	F	K	E	J	G	I	D	B
8	L	D	C	B	F	A	E	H	G	K	I	J	L	D
9	C	L	F	D	E	B	G	A	I	H	J	K	C	L
10	F	C	E	L	G	D	I	B	J	A	K	H	F	C
11	E	F	G	C	I	L	J	D	K	B	H	A	E	F
12	G	E	I	F	J	C	K	L	H	D	A	B	G	E

TREATMENT KEY

AIRCRAFT LEVEL	WINDOW CONDITION OPEN	CLOSED	DUMMY	STORM
HIGH	A	D	G	J
MEDIUM	B	E	H	K
LOW	C	F	I	L

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TABLE III.- PRESENTATION ORDER OF EXPERIMENTAL TREATMENTS
TO TEST SUBJECT GROUPS IN AR EXPERIMENT

SUBJECT	ORDER OF EXPERIMENTAL TREATMENTS																								
GROUP	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16	17	18	19	20	21	22	23	24
1	J	H	K	F	L	G	I	D	B	A	C	E		J	B	C	E	K	A	H	D	G	I	F	L
2	K	J	L	H	I	F	B	G	C	D	E	A		C	J	K	B	H	E	G	A	F	D	L	I
3	L	K	I	J	B	H	C	F	E	G	A	D		K	C	H	J	G	B	F	E	L	A	I	D
4	I	L	B	K	C	J	E	H	A	F	D	G		H	K	G	C	F	J	L	B	I	E	D	A
5	B	I	C	L	E	K	A	J	D	H	G	F		G	H	F	K	L	C	I	J	D	B	A	E
6	C	B	E	I	A	L	D	K	G	J	F	H		F	G	L	H	I	K	D	C	A	J	E	B
7	E	C	A	B	D	I	G	L	F	K	H	J		L	F	I	G	D	H	A	K	E	C	B	J
8	A	E	D	C	G	B	F	I	H	L	J	K		I	L	D	F	A	G	E	H	B	K	J	C
9	D	A	G	E	F	C	H	B	J	I	K	L		D	I	A	L	E	F	B	G	J	H	C	K
10	G	D	F	A	H	E	J	C	K	B	L	I		A	D	E	I	B	L	J	F	C	G	K	H
11	F	G	H	D	J	A	K	E	L	C	I	B		E	A	B	D	J	I	C	L	K	F	H	G
12	H	F	J	G	K	D	L	A	I	E	B	C		B	E	J	A	C	D	K	I	H	L	G	F
13	L	F	I	G	D	H	A	K	E	C	B	J		E	C	A	B	D	I	G	L	F	K	H	J
14	I	L	D	F	A	G	E	H	B	K	J	C		A	E	D	C	G	B	F	I	H	L	J	K
15	D	I	A	L	E	F	B	G	J	H	C	K		D	A	G	E	F	C	H	B	J	I	K	L
16	A	D	E	I	B	L	J	F	C	G	K	H		G	D	F	A	H	E	J	C	K	B	L	I
17	E	A	B	D	J	I	C	L	K	F	H	G		F	G	H	D	J	A	K	E	L	C	I	B
18	B	E	J	A	C	D	K	I	H	L	G	F		H	F	J	G	K	D	L	A	I	E	B	C
19	J	B	C	E	K	A	H	D	G	I	F	L		J	H	K	F	L	G	I	D	B	A	C	E
20	C	J	K	B	H	E	G	A	F	D	L	I		K	J	L	H	I	F	B	G	C	D	E	A
21	K	C	H	J	G	B	F	E	L	A	I	D		L	K	I	J	B	H	C	F	E	G	A	D
22	H	K	G	C	F	J	L	B	I	E	D	A		I	L	B	K	C	J	E	H	A	F	D	G
23	G	H	F	K	L	C	I	J	D	B	A	E		B	I	C	L	E	K	A	J	D	H	G	F
24	F	G	L	H	I	K	D	C	A	J	E	B		C	B	E	I	A	L	D	K	G	J	F	H

TREATMENT KEY

AIRCRAFT	WINDOW CONDITION			
LEVEL	OPEN	CLOSED	STORM	LOW LEVEL OPEN
HIGH	A	D	G	J
MEDIUM	B	E	H	K
LOW	C	F	I	L

TABLE IV.- NOISE LEVELS OF EXPERIMENTAL TREATMENTS IN IER EXPERIMENT

EXPERIMENTAL TREATMENT	OASPL	L_A	L_B	L_C	L_D	L_E	PNL	LL	LL_Z	PL
AVERAGE MAXIMUM LEVELS OF 2 FLYOVERS PER EXPERIMENTAL TREATMENT										
A	90.0	82.0	87.7	89.9	87.6	86.6	94.5	92.2	97.2	85.1
B	78.2	71.7	75.1	77.8	79.8	77.0	86.5	84.0	89.3	76.0
C	69.1	60.3	66.9	66.5	68.9	66.0	71.6	72.2	77.3	64.7
D	85.1	72.4	81.7	84.9	80.8	79.1	85.7	84.3	87.3	76.1
E	73.5	60.4	69.9	73.3	69.0	67.3	72.9	73.5	76.3	64.6
F	64.0	51.3	60.7	63.9	59.9	58.1	63.6	64.1	66.6	55.4
G	85.1	72.4	81.7	84.9	80.8	79.1	85.7	84.3	87.3	76.1
H	73.5	60.4	69.9	73.3	69.0	67.3	72.9	73.5	76.3	64.6
I	64.0	51.3	60.7	63.9	59.9	58.1	63.6	64.1	66.6	55.4
J	80.2	67.8	76.9	79.9	76.0	74.4	80.5	79.9	81.9	71.4
K	67.5	54.3	63.1	63.1	62.2	60.6	66.8	67.3	71.0	59.1
L	58.6	45.9	55.3	55.3	54.5	52.7	61.1	58.6	60.7	50.2
AVERAGE DURATION CORRECTED LEVELS OF 2 FLYOVERS PER EXPERIMENTAL TREATMENT										
A	90.8	81.8	87.7	90.5	87.9	86.6	94.5	92.6		85.1
B	82.0	73.3	78.7	81.8	80.0	78.2	86.4	85.6		77.6
C	70.8	61.7	68.0	70.6	67.8	66.7	74.1	74.3		66.5
D	85.5	71.9	81.3	85.2	80.4	78.7	85.2	84.6		76.0
E	77.0	62.7	72.3	76.6	71.4	69.7	75.6	76.4		67.6
F	65.3	51.9	61.2	65.0	60.4	58.7	67.5	64.6		56.9
G	85.5	71.9	81.3	85.2	80.4	78.7	85.2	84.6		76.0
H	77.0	62.7	72.3	76.6	71.4	69.7	75.6	76.4		67.6
I	65.3	51.9	61.2	65.0	60.4	58.7	67.5	64.6		56.9
J	80.8	67.0	76.4	80.4	75.5	73.9	79.5	79.6		71.0
K	71.0	57.0	66.3	70.6	65.5	63.9	71.5	70.7		62.3
L	59.8	59.8	55.7	59.5	54.8	53.2	64.5	58.6		51.5

TREATMENT KEY

AIRCRAFT LEVEL	WINDOW CONDITION			
	OPEN	CLOSED	DUMMY	STORM
HIGH	A	D	G	J
MEDIUM	B	E	H	K
LOW	C	F	I	L

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TABLE V.- NOISE LEVELS OF EXPERIMENTAL TREATMENTS IN AR EXPERIMENT

EXPERIMENTAL TREATMENT	OASPL	L_A	L_B	L_C	L_D	L_E	PNL	LL	LL_Z	PL
AVERAGE MAXIMUM LEVELS OF 2 FLYOVERS PER EXPERIMENTAL TREATMENT										
A	92.2	82.3	89.7	92.1	89.3	87.8	95.8	93.5	97.7	86.4
B	80.5	72.2	78.3	80.4	79.2	77.3	85.3	83.8	89.7	76.0
C	70.0	60.6	67.8	70.0	67.3	66.0	73.1	73.0	77.3	64.9
D	84.9	72.3	81.9	84.8	81.0	79.2	86.0	84.6	86.7	76.4
E	72.2	60.1	69.4	72.1	68.6	66.8	73.3	73.0	75.5	64.0
F	64.6	52.3	61.8	64.5	60.9	59.1	64.1	65.0	66.7	55.7
G	78.9	67.1	76.1	78.8	75.3	73.6	79.5	78.6	81.5	70.4
H	66.5	54.6	63.7	66.4	62.9	61.2	66.7	67.5	70.2	58.8
I	57.6	45.6	54.8	57.5	54.1	52.3	58.2	58.0	60.3	49.7
J	77.7	67.8	75.2	77.6	74.8	73.3	81.3	79.0	83.2	71.9
K	63.0	54.7	60.8	62.9	61.7	59.8	67.8	66.3	72.2	58.5
L	55.5	46.1	53.3	55.5	52.8	51.5	58.6	58.5	62.8	50.4

TREATMENT KEY

AIRCRAFT LEVEL	WINDOW CONDITION			
	OPEN	CLOSED	STORM	LOW LEVEL OPEN
HIGH	A	D	G	J
MEDIUM	B	E	H	K
LOW	C	F	I	L

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TABLE VI.- SUMMARY OF ANALYSES OF VARIANCE FOR AR EXPERIMENT

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO	SIGNIFICANCE LEVEL
BLOCKS	1	0.070	0.070		
WINDOW CONDITION	3	2051.468	683.823	29.982*	<0.01
AIRCRAFT LEVEL	2	3446.257	1723.128	75.549*	<0.01
WINDOW X AIRCRAFT	6	136.847	22.808	6.381	0.004
BLOCK ERROR	11	39.315	3.574		
SAMPLING ERROR	1128	2942.271	2.608		
TOTAL	1151	8616.228			

*These F-ratio use Window x Aircraft Interaction mean square as error term.

