

# NASA TECHNICAL MEMORANDUM

NASA TM X-71938  
COPY NO.

NASA TM X-71938

## EFFECTS OF A TRAFFIC NOISE BACKGROUND ON JUDGMENTS OF AIRCRAFT NOISE

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(NASA-TM-X-71938) EFFECTS OF A TRAFFIC  
NOISE BACKGROUND ON JUDGMENTS OF  
AIRCRAFT NOISE (NASA) 15 p HC \$4.00

N74-21308

CSCL 20A

G3/23

Unclas  
35317

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

1. Report No. NASA TM X-71938		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle EFFECTS OF A TRAFFIC NOISE BACKGROUND ON JUDGMENTS OF AIRCRAFT NOISE				5. Report Date	
				6. Performing Organization Code	
7. Author(s) Clemans A. Powell and C. G. Rice*				8. Performing Organization Report No. TM X-71938	
9. Performing Organization Name and Address NASA-Langley Research Center Hampton, VA 23665 *Institute of Sound and Vibration Research, University of Southampton, England				10. Work Unit No. 504-29-11-01	
				11. Contract or Grant No. N/A	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546				13. Type of Report and Period Covered Technical Memorandum	
				14. Sponsoring Agency Code	
15. Supplementary Notes Presented at the 87th Meeting of the Acoustical Society of America, April 23-26, 1974, New York City.					
16. Abstract  A study was conducted in which subjects judged aircraft noises in the presence of road traffic background noise. Two different techniques for presenting the background noises were evaluated. For one technique, the background noise was continuous over the whole of a test session. For the other, the background noise was changed with each aircraft noise. A range of aircraft noise levels and traffic noise levels were presented to simulate typical indoor levels.					
17. Key Words (Suggested by Author(s)) (STAR category underlined)  Aircraft Noise, Subjective Acoustics, Traffic Noise, Background Noise			18. Distribution Statement  Unclassified  Unlimited		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 13	22. Price* \$3.00

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

## SUMMARY

A study was conducted in which subjects judged aircraft noises in the presence of road traffic background noise. Two different techniques for presenting the background noises were evaluated. For one technique, the background noise was continuous over the whole of a test session. For the other, the background noise was changed with each aircraft noise. A range of aircraft noise levels and traffic noise levels were presented to simulate typical indoor levels.

The important findings of the study were:

1. A significant effect due to background noise was observable only for the case of continuous background noise over the test sessions.
2. An increase in background noise level caused a decrease in subjective response to the aircraft noises. The decrease in response was equivalent to a 5dB reduction in aircraft noise when the background noise and aircraft noises were of nearly the same level.
3. The subjective response to the aircraft noises for the various background noise levels was found to be highly correlated with calculations of Robinson's noise pollution level.

## INTRODUCTION

Very little information is available on the effects of background noise levels on the annoyance reactions due to aircraft noise and what information is available is in general inconsistent as to the magnitude of the possible effects.

Pearsons (ref. 1) included a limited study on the effects of background noise on perceived noisiness in conjunction with a study on duration effects. The addition of background noise was found to reduce the perceived noisiness of the aircraft noises by about 5dB when the aircraft and background noises were of equal intensity. Nagel, et al., (ref. 2) used cross modality tests to conduct a study to measure the effects of background noise on the judged noisiness of bands of noise. The data reported by Nagel suggest that the addition of background noise of similar spectral shape could reduce the noisiness of aircraft by about 28dB when the aircraft and background noises were of equal intensity. In another recent study, Wells (ref. 3) found that "noise complaint potential" was a function of not only the difference in aircraft and background noises but also of the level of the background noise. In reference 4, Robinson developed the concepts of "noise pollution level" to account for background noise and its fluctuations. These concepts included the capability of evaluating either single noise events or an arbitrary series of noise events.

