EFFECTS OF INTERIOR AIRCRAFT NOISE ON SPEECH INTELLIGIBILITY AND ANNOYANCE

Karl S. Pearsons
Ricarda L. Bennett

August 1977

Prepared Under Contract No. NAS1-14463
Submitted to:

NASA
National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia
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EFFECTS OF INTERIOR AIRCRAFT NOISE ON SPEECH INTELLIGIBILITY AND ANNOYANCE

By Karl S. Pearsons and Ricarda L. Bennett
Bolt Beranek and Newman Inc.

SUMMARY

This report focussed upon the effects of interior aircraft background levels and speech intelligibility on perceived annoyance. Sample recordings of the aircraft ambiance from ten different types of aircraft were used in conjunction with four distinct speech interference tests as stimuli for this study. Thirty-six subjects evaluated the background stimuli, which were presented with and without speech, on two annoyance response scales. They first rated the background in terms of its general annoyance. Then they rated the background for its suitability as a speech communication environment.

Both speech intelligibility and background level significantly affected judged annoyance. However, the interaction between the two variables showed that above an 85 dB background level the speech intelligibility results had a minimal effect on annoyance ratings. But, below this level people rated the background as less annoying if there was adequate speech intelligibility.
BACKGROUND

Noise as a product of progress in the design and use of air transports can become a factor which places very real limitations upon the operational use of such vehicles. Unwanted noise inside an aircraft can present problems of varying magnitude for both aircraft personnel and aircraft passengers. The air-crew, by virtue of being exposed to high noise levels over longer periods, can experience auditory fatigue, or more seriously, suffer permanent noise-induced hearing loss. However, noise interference with voice communications affects anyone engaged in air travel. Thus, crew members and passengers alike would experience a general physical fatigue due to increased vocal effort required to achieve successfully face-to-face communication (Ref. 1). Further, even with the aid of electroacoustical systems (intercom), efforts at voice communication may be frustrated due to the masking effects of the background noise. In addition to increasing people's annoyance with their immediate environment, a more paramount concern is that lack of adequate voice communication could result in an increase in aircraft related accidents. For example, due to high noise levels, the pilot could fail to understand the landing instructions; or the passengers could delay in responding to the crewmember's commands in an emergency situation. This concern for the safety and comfort of people who use air transportation vehicles merits careful assessment of the effects of interior background noise.
This study focused on two effects of aircraft interior noise: speech intelligibility and annoyance judgments. Recent research on the relationship of these two factors used traffic noise as the speech interfering background. The interdependency of judged annoyance and the amount of speech intelligibility available to the listener was clearly evident (Ref. 2). Thus, for a constant level of background noise, annoyance ratings of the noise varied with the speech to noise ratio, a value which determines the degree of speech intelligibility. However, it was also noted that as the background noise level increased, the correlative annoyance ratings also increased. When the background noise was presented at a certain high level, the listeners rated the noise as highly annoying regardless of whether the noise interfered with the speech intelligibility or not.

Thus, prior research using stimuli other than aircraft noise suggests that speech intelligibility should be considered in specifications for aircraft interior noise.

This study examined the effect of noise level and speech intelligibility on annoyance ratings using a wide variety of aircraft ranging from helicopters to commercial jet aircraft.

APPROACH

Stimuli

Aircraft Interior Noise

Interior noise environments of ten different aircraft
were recorded. The recordings represented five classes of aircraft body design: (1) general aviation, (2) narrow body jets, (3) wide body jets, (4) turboprop aircraft, and (5) helicopters. The specific background interior stimuli and presentation levels are listed in Table I and the spectra are plotted in Figures 1 through 5.

Speech

Four different types of speech interference tests were used to assess the effects of background noise on speech intelligibility and the interaction of speech intelligibility with annoyance. The recorded speech material was presented with various aircraft backgrounds to the test subjects. Levels of speech were presented at values shown in Table I and the spectra are plotted in Figures 6 and 7.

The speech material includes: (1) Continuous Discourse, (2) Speech Perception in Noise Tests (SPIN Test) (Ref. 3), (3) Tri-Rhyme (Ref. 4), and (4) Phonetically Balanced Word List (PB Words) (Ref. 5). The Continuous Discourse test was used solely in assessing annoyance and not in determining speech intelligibility. An explanation of the speech intelligibility tests, the test instructions, and sample response sheets are in the Appendix.