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TABLE VII.- REGRESSION ANALYSES FOR AR EXPERIMENT

NOISE MEASURE	REGRESSION COEFFICIENT			CONSTANT TERM			CORRELATION COEFFICIENT
	COEFFICIENT	95% CONFIDENCE LIMITS		CONSTANT	95% CONFIDENCE LIMITS		
		LOWER	UPPER		LOWER	UPPER	
OASPL	0.197	0.188	0.206	-10.510	-11.156	- 9.864	0.772
L_A	0.201	0.192	0.209	- 8.635	- 9.158	- 8.113	0.795
L_B	0.199	0.190	0.208	-10.151	-10.771	- 9.531	0.777
L_C	0.197	0.189	0.206	-10.517	-11.162	- 9.871	0.772
L_D	0.201	0.192	0.209	-10.159	-10.762	- 9.556	0.785
L_E	0.201	0.192	0.210	- 9.853	-10.441	- 9.265	0.786
PNL	0.194	0.186	0.202	-10.736	-11.341	-10.132	0.797
LL	0.207	0.198	0.215	-11.488	-12.139	-10.837	0.790
LL_z	0.202	0.194	0.211	-11.894	-12.541	-11.247	0.799
PL	0.202	0.193	0.210	- 9.480	-10.034	- 8.926	0.796

TABLE VIII.- SUMMARY OF ANALYSES OF VARIANCE FOR IER EXPERIMENT

0 to 9 Numerical Scale

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO	SIGNIFICANCE LEVEL
WINDOW CONDITION	3	543.936	181.312	31.057	<0.01
AIRCRAFT LEVEL	2	1097.056	548.528	127.802	<0.01
WINDOW x AIRCRAFT	6	35.028	5.838	1.360	0.229
ERROR	564	2420.688	4.292		
TOTAL	575	4096.707	7.125		

5-point Verbal Scale

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO	SIGNIFICANCE LEVEL
WINDOW CONDITION	3	110.547	36.849	50.409	<0.01
AIRCRAFT LEVEL	2	208.483	104.241	142.601	<0.01
WINDOW x AIRCRAFT	6	8.073	1.345	1.841	0.089
ERROR	564	412.271	0.731		
TOTAL	575	739.373	1.286		

TABLE IX.- REGRESSION ANALYSES FOR 0 TO 9 NUMERICAL SCALE IN IER EXPERIMENT

NOISE MEASURE	REGRESSION COEFFICIENT			CONSTANT TERM			CORRELATION COEFFICIENT
	COEFFICIENT	95% CONFIDENCE LIMITS		CONSTANT	95% CONFIDENCE LIMITS		
		LOWER	UPPER		LOWER	UPPER	
AVERAGE MAXIMUM LEVELS OF 2 FLYOVERS PER EXPERIMENTAL TREATMENT							
OASPL	0.174	0.156	0.191	- 8.989	-10.285	- 7.692	0.612
L_A	0.162	0.147	0.177	- 6.259	- 7.237	- 5.282	0.631
L_B	0.172	0.155	0.189	- 8.299	- 9.513	- 7.085	0.617
L_C	0.170	0.153	0.187	- 8.649	- 9.927	- 7.372	0.608
L_D	0.169	0.153	0.186	- 8.103	- 9.261	- 6.945	0.629
L_E	0.168	0.152	0.184	- 7.701	- 8.821	- 6.581	0.629
PNL	0.162	0.146	0.117	- 8.336	- 9.502	- 7.171	0.634
LL	0.171	0.155	0.188	- 8.960	-10.196	- 7.723	0.630
LL_Z	0.162	0.146	0.177	- 8.768	- 9.984	- 7.553	0.631
PL	0.167	0.151	0.183	- 7.240	- 8.309	- 6.171	0.631
AVERAGE DURATION CORRECTED LEVELS OF 2 FLYOVERS PER EXPERIMENTAL TREATMENT							
OASPL	0.178	0.160	0.196	- 9.671	-11.038	- 8.305	0.612
L_A	0.168	0.152	0.185	- 6.808	- 7.843	- 5.772	0.629
L_B	0.178	0.161	0.196	- 8.961	-10.227	- 7.694	0.620
L_C	0.179	0.161	0.197	- 9.642	-11.001	- 8.282	0.613
L_D	0.175	0.158	0.192	- 8.608	- 9.826	- 7.391	0.625
L_E	0.175	0.158	0.192	- 8.315	- 9.503	- 7.127	0.626
PNL	0.194	0.176	0.213	-11.140	-12.561	- 9.719	0.636
LL	0.171	0.155	0.188	- 9.178	-10.461	- 7.896	0.622
PL	0.177	0.160	0.194	- 8.130	- 9.296	- 6.964	0.627

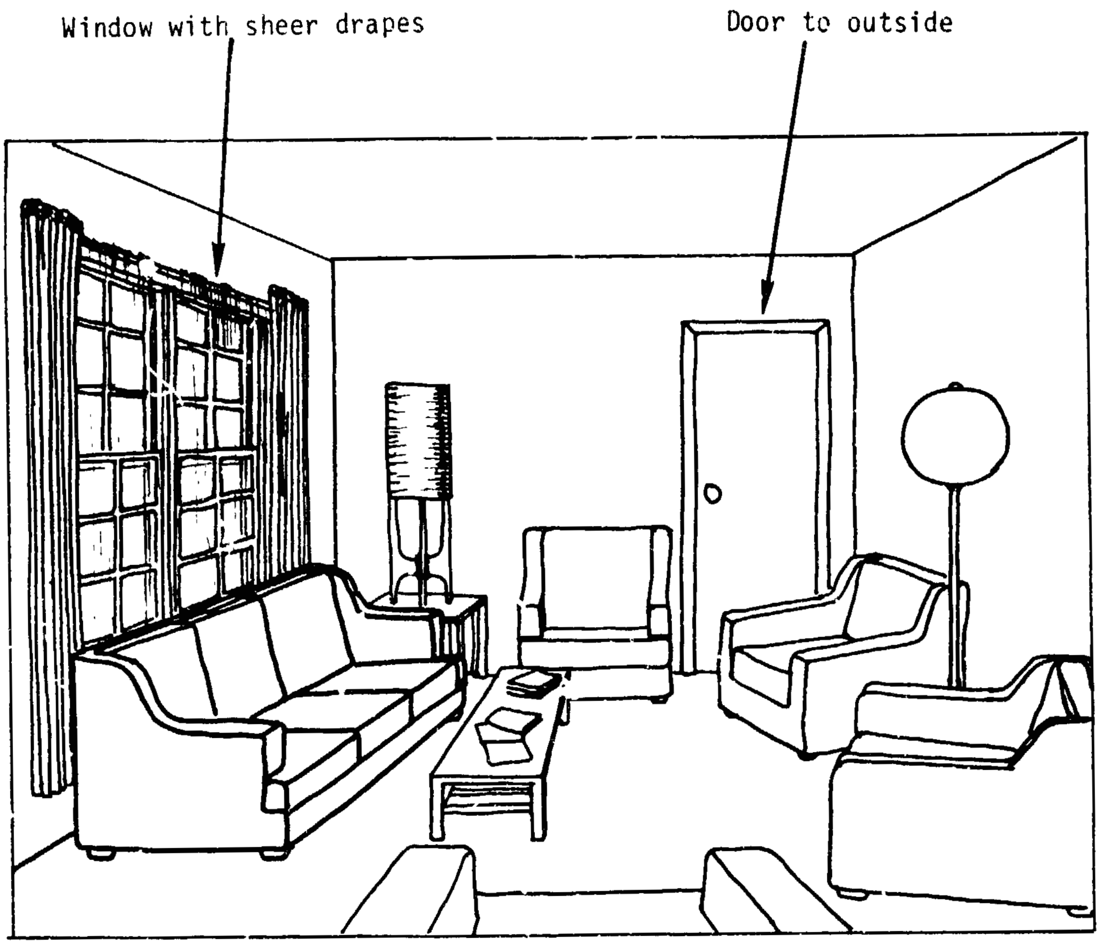

Figure 1.- Simulated Living Room Used in Interior Effects Room (IER) Experiment.

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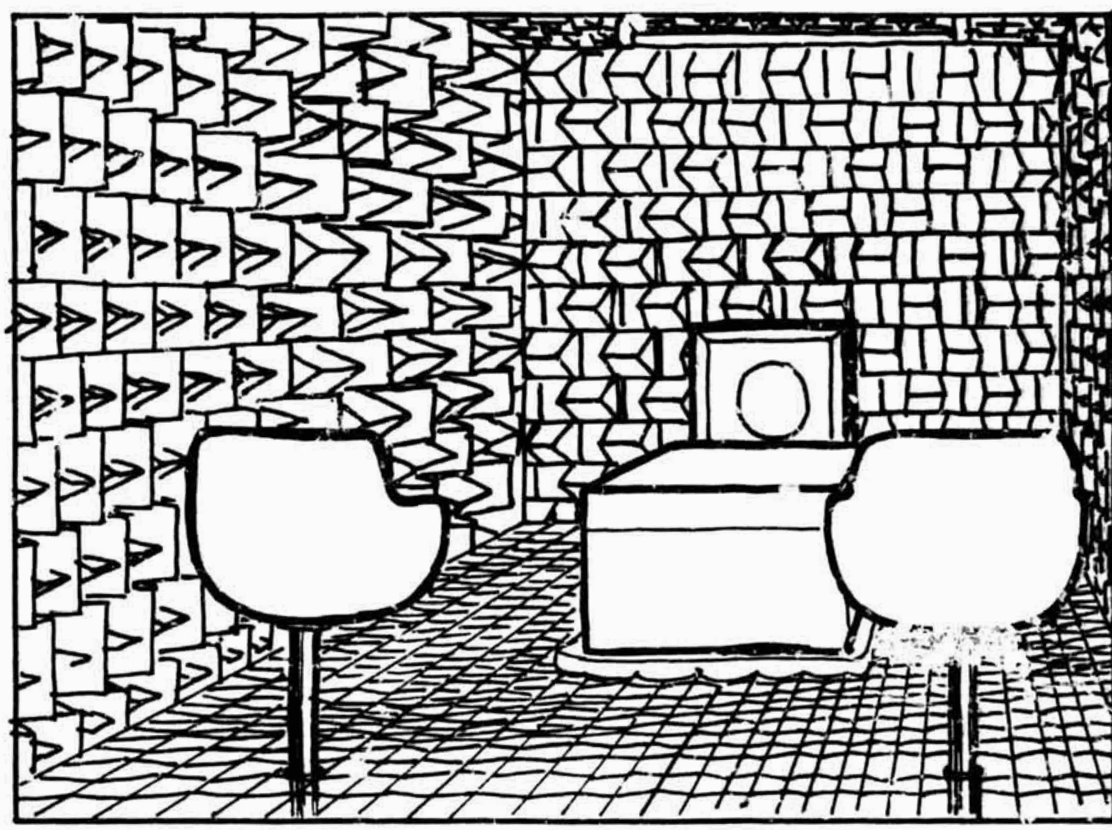

Figure 2.- Anechoic Audiometric Test Chamber Used in Anechoic Room (AR) Experiment.