In references 1 and 2, it was suggested that reference sound testing methods such as pair-comparison and magnitude estimation techniques would be ineffective in determining the effects of background noise. Intuitively, this seems logical because test subjects would have very little time to acclimatize to different background levels between the reference noise and the test noises. As an extension of this rationale, it was thought by the authors of this paper that if the background noise level was changed abruptly in between stimuli presentations for other testing methods, such as numerical category scaling, similar difficulties would be encountered. In a very recent study by Sternfeld, et al., (ref. 5) only a very small effect of background noise level was observed in a set of pair-comparison tests where the reference noises were in an "NC-30" (40dB(A)) background noise and the comparison noises were in traffic noises of 47dB(a). A slight increase in annoyance (significance not given) was observed for the higher background levels. However, it should be pointed out that the subjects were not asked to rate the aircraft sounds but rather were asked to rate the "comparison sounds" with the "test sounds." Also a possible order effect could have caused such a small difference in response. The results of these tests point out the fact that the instructions and test methodology are of utmost importance in subjective tests where subsidiary effects such as those due to background noise level are of importance.

In consideration of these observations, a subjective laboratory study was conducted at the Institute of Sound and Vibration Research, University of Southampton to investigate the effects of background noise on judgments of aircraft noise. The specific objectives of the study were the following:

1. To determine if aircraft noise could be judged more consistently in background noise conditions which are continuous over a test session rather than discontinuous with changes in levels for each aircraft noise.
2. To determine the magnitude of background noise effects on annoyance due to aircraft noise.
3. To determine if a measuring unit such as "noise pollution level" could account for any observed effects due to background noise.

## EXPERIMENTAL DESIGN (Figure 1)

The psychometric method of successive categories (numerical category scaling, 1 to 9) was chosen for this investigation so that any given aircraft noise could be rated without the necessity of making reference to a previous noise. Each of the 12 test subjects (graduate students and staff of I.S.V.R.) rated each of the nine aircraft noises (Boeing 747, three flyover modes, three levels each) during each of six test sessions as shown by the diagram in figure 1. During three of the sessions, the background level (automobile traffic noise) was continuous over the session. During the other three sessions, the traffic noise level was discontinuous, that is, changed for each aircraft noise.

The tests were conducted in a small anechoic chamber. The outdoor aircraft and traffic noise tape recordings were played back to the subjects through a -3dB/octave filter to simulate the attenuation afforded by a typical residential dwelling and were presented at typical indoor levels. The overall response of the sound presentation system was  $\pm 3$ dB to pure tone sweep and  $\pm 1$ dB to one third octave bands of pink noise from 50 Hz to 12.5 kHz.