Subjects

A total of thirty-six test subjects participated in this study. There were twenty-two women and fourteen men. The average age was 31.0 years.
<table>
<thead>
<tr>
<th>TYPE OF AIRCRAFT</th>
<th>INTERIOR A/C</th>
<th>SPEECH INTELLIGIBILITY TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tri-Rhyme</td>
</tr>
<tr>
<td>GENERAL AVIATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rockwell Commander 112A</td>
<td>91.0</td>
<td>82.3, 77.3</td>
</tr>
<tr>
<td>Beechcraft 35B-33 Debonair</td>
<td>89.6</td>
<td>83.3, 78.3</td>
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<td>NARROW BODY JETS</td>
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<td></td>
</tr>
<tr>
<td>Boeing 727</td>
<td>80.6</td>
<td>75.3, 70.3</td>
</tr>
<tr>
<td>Douglas DC-9</td>
<td>78.4</td>
<td>73.3, 68.3</td>
</tr>
<tr>
<td>WIDE BODY JETS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boeing 747</td>
<td>70.0</td>
<td>67.3</td>
</tr>
<tr>
<td>Douglas DC-10</td>
<td>72.3</td>
<td>69.3</td>
</tr>
<tr>
<td>TURBOPROP AIRCRAFT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lockheed Electra</td>
<td>78.2</td>
<td>73.3, 68.3</td>
</tr>
<tr>
<td>Lockheed P3-B Orion</td>
<td>82.8</td>
<td>76.3, 71.3</td>
</tr>
<tr>
<td>HELICOPTERS</td>
<td></td>
<td></td>
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<tr>
<td>Bell 206-S</td>
<td>86.8</td>
<td>78.3</td>
</tr>
<tr>
<td>Sikorsky S-61 (H-3)</td>
<td>93.2</td>
<td>82.3</td>
</tr>
</tbody>
</table>
All subjects were audiometrically screened to within 20 dB of normal hearing as defined in ISO recommended standards (Ref. 6). The subjects were divided into six groups. An attempt was made to maintain an equal distribution of males and females in each group. Some of the subjects had participated in previous subjective tests at the NASA facility.

Test Description

Test Design

The ten aircraft interior noises were heard with and without speech for a total number of 35 test conditions. A counterbalanced test design was utilized to minimize effects associated with presentation order. For example, three of the groups heard the backgrounds alone, as their first ten stimuli. This was balanced by presenting the ten backgrounds as the last conditions for the remaining three groups. The other 25 conditions were arranged by speech intelligibility tests within each experimental set and counterbalanced such that no one group faced the same order of presentation.

In an effort to simulate realistic speech communication situations, information on actual speaking and background levels (Ref. 7) were utilized as guidelines in this study for setting the speech to background ratios. Careful attention was paid to maintaining a realistic speech to noise ratio even as the background noise level increased.
This criterion was modified when the speech to noise ratio was lowered by 5 dB for six of the backgrounds combined with the Tri-Rhyme Test. These stimuli were presented twice, first at a realistic speech to noise ratio and later at the decreased ratio.

Procedure

The subjects were instructed to judge each background noise on a five point annoyance scale from the perspective of hearing the noise while riding in an aircraft. The annoyance scale on the Rating Response Questionnaire (Appendix and below) incorporated numbers with adjective modifiers. An example of the scale is: 0 - not at all annoying, 1 - slightly annoying, 2 - moderately annoying, 3 - very annoying, and 4 - extremely annoying.

After each background noise presentation (with or without speech), the subjects used this scale to first rate the general annoyance of the background noise. The second scale on the questionnaire instructed the subjects to rate the annoyance of the background noise assuming that people would want to be able to converse in it. This rating was later termed the communication annoyance rating. The aim here was to provide the subjects with a more defined framework within which to judge their annoyance of the ambiance.

When the aircraft backgrounds were presented with speech, the subjects were asked to complete a speech intelligibility test. For the Tri-Rhyme Test, the subjects indicated the word they thought they heard, by circling one
of six words. The other three tests: SPIN, PB Words, and Continuous Discourse required the subjects to write in the word they thought they heard. While the subjects were asked to complete the questions for the Continuous Discourse Test, the responses were not analyzed and included in the speech intelligibility results.

Equipment

The tests were performed in the exterior effects room at NASA Langley's laboratory facilities. A block diagram for the equipment is shown in Figure 8. Subjects were seated as shown in the photograph in Figure 9. All equipment shown in the block diagram was furnished by the NASA laboratory with the exception of the mixer which was supplied by Bolt Beranek and Newman Inc.

The speech and noise stimuli levels were independently controlled by attenuators to enable precise control of the speech to noise ratios. Noise levels in the exterior effects room were continually monitored throughout the experiment at a central location.