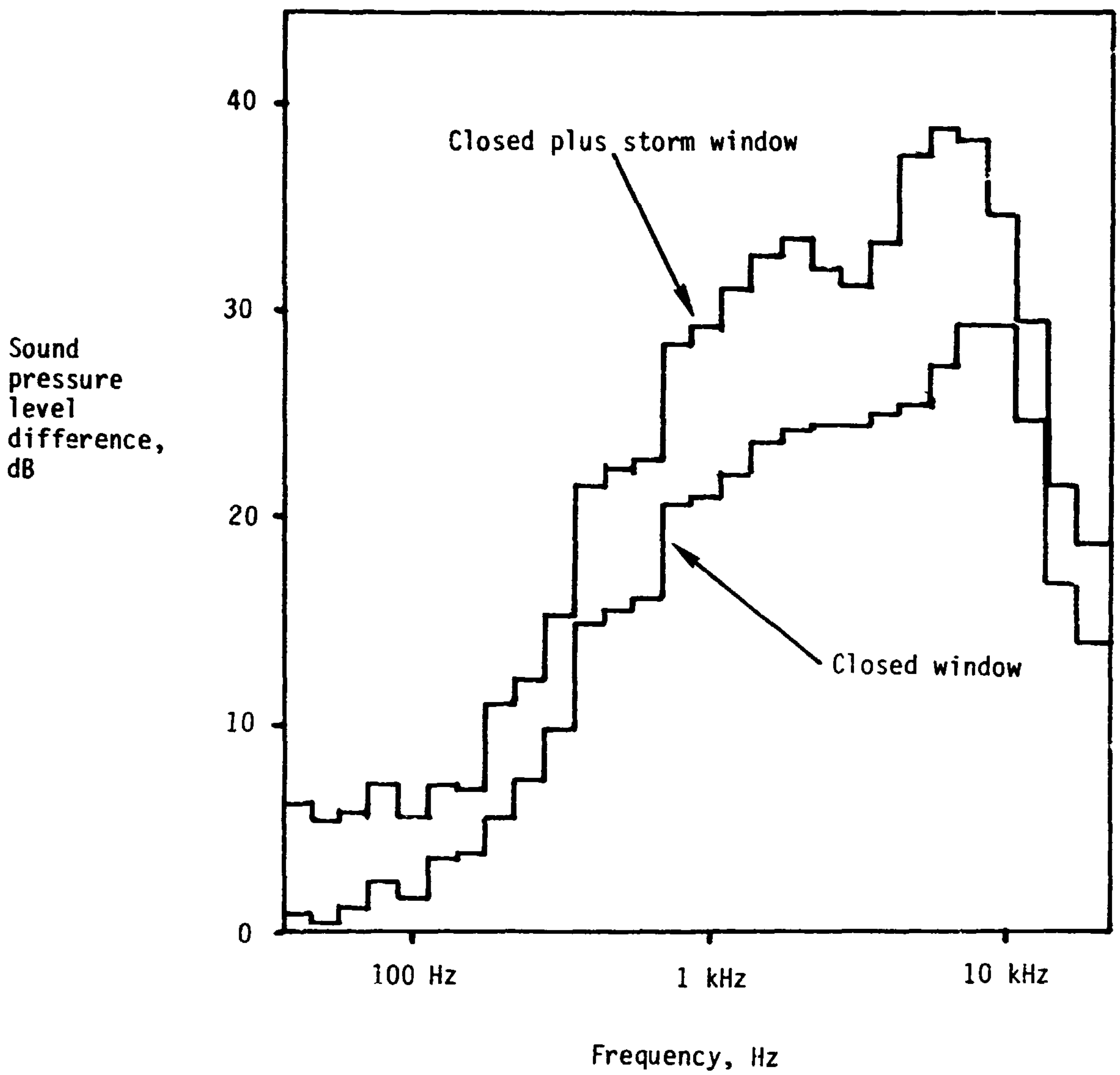

Figure 3.- Sound Pressure Level Difference Between Closed Window and Closed Plus Real Storm Window Conditions, and Open Window Conditions (in One-Third Octave Bands).

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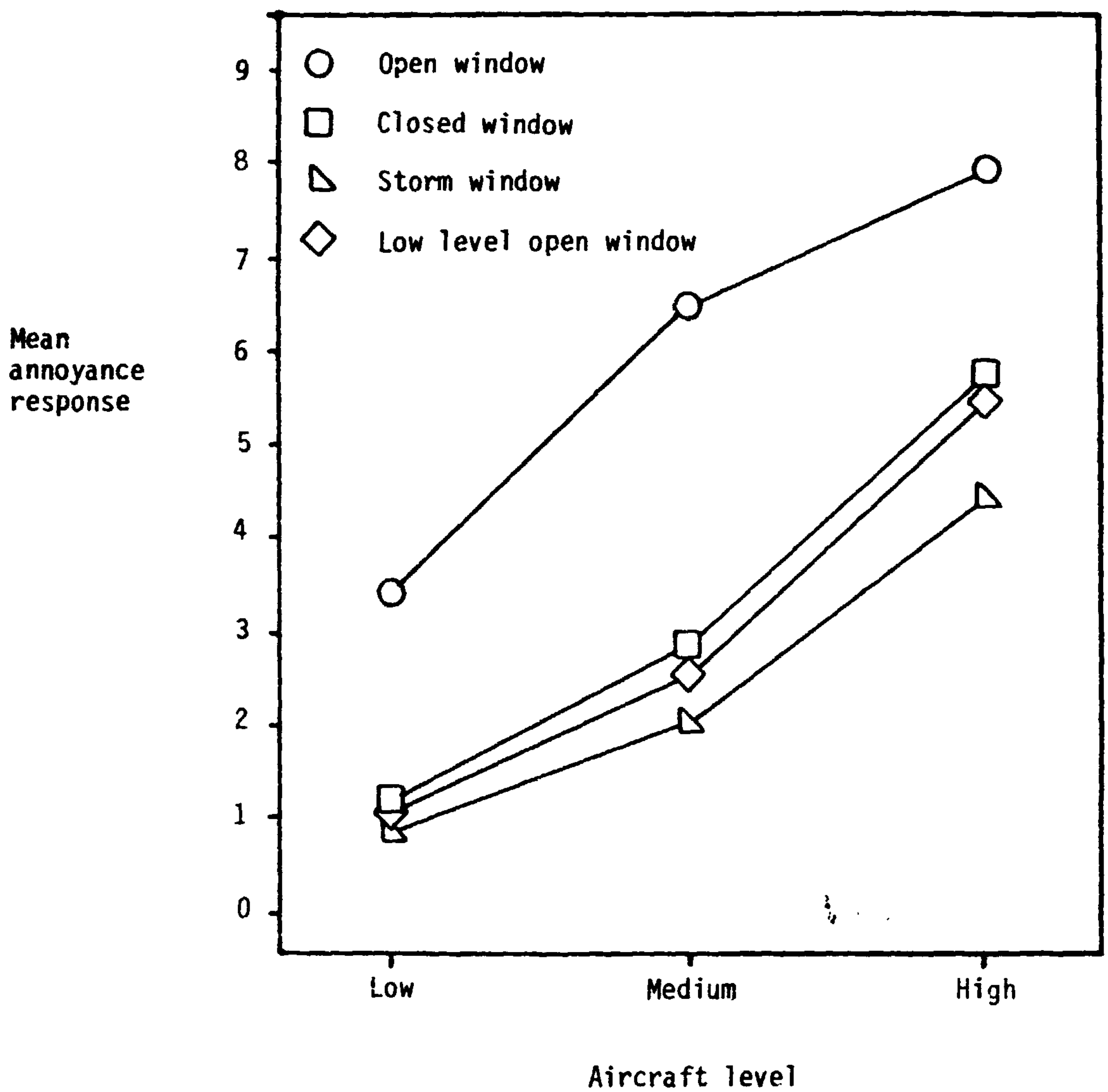

Figure 4.- AR Experiment - Window Condition and Aircraft Level Interaction.