- PSYCHOMETRIC METHOD - NUMERICAL CATEGORY SCALING
- ENVIRONMENT - SMALL ANECHOIC CHAMBER
- TEST PARAMETERS

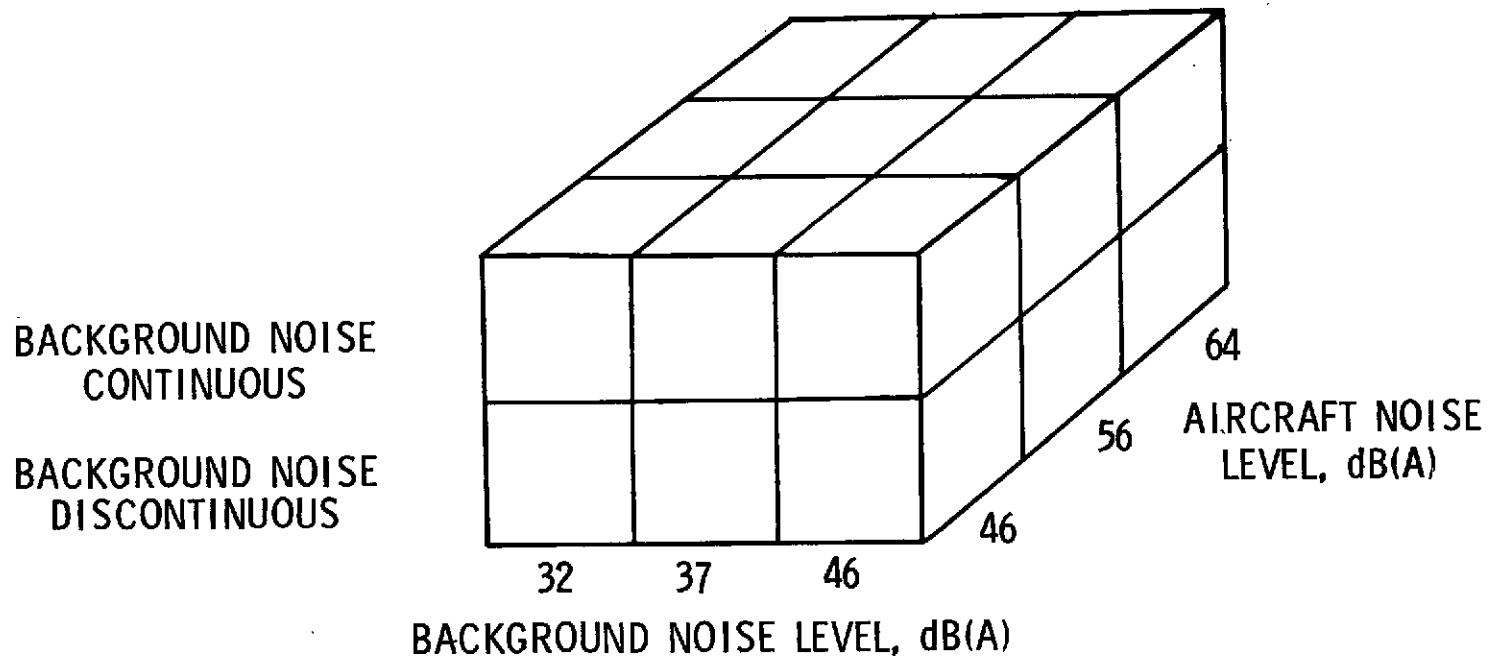


Figure 1.- Experimental design.

DIFFERENCES DUE TO METHODS OF PRESENTING BACKGROUND NOISE  
(Figure 2)

The primary differences in subjective responses due to the two methods of presenting the background noises are shown in figure 2. The left figure shows the least square regression lines of mean subjective response on aircraft noise level for the three background noise levels for test sessions in which the background level was changed between each aircraft noise. The figure on the right shows similar data from the test sessions in which the background level was continuous over the entire session. For the discontinuous case, the regression lines cross whereas for the continuous case the lines clearly separate for the three background noise levels. Analysis of covariance showed that a significant effect (at 0.01 level) due to background noise existed for the continuous background data but no significant effect existed for the discontinuous case.