RESULTS

The results are presented in two parts. First the speech intelligibility results are given in terms of percent of words correctly understood and compared with earlier speech intelligibility data.
The second part concerns itself with the annoyance judgments of aircraft interior noise. The general annoyance is presented first without speech for two measurement procedures: A-level and Speech Interference Level. Next the results are given for test conditions with speech present. A comparison of general and communication annoyance instructions follows.

Speech Intelligibility

Speech intelligibility was measured with three standard tests: (1) Tri-Rhyme, (2) Spin Test, and (3) Phonetically Balanced Words (PB).

Figure 10 shows the results for the speech intelligibility tests relative to the calculated Articulation Index for each background. The Articulation Indices (AI) were computed from samples of the narrator's speech for each of the intelligibility tests. AI scores (Ref. 8) represent the percentage of speech material that is not masked by the background noise; i.e., the weighted difference in one-third octave bands between speech level and the background noise.

The percent correct for the PB word test and the SPIN test agreed fairly well with the psychometric curve that described the results for 1000 PB words found in the ANSI Standard (Ref. 8). However, the percent correct for the Tri-Rhyme test yielded a much flatter psychometric function positioned mid-way between the Rhyme test and the 1000 PB words.
Annoyance

Information on the test subjects' annoyance with the background noises was derived from the general annoyance and communication annoyance scales. The annoyance judgments were initially made on a 5 point scale, with potential responses ranging from not at all annoying to extremely annoying. The data analysis, however, concentrated on the last two categories very and extremely annoying. The results for these two categories were combined, compared to the total responses, and plotted as 'percent highly annoyed'.

Figure 11 shows the increase in the percent highly annoyed as a function of increasing background noise levels. This relationship held for the general annoyance instructions for the ratings of background noises without speech. A strong relationship between level and annoyance was observed ($r = .95$) over a range of 23 dB.

Another strong relationship ($r = .90$) between percent highly annoyed and SIL* was observed in Figure 12. It may be inferred from the regression lines of Figures 11 and 12 that 28 percent highly annoyed corresponds to an SIL of 65 dB which is comparable to 77 dB in Figure 11. Hence, the difference between the A-level and SIL measurement procedures was 12 dB.

*Speech Interference Level (SIL) is a method of estimating the effect of noise interference on speech communication using an arithmetic average of four octave bands (500, 1000, 2000, & 4000 Hz) of the ambient noise.
Figure 13 plots percentage highly annoyed versus background noise levels in the presence of speech. The speech material was contained in three intelligibility tests, and annoyance was judged on the general annoyance scale. The spread in percent highly annoyed across all levels, particularly in the central region, from 75 dB to approximately 85 dB, increased greatly. The correlation coefficient between percent highly annoyed and level for all data decreased to $r = .85$.

Differences between general annoyance ratings and annoyance ratings for a communication environment were examined in Figure 14. The Tri-Rhyme intelligibility test was used to illustrate the effect of this difference in annoyance instructions. The most notable differences in annoyance ratings (up to 38%) were observed for the middle ambient levels, between 75 and 85 dB.

To further illustrate the difference in annoyance instructions, the increase in percent highly annoyed was plotted in Figures 15 and 16 for all backgrounds presented with and without speech. The points on the graphs correspond to the increase in percent highly annoyed for communication annoyance responses relative to the general annoyance responses indicated by the base line at zero percent.

Since most of the points in Figures 15 and 16 lie above the base line, it can be inferred that the majority rated the background noise more annoying when asked to judge its adequacy for a communication environment. Figure 15 contains the results for all ten backgrounds which were
presented without speech. For noise levels between 75 and 85 dB the average increase was 12 percent. This was compared at the same noise levels to the average increase of 18 percent between ratings of communication and general annoyance for backgrounds presented with speech (Figure 16). Thus, when using the communication scale, more subjects rated the backgrounds highly annoying when they contained speech.

At levels outside the 75 - 85 dB range the effects of instructions were not as great. In the analysis of the data with no speech, the increase was 0 percent for levels below 75 dB and 3 percent for levels above 85 dB. Similarly, for tests where speech was present, the average annoyance increase due to instructions was 6 percent for levels below 75 dB and 5 percent for levels above 85 dB.

DISCUSSION

Speech Intelligibility

The Articulation Indices and percent correct results for the data of the three speech intelligibility tests were compared in Figure 10. This graph illustrates the difference between the tests themselves and how they related to prior research conducted with Modified Rhyme Tests (Ref. 9) and PB words.

The most obvious difference was between the 'closed set' test design (exemplified by the Tri-Rhyme Test) and the 'open set' design (such as the SPIN test and PB words). Undoubtedly the higher percent correct for the Tri-Rhyme
test was due to a limited possibility of answers. That is, the subject could choose from a group of 6 words and circle the word he thought he heard and obtain 17 percent correct by chance alone. In an 'open set' design, the test subject has to write the word he thought he heard. This allowed an unlimited choice, especially if the carrier sentence was not contextually related to the correct answer.