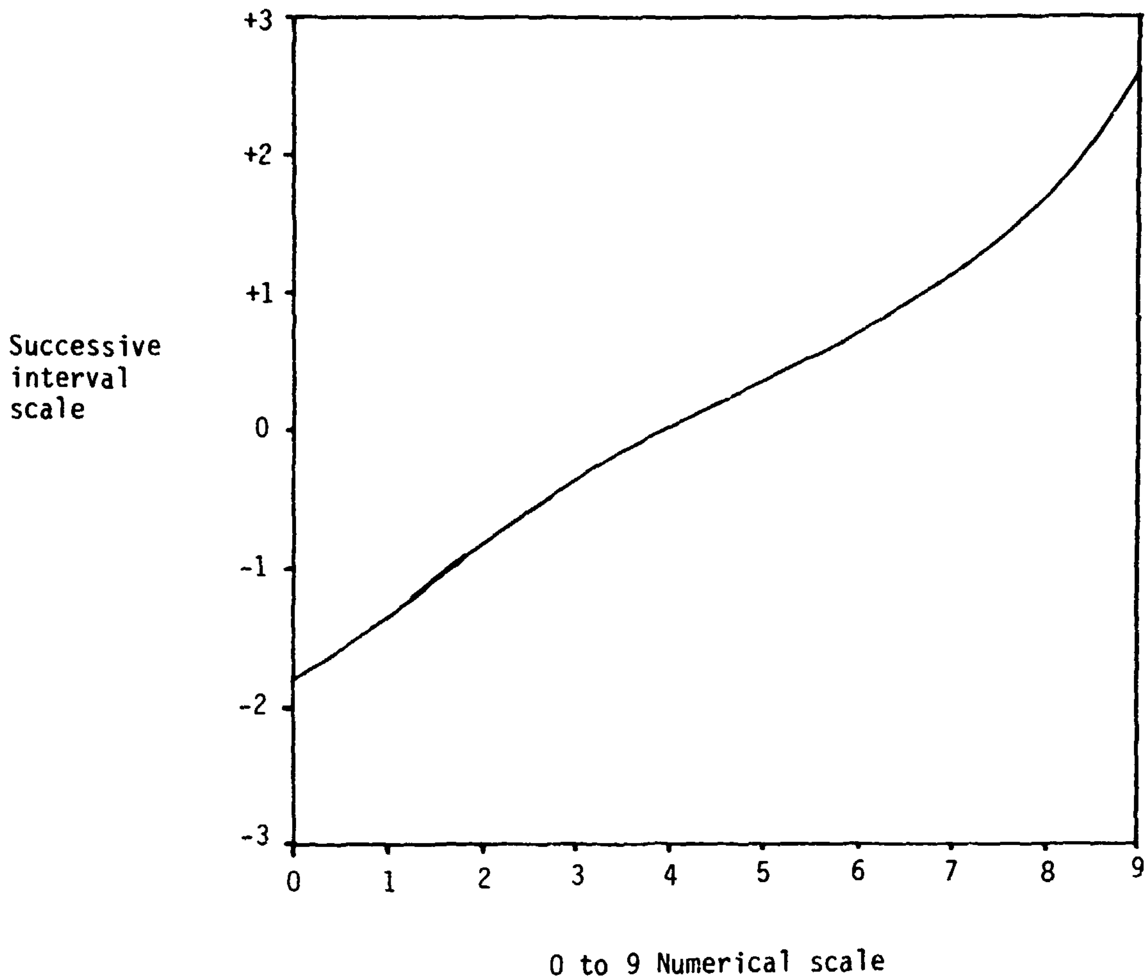

Figure 5.- AR Experiment - Successive Interval Scale Transform.

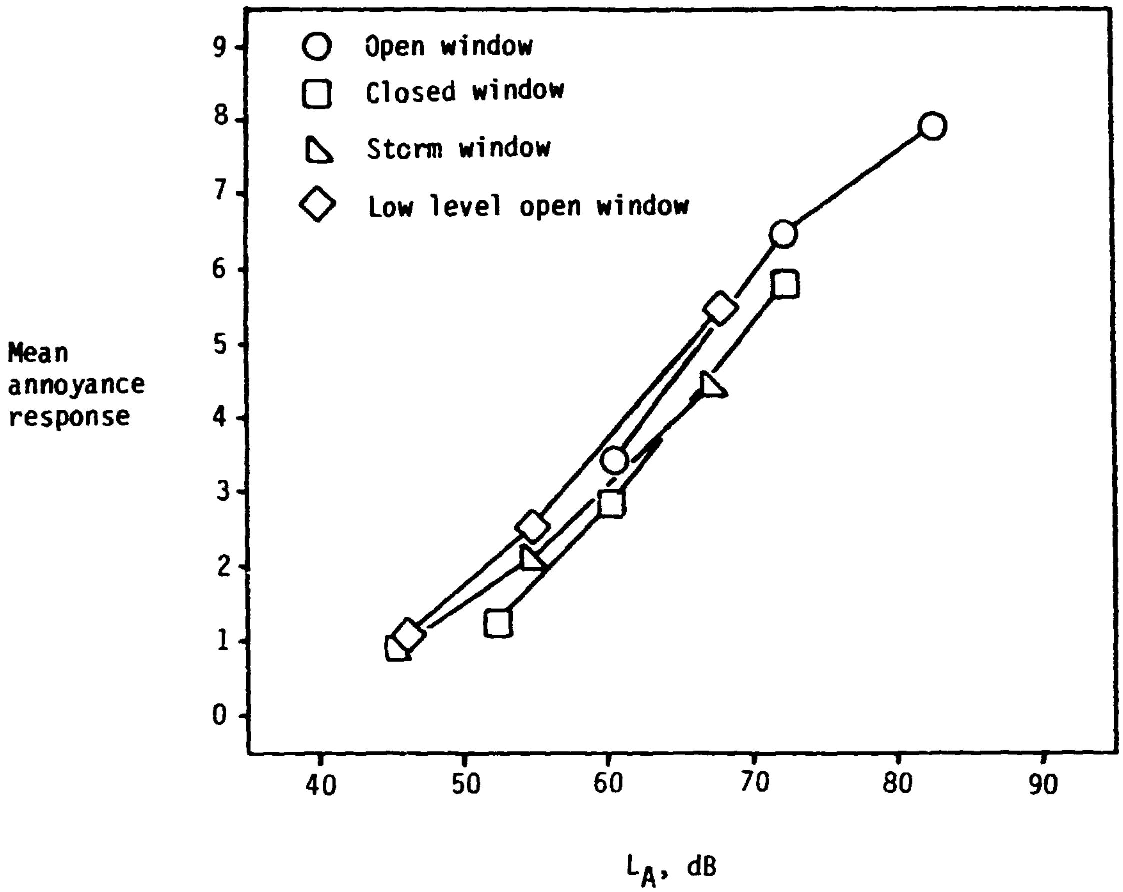

Figure 6.- AR Experiment - Effects of Aircraft Level and Window Condition - L_A and 0 to 9 Numerical Scale.

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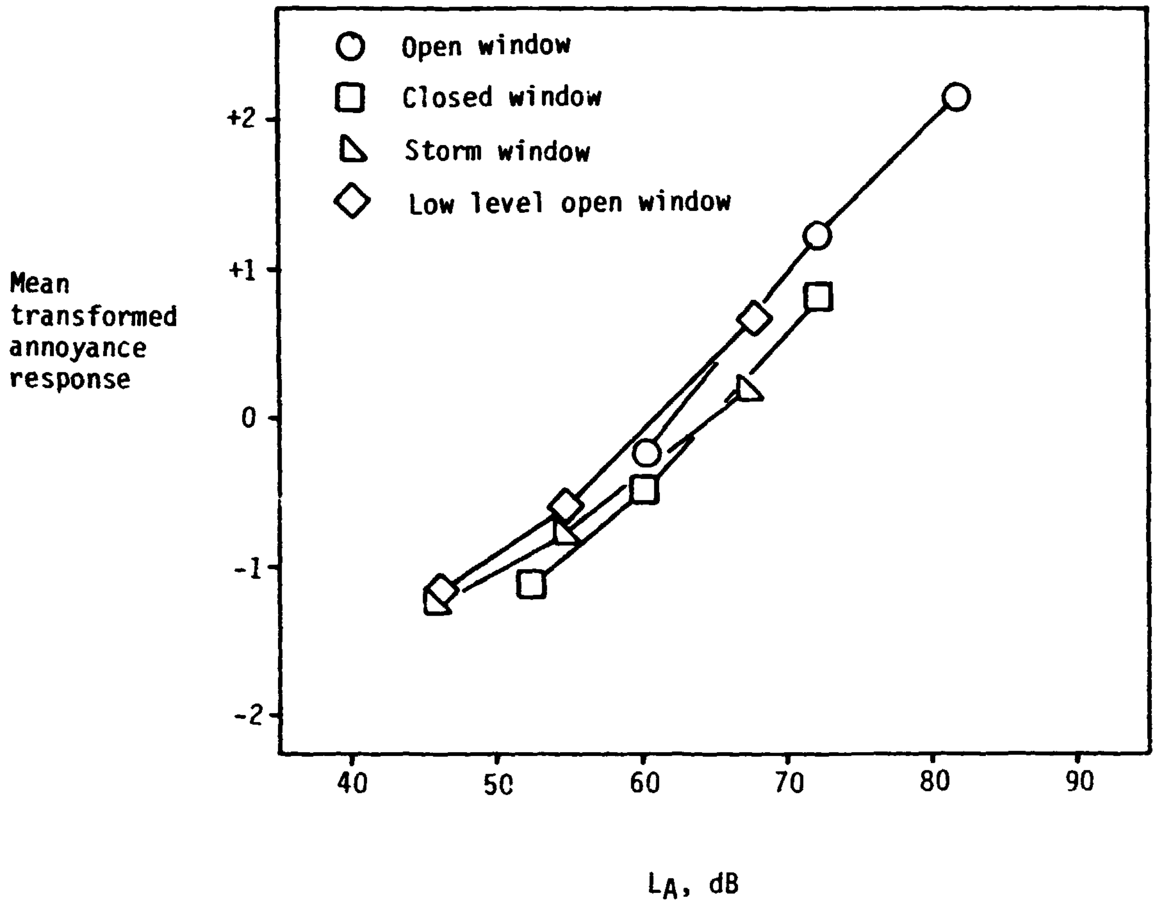

Figure 7.- AR Experiment - Effects of Aircraft Level and Window Condition - L_A and Mean Successive Interval Scale Transformed Responses.