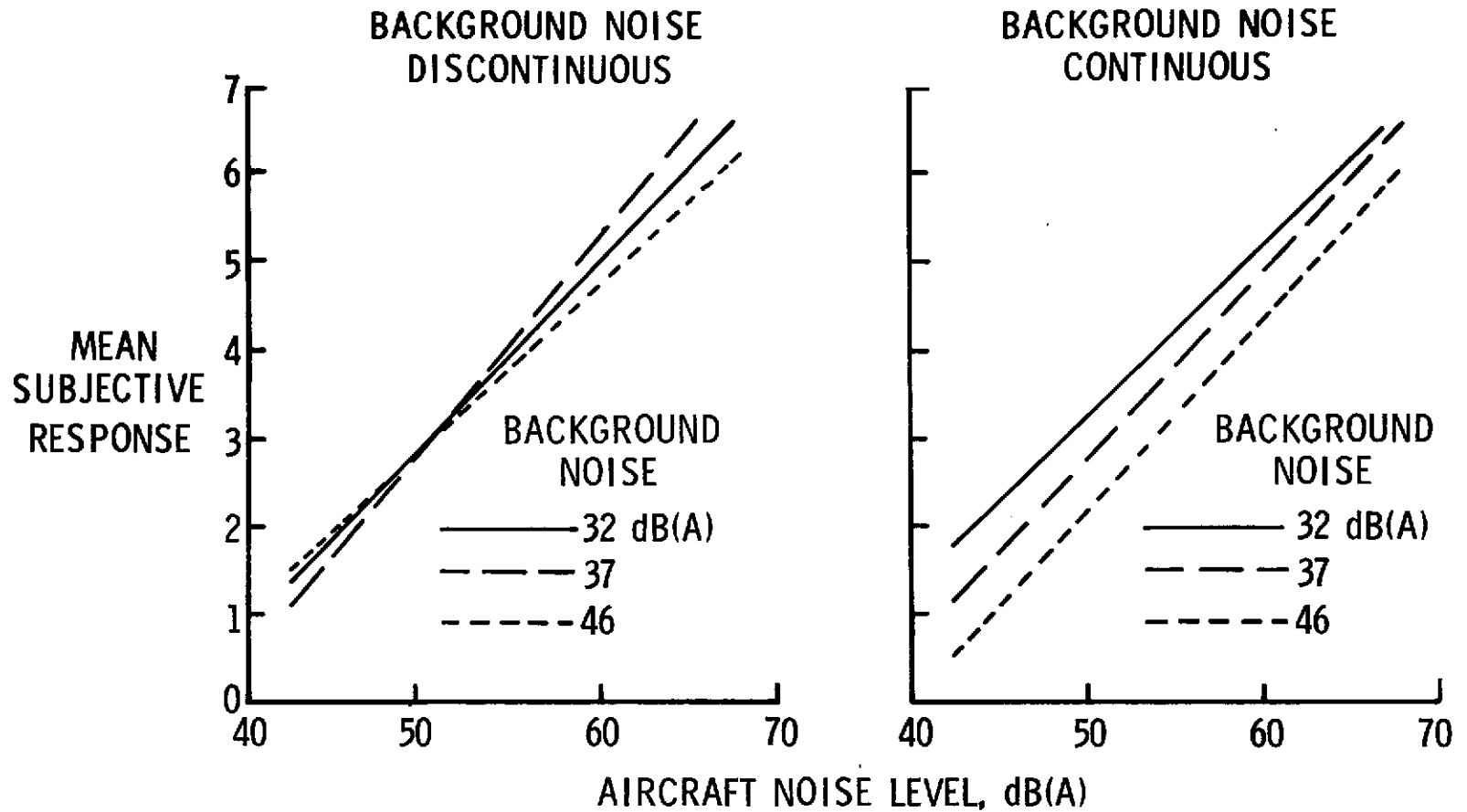


Figure 2.- Differences due to methods of presenting background noise.

MAGNITUDE OF THE EFFECTS DUE TO BACKGROUND LEVEL  
(Figure 3)

The relative magnitude of the effects of background noise level on the subjective response to the aircraft noises is shown in figure 3. The least square regressions of mean subject response on aircraft level are given for the three background noise levels. Careful examination of the data points shows that a consistent reduction in subjective response with increased background level occurred over the range of aircraft noise levels examined. The reduction in subjective response between the 32dB(A) and 46dB(S) background noise levels at the lowest aircraft noise levels is approximately one subjective unit. This would correspond to approximately a 5dB reduction in perceived noisiness of the aircraft noise. This result is in very good agreement with that of Pearsons (ref. 1). Although there appears to be less effect at the higher aircraft noise levels, no significant difference in slope was obtained for the different background levels.