While the results from this study closely approximated earlier findings, there were noticeable differences from the two psychometric curves plotted in Figure 10. These differences can be explained in terms of modification in test design and presentation.

The major change in test presentation was that for this study the test subjects received no exposure to the word lists prior to taking the actual test. This lack of familiarity with the possible answers probably accounted for the lower percent correct scores for PB words as noted for the data in Figure 10.

The Tri-Rhyme test results paralleled the trend of the psychometric curve (Figure 10) which described the results for the Modified Rhyme Test (Ref. 9). The overall percent correct, however, was lower for the same AI results. The difference in the results could be attributed to a difference in the test design. For the Tri-Rhyme test, the test subjects had to identify three words (one from each of three groups containing six words). In the Modified Rhyme Test, the subject was required only to
identify one word at a time out of six possibilities. Thus, an increase in task difficulty could account for the decrease in performance.

In addition, the Articulation Indices for the PB words were lower than the results for the SPIN or Tri-Rhyme Test, even though the speech to noise ratio was slightly better. This is because AI, which is based on the speech to noise ratio for certain critical one-third octave bands, shows the effect of the narrator's word articulation on speech intelligibility. An analysis of the narrator's speech spectrum (Figure 7) used in the PB test revealed higher sound pressure levels at the low frequencies where the AI weighting factors were less influential.

Speech Intelligibility and Annoyance

The analysis of the annoyance data showed (most notably in Figures 14, 15, and 16) that the question directed to communication annoyance elicited a greater percentage of highly annoyed responses. Thus, the communication annoyance ratings were used as a more sensitive measure of people's perception of an acceptable background in an environment where conversation would take place. It therefore appeared worthwhile to re-focus the data analysis in terms of the communication annoyance instructions. However, comparisons were made to the results obtained from the general annoyance instructions when relevant.

Figure 17 illustrates the effect of speech intelligibility on judged annoyance using the communication instructions.
A third dimension was added to this graph to show the effect of high background levels. The points were coded to indicate which background noises were heard at levels above (open symbols) and below (closed symbols) 85 dB. For the stimuli presented at levels of 85 dB and above, all of the responses were above 70 percent highly annoyed. It was also noted that none of the responses exceeded 80 percent correct on the speech intelligibility tests. However, for stimuli with levels below 85 dB only 28 percent of the responses were above 70 percent on the annoyance axis. There was also a comparable increase in the percent of responses falling above 80 percent correct.

The regression lines in Figure 17 were calculated to explore the relationship between speech intelligibility and communication-annoyance. The solid regression line represents the relationship for all of the speech data. The resulting coefficient \( r = -.74 \) was compared to the stronger relationship \( r = -.85 \) for the broken regression line derived from an analysis of the same data without the high level stimuli.

Partial correlations were calculated to further examine the interdependency of the three variables: speech intelligibility (measured in percent correct), background level, and annoyance in a communication environment. Using the Tri-Rhyme results, the partial correlation between perceived annoyance and speech intelligibility with the ambient level held constant was -.79.

The partial correlation between annoyance and background level with speech intelligibility held constant was .91.
Thus, while there was a significant relationship between annoyance and speech intelligibility, a greater impact on judged annoyance was made by the changes in background level. For the higher background levels, as shown in Figure 17, the high intelligibility scores seemed to play a subordinate role to level in influencing the test subjects' annoyance ratings.

Annoyance

Figures 18 and 19 both contain the same data but indicate different data groupings. They differ from Figure 13 only in that the percent highly annoyed was based upon communication instructions rather than general annoyance instructions. A comparison of the correlation coefficients for all the data showed that there was more association with background level for general annoyance instructions (Figure 13) \((r = .85)\) than (Figure 18) for communication annoyance instructions \((r = .75)\). Nevertheless, the communication-annoyance data were used because the results appeared to be a more sensitive measure of perceived annoyance.

The same data which appears in Figure 18 were plotted in Figure 19, but with additional analyses of the speech intelligibility results. Three regression lines were calculated to determine the relationships of speech intelligibility (as measured by percent correct) to annoyance and background level. The data were divided into three groups based upon the percentage of correct answers achieved over all of the speech intelligibility tests. Group 1 was 0-40% correct response with a correlation coefficient of \(r = .58\),
Group 2 was 40-70% correct response with $r = .90$, and
Group 3 was 70-100% correct response with $r = .96$.