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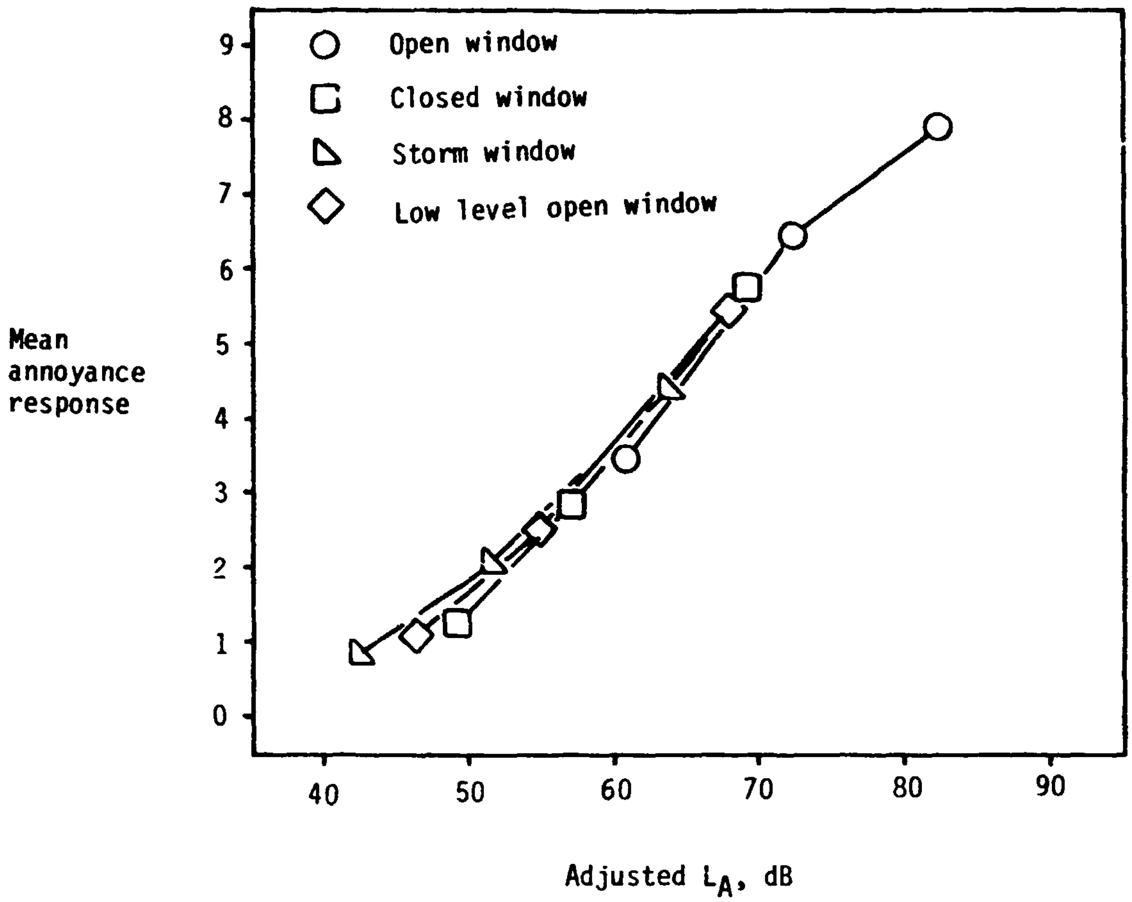

Figure 8.- AR Experiment - Effects of Aircraft Level and Window Condition - L_A Adjusted for Decibel Equivalent Window Effect.

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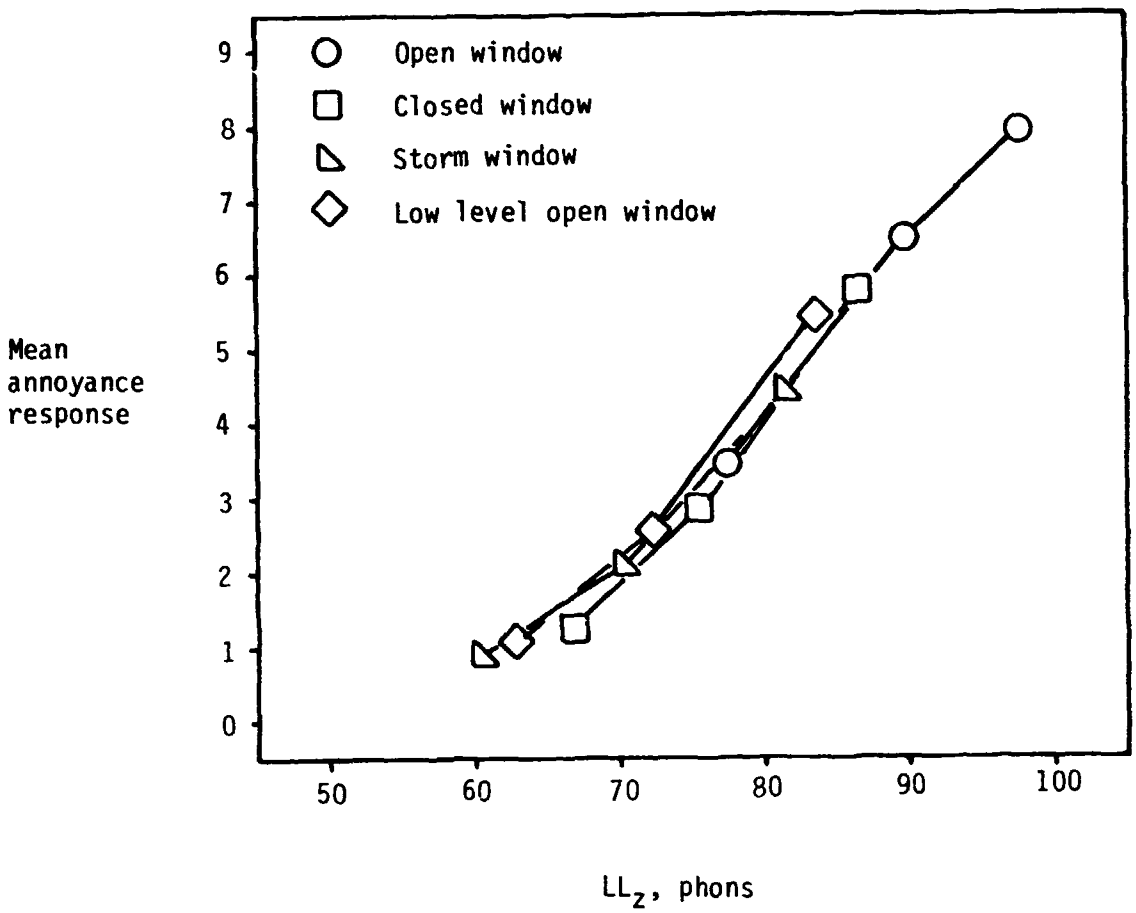

Figure 9.- AR Experiment - Effects of Aircraft Level and Window Condition - LL_z.

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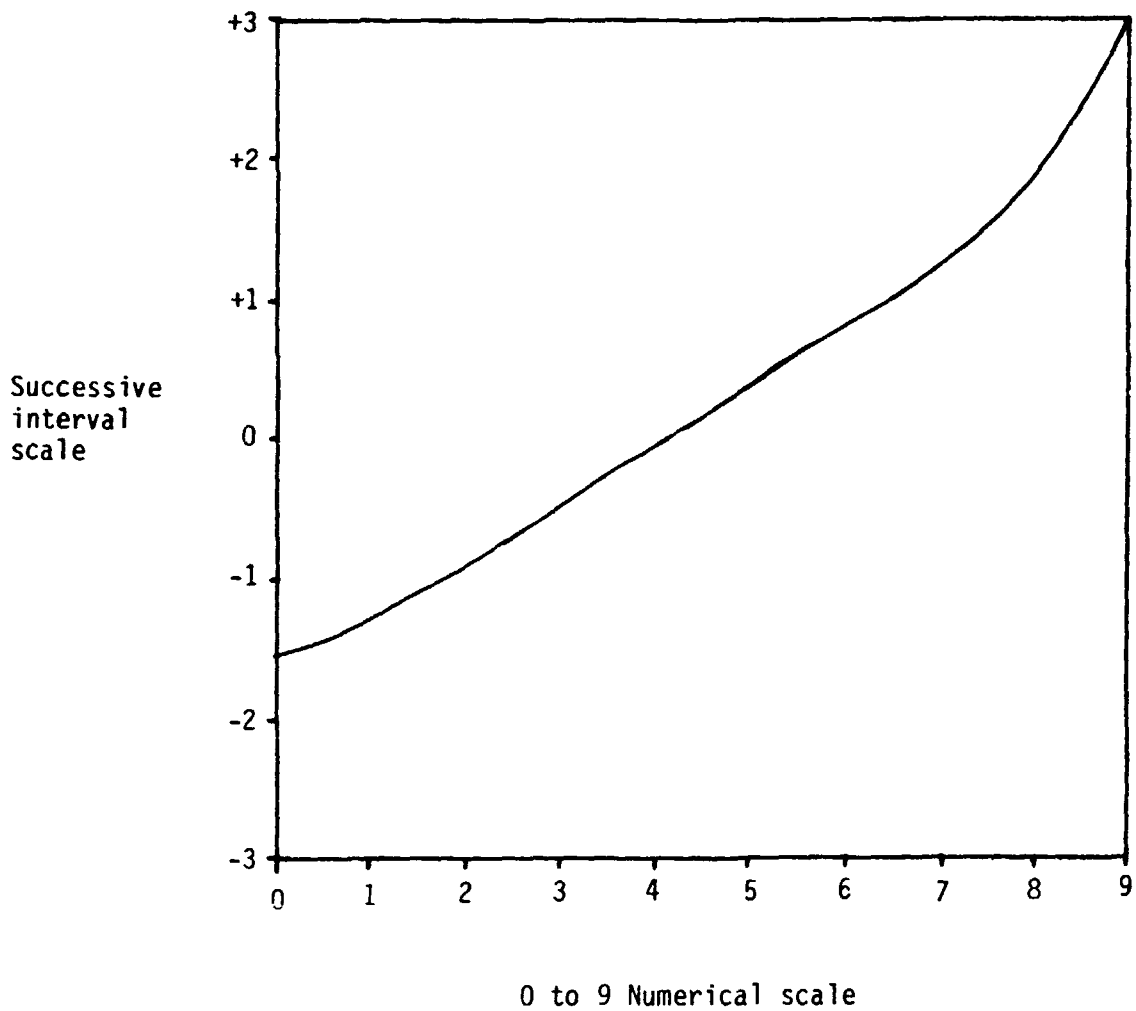

Figure 10.- IER Experiment - Successive Interval Scale Transform,
0 to 9 Numerical Scale.