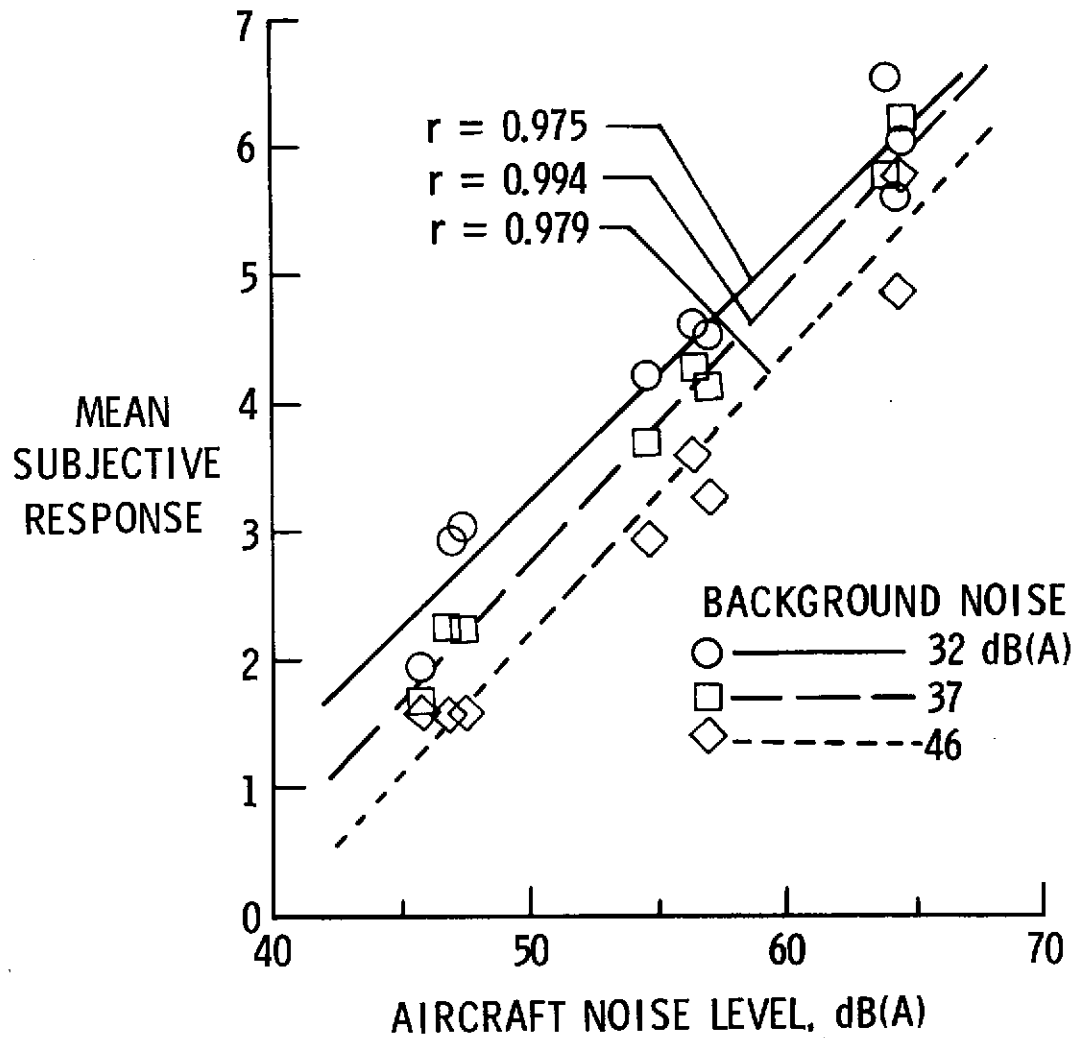


Figure 3.- Magnitude of the effects due to background level.

COMPARISON OF DATA WITH NOISE POLLUTION LEVEL  
(Figure 4)

A comparison of the mean subjective response with calculations of noise pollution level is shown in figure 4. The calculated values of the noise pollution level were determined by assuming the aircraft noises had a triangular shaped time history and a total duration equal to the total time the noise event was considered. These assumptions resulted in the following formation of the noise pollution level,  $L_{NP}$ .

$$L_{NP} = L_0 + 1.48 (L_{max} - L_0)$$

where  $L_0$  is the background noise level and  $L_{max}$  is the peak aircraft noise level.

As shown in the figure, the data for each of the background levels, as indicated by the different shaped symbols, were collapsed into a single regression line. The correlation for this line ( $r = 0.983$ ) was the same as was obtained by performing a multiple correlation analysis with aircraft and background noises as independent variables. This correlation is also in general as good as the single correlations shown in figure 3. Although the range of background noise levels was somewhat limited in this study, the noise pollution level calculations did account for the observed differences in subjective response.