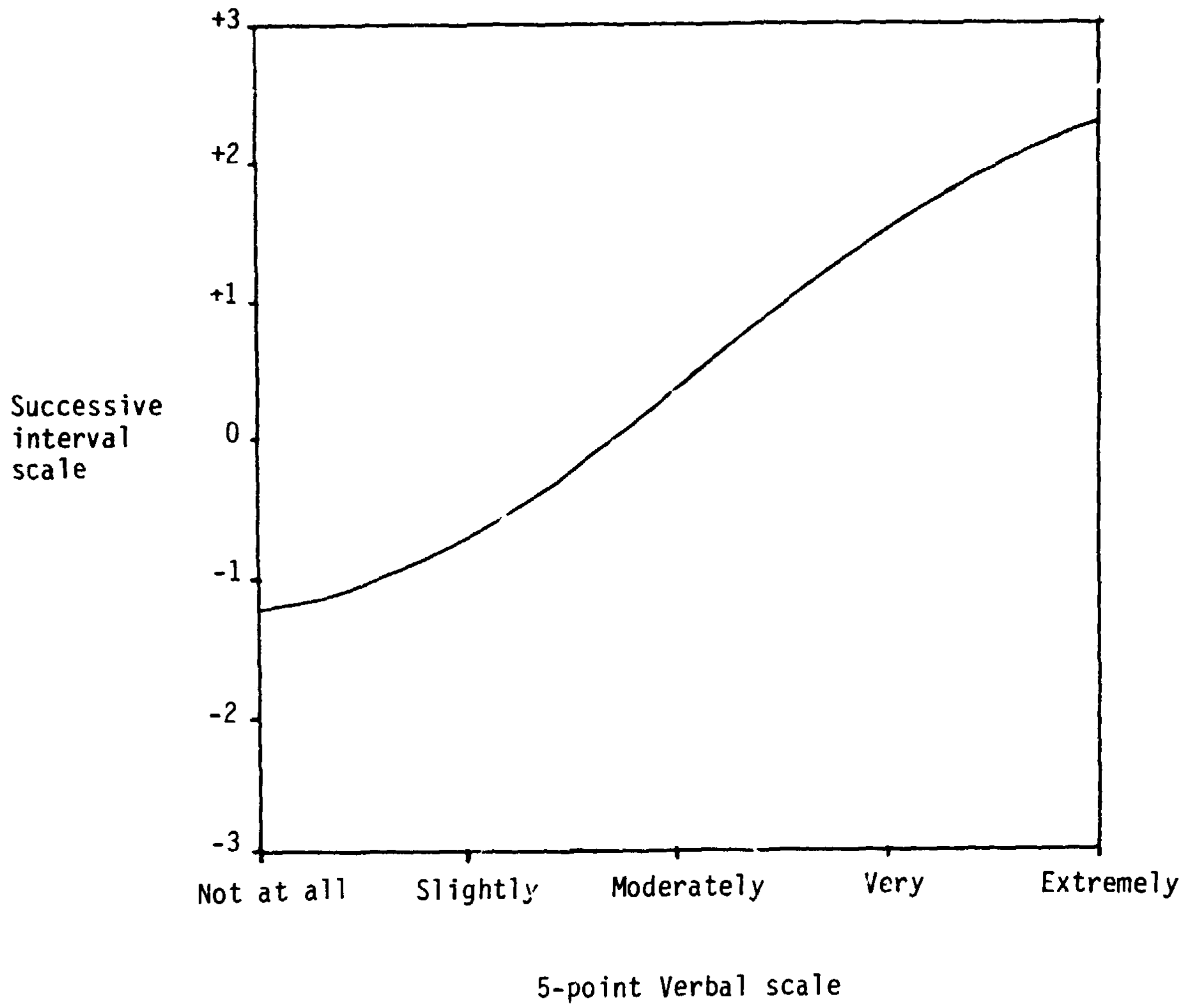

Figure 11.- IER Experiment - Successive Interval Scale Transform, 5-Point Verbal Scale.

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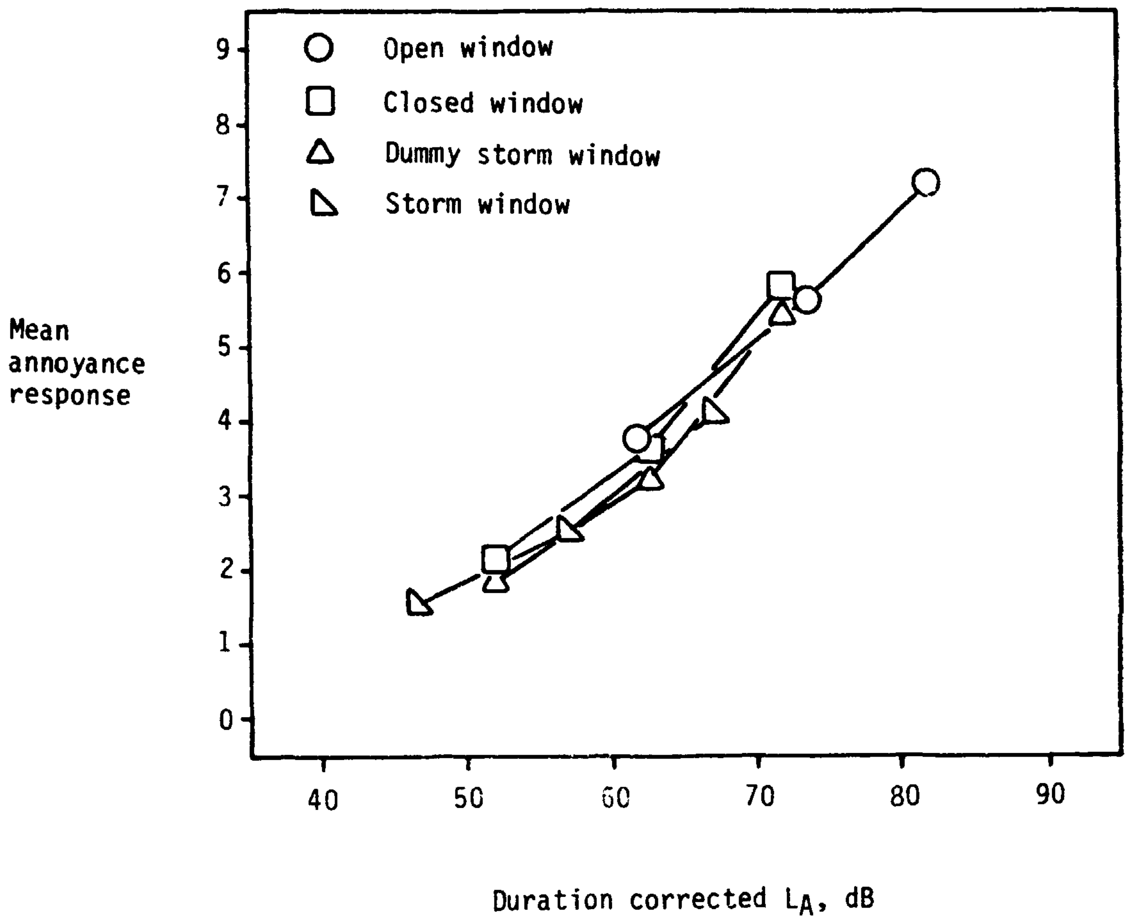

Figure 12.- IER Experiment - Effects of Aircraft Level and Window Condition - Duration Corrected L_A and 0 to 9 Numerical Scale.

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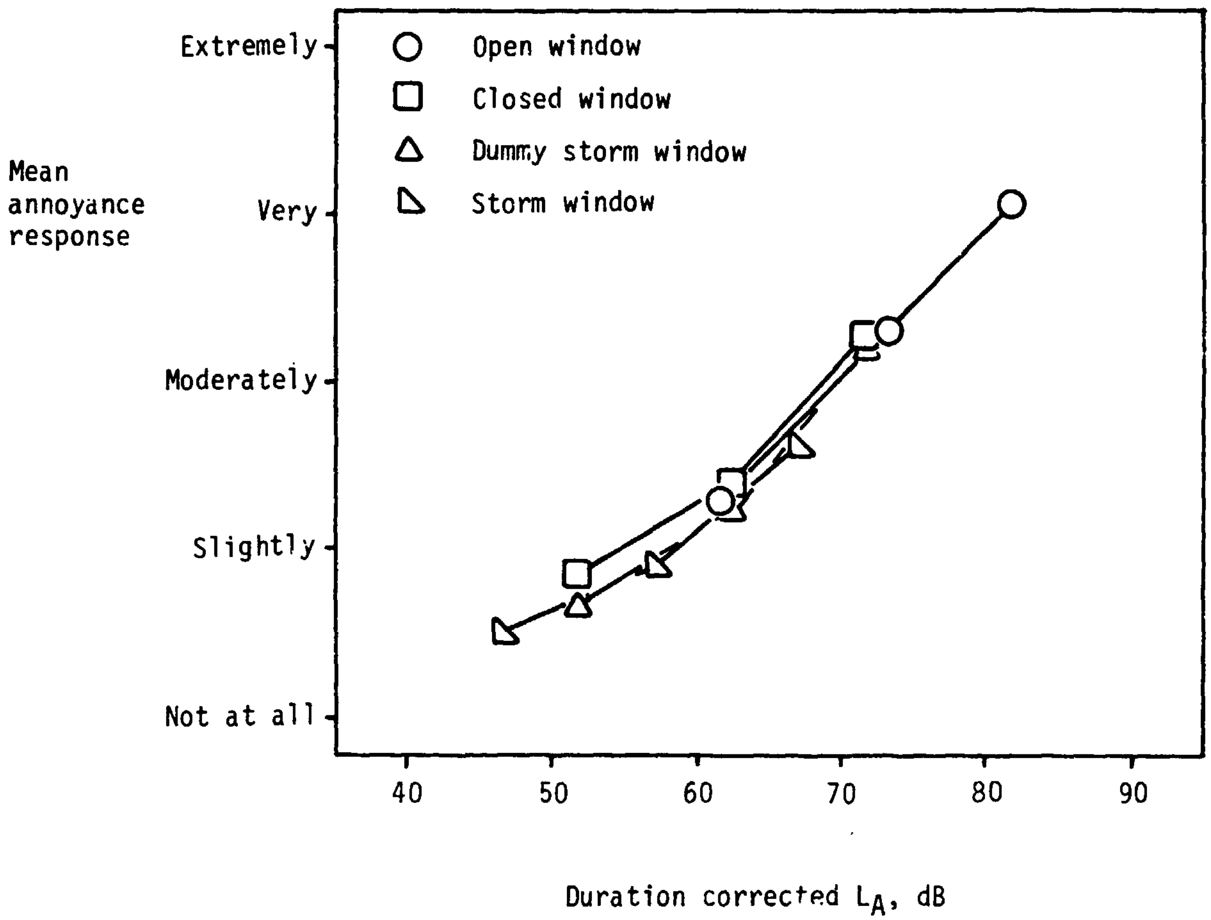