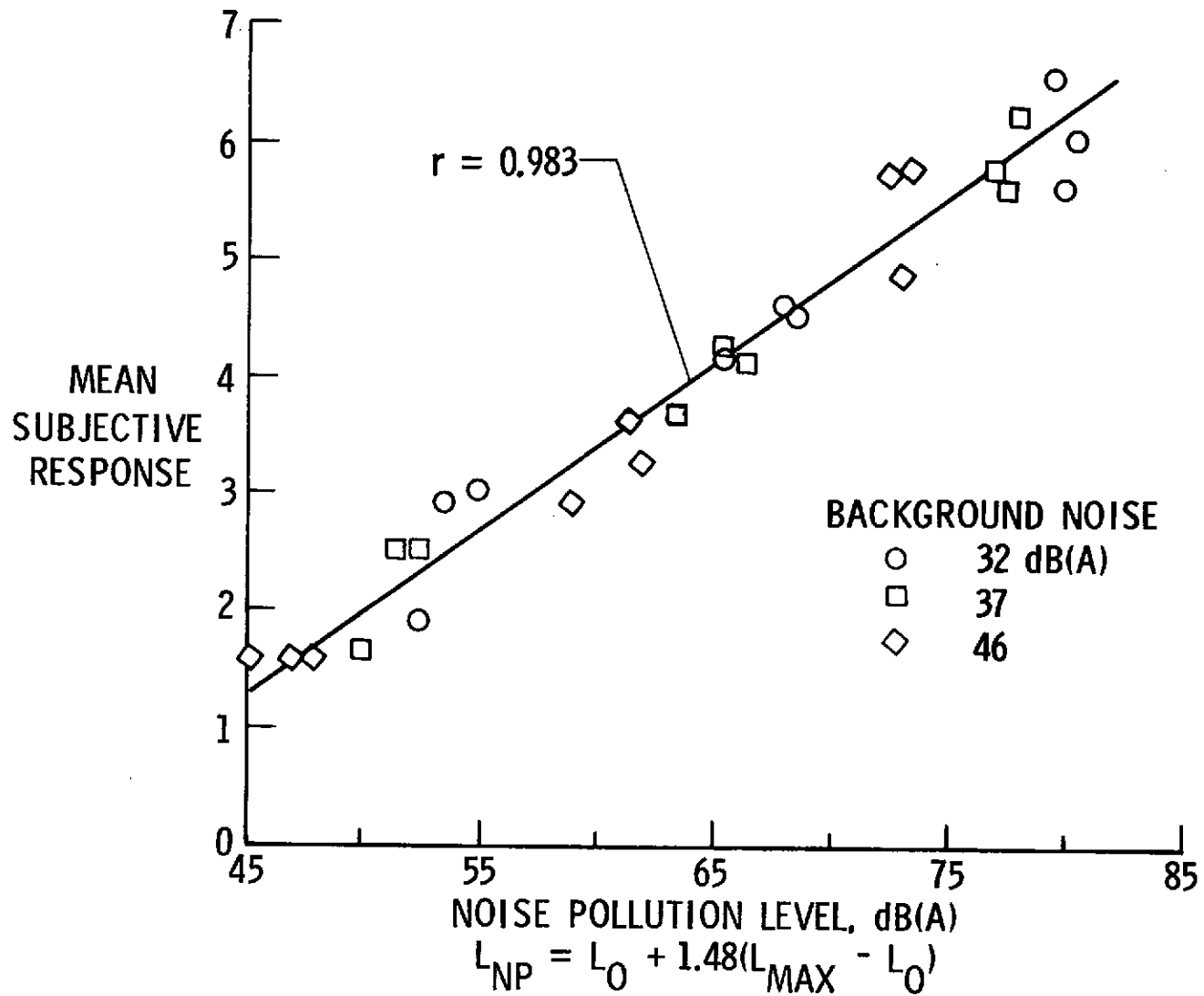


Figure 4.- Comparison of data with Noise Pollution Level.

## CONCLUSIONS

Subjective tests were conducted to investigate the effects of a traffic noise background on the judgments of aircraft noise. The primary conclusions from the study are as follows:

1. Distinguishable effects of background noise on subjective response were obtained for test sessions with a continuous background noise. When the background noise level was changed between each aircraft noise, no significant effects were noted.
2. An increase in continuous background noise level caused a decrease in subjective response to the aircraft noises. When the aircraft and background noise were nearly the same level, the decrease in response was the equivalent of approximately a 5dB reduction in aircraft noise.
3. The subjective responses to the aircraft noises for the various background noises were highly correlated to the calculated noise pollution levels.

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