Figure 13.- IER Experiment - Effects of Aircraft Level and Window Condition - Duration Corrected L_A and 5-Point Verbal Scale.

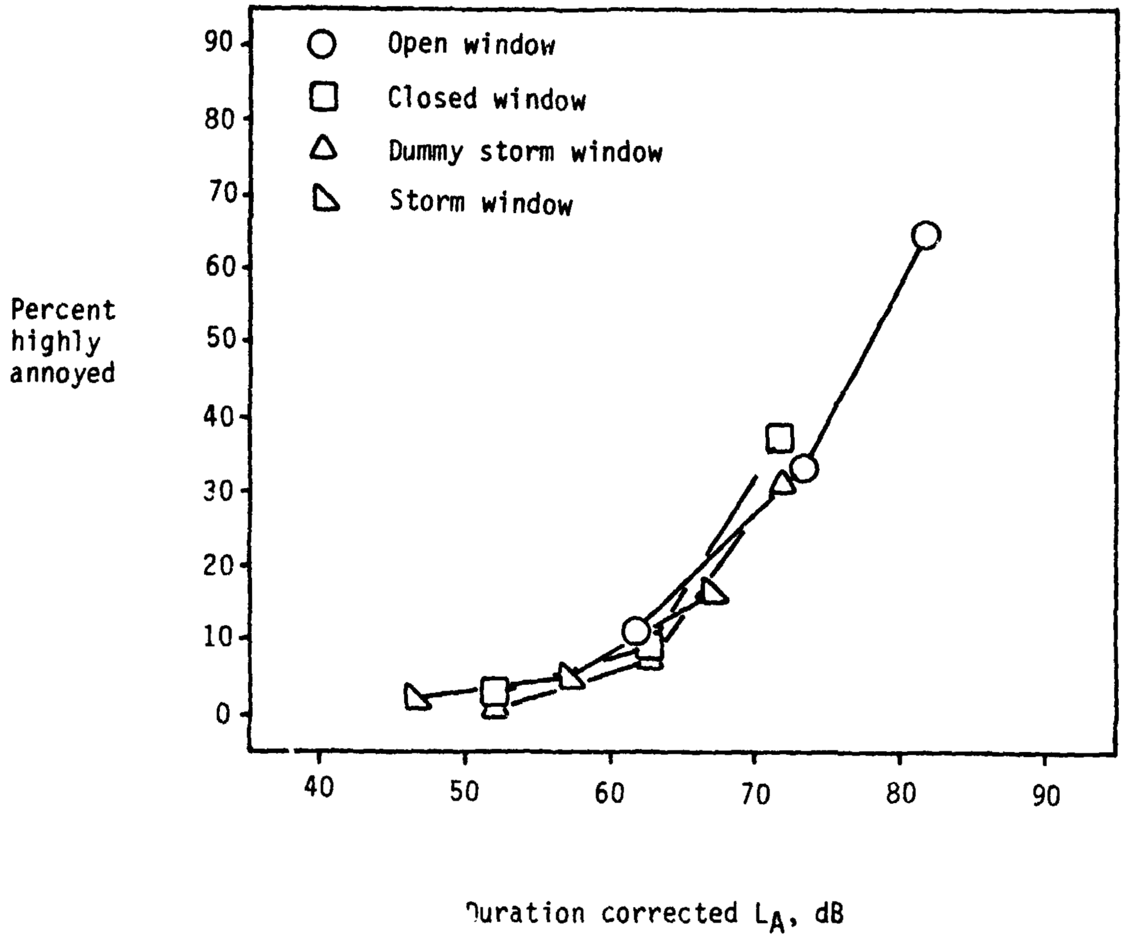

Figure 14.- IER Experiment - Effects of Aircraft Level and Window Condition - Duration Corrected L_A and Percent Highly Annoyed.

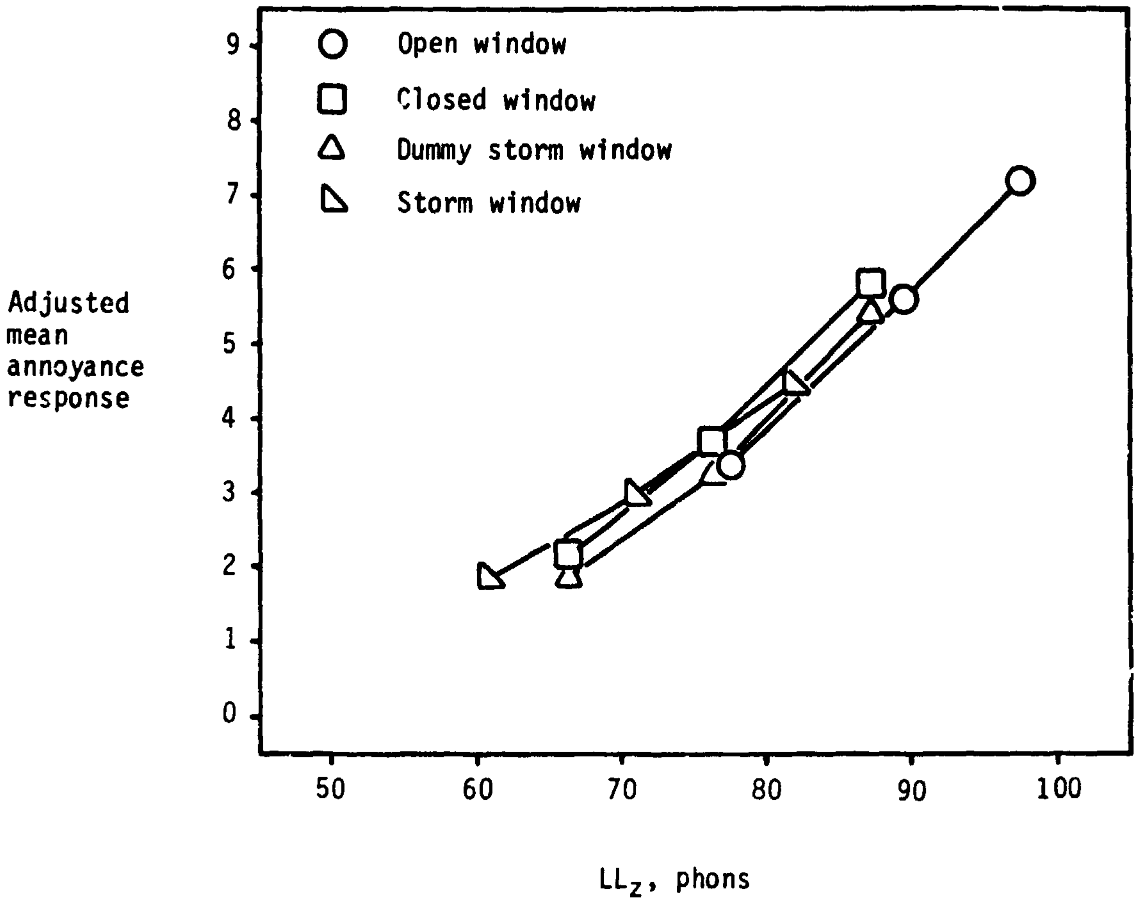

Figure 15.- IER Experiment - Effects of Aircraft Level and Window Condition - LL_z and 0 to 9 Numerical Scale Adjusted for Simulated Condition Cue Overreaction.

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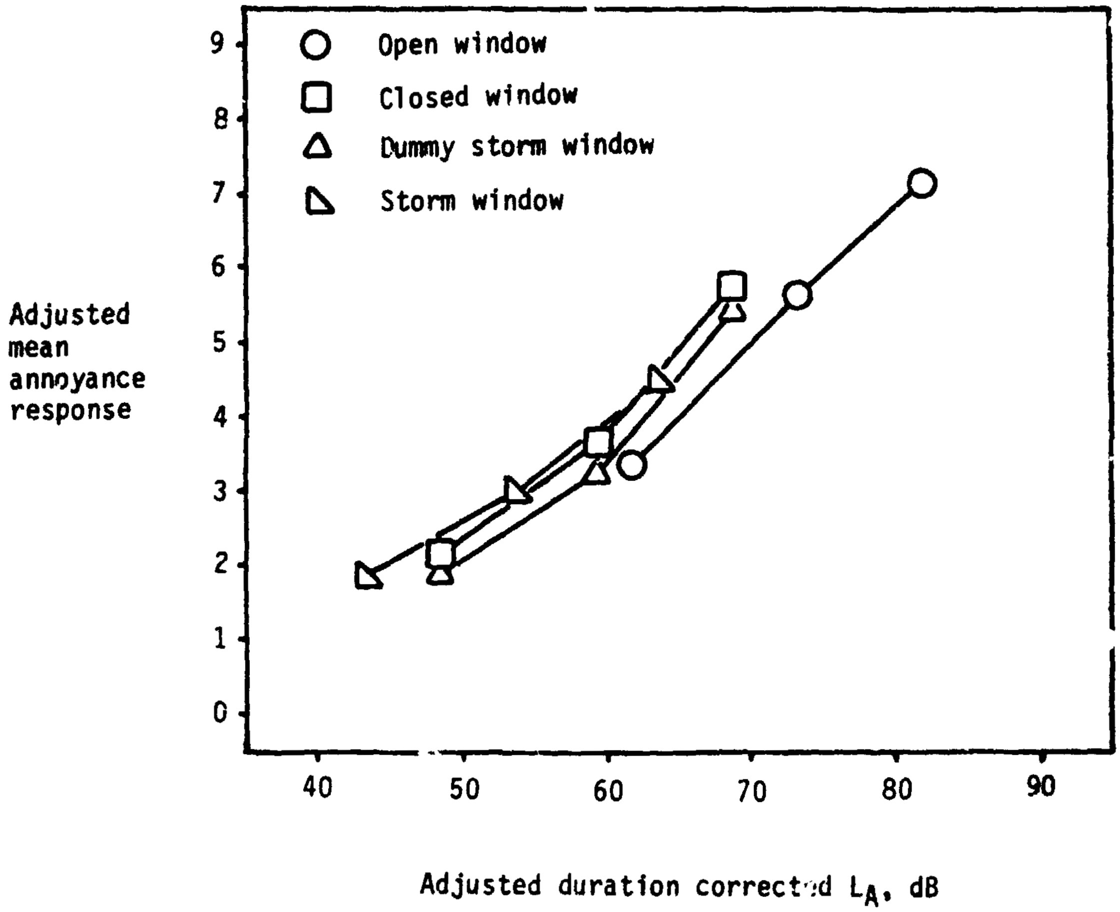

Figure 16.- IER Experiment - Effects of Aircraft Level and Window Condition - Duration Corrected L_A Adjusted for Decibel Equivalent Window Effect and Mean 0 to 9 Numerical Scale Responses Adjusted for Simulated Condition Cue Overreaction.

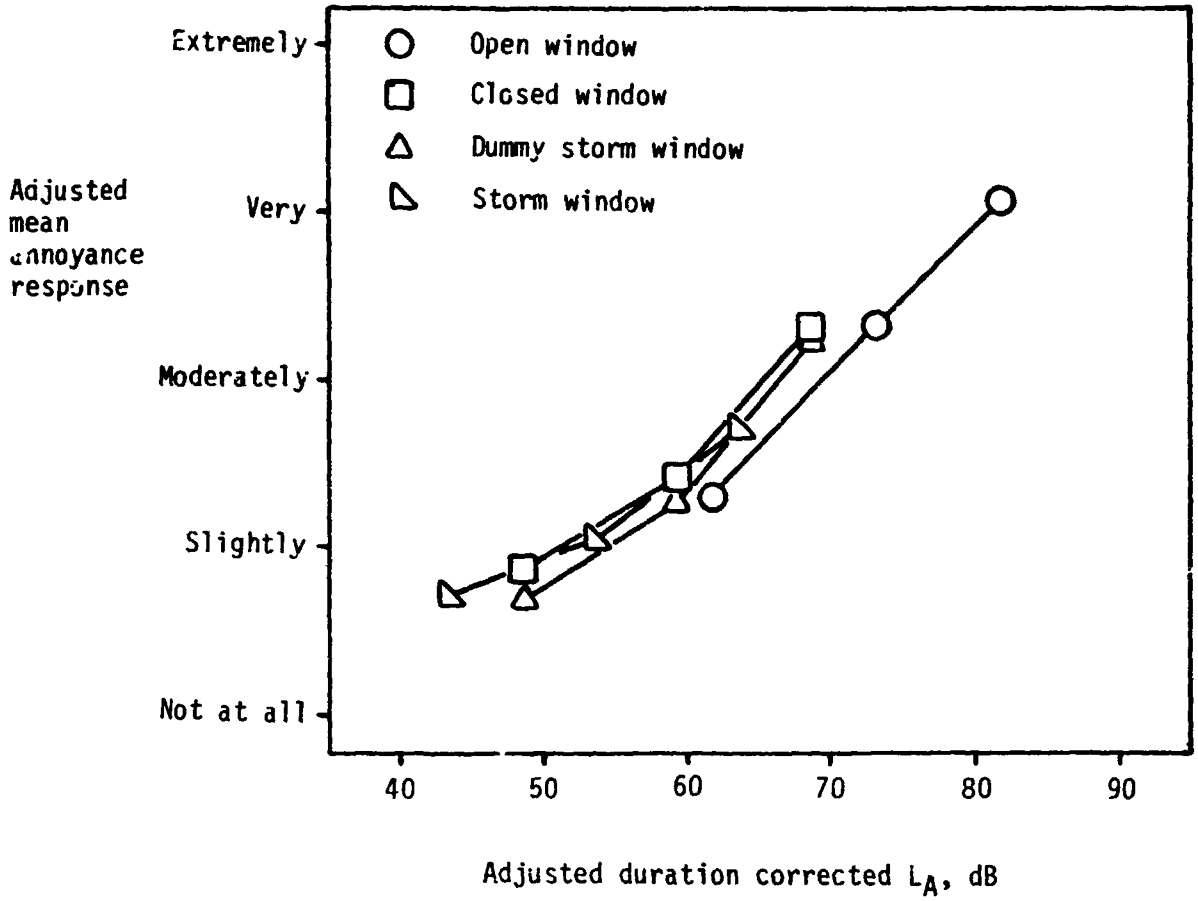

Figure 17.- IER Experiment - Effects of Aircraft Level and Window Condition - Duration Corrected L_A Adjusted for Decibel Equivalent Window Effect and Mean 5-Point Verbal Scale Responses Adjusted for Simulated Condition Cue Overreaction.

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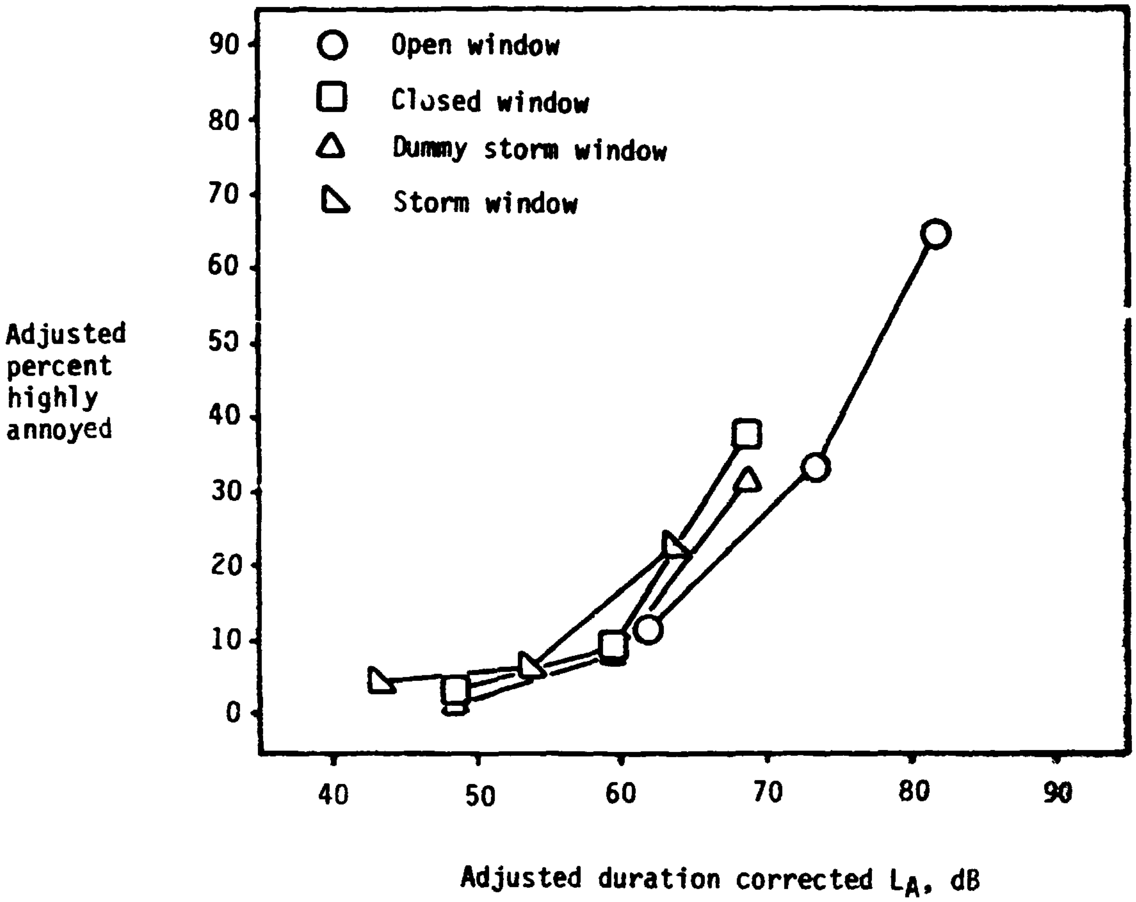

Figure 18.- IER Experiment - Effects of Aircraft Level and Window Condition - Duration Corrected L_A Adjusted for Decibel Equivalent Window Effect and Percent Highly Annoyed Adjusted for Simulated Condition Cue Overreaction.