An examination of percent highly annoyed to speech intelligibility for Group 1 shows that 100 percent of the responses were above 70 percent highly annoyed. The results for Group 2, where subjects achieved between 40 and 70% correct on the speech intelligibility tests, yielded 58 percent of these responses above 70 percent highly annoyed. Group 3 which achieved between 70 and 100% correct had only 20 percent of the responses above 70 percent highly annoyed. Thus as speech intelligibility increased, there was a correlative decrease in perceived annoyance.

The effect of background level on annoyance for a communication environment was also explored. The average background level for stimuli used in Group 1 was 87 dB and the average percent highly annoyed was 93 percent. This was compared to Group 2 with an average background level of 84 dB and 74 percent highly annoyed; and Group 3 with an average ambient level of 79 dB but only 37 percent highly annoyed. There was only an 8 dB difference between the average background levels of Group 1 and 3, but the average percent highly annoyed differed by 56 percent. While this indicated a significant relationship between level and annoyance, the interaction of speech intelligibility partially contributed to the high annoyance ratings.

The average percent correct for speech intelligibility for Group 1 was 19 percent and for Group 2 and 3 it was 62 percent and 81 percent respectively. Again supporting the
previous finding that people's rating of the background level is markedly influenced by the adequacy of the speech communication.

The orderly progression of the annoyance data when grouped according to degrees of intelligibility (Figure 19) indicated the pronounced effect intelligibility had on annoyance judgments of aircraft interior noise. Similar results were also found for the general annoyance ratings. Since speech communication is a common and important occurrence in aircraft, it is vital that intelligibility as well as level be considered in determining appropriate environments inside aircraft.

CONCLUSIONS

1. Annoyance of aircraft interior noise depends primarily upon level. Speech intelligibility also influences annoyance judgments, especially at levels below 85 dB.

2. A greater percentage of people rated the background noise highly annoying when instructed to consider it as a speech communication environment, then when asked to rate the noise quality alone.

3. Results for the speech intelligibility tests in aircraft interior background noise may be approximated using the Articulation Index procedure. However, direct application of AI results to the standard curves would result in over estimation of the speech intelligibility.

4. The type of speech intelligibility test used can greatly influence the results for the same Articulation Index calculation.
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6. Speech Spectra for Speech Intelligibility Tests - Continuous Discourse
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8. Block Diagram of Equipment for Aircraft Interior Noise Assessment
10. Results of Speech Intelligibility Tests with Aircraft Interior Noise
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14. General Annoyance and Communication Annoyance for Various Backgrounds During Presentation of Tri-Rhyme Intelligibility Tests
15. Increased Annoyance Assuming a Communication Environment for Various Aircraft Interior Noises
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FIGURE 4. TURBO-PROP AIRCRAFT INTERIOR NOISE SPECTRA
FIGURE 5. HELICOPTER INTERIOR NOISE SPECTRA
ADJUSTMENT SCALE FOR SPEECH LEVELS

<table>
<thead>
<tr>
<th>TYPE OF AIRCRAFT</th>
<th>CONTINUOUS DISCOURSE</th>
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<tr>
<td>727</td>
<td>Narration</td>
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<tr>
<td>DC-9</td>
<td>&quot;</td>
</tr>
<tr>
<td>747</td>
<td>&quot;</td>
</tr>
<tr>
<td>P3-B</td>
<td>&quot;</td>
</tr>
<tr>
<td>DC-10</td>
<td>Radio Theater</td>
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<tr>
<td>Electra</td>
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One-Third Octave Band Sound Pressure Level in dB re 20 μPascals

FIGURE 6. SPEECH SPECTRA FOR SPEECH INTELLIGIBILITY TESTS - CONTINUOUS DISCOURSE
ADJUSTMENT SCALE FOR SPEECH LEVELS

SPEECH INTELLIGIBILITY TESTS

<table>
<thead>
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<th>SPIN</th>
<th>PB WORDS</th>
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<td>Rockwell</td>
<td>+7, +2</td>
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<tr>
<td>Beechcraft</td>
<td>+8, +3</td>
<td>+8</td>
<td></td>
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<tr>
<td>727</td>
<td>0.0, -5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DC-9</td>
<td>-2, -7</td>
<td>-1</td>
<td>-2</td>
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<tr>
<td>747</td>
<td>-8</td>
<td>-7</td>
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<tr>
<td>DC-10</td>
<td>-6</td>
<td>-5</td>
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<tr>
<td>Electra</td>
<td>-2, -7</td>
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</tr>
<tr>
<td>P3-B</td>
<td>+1, -4</td>
<td>+1</td>
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<tr>
<td>Bell Helicopter</td>
<td>+3</td>
<td>+4</td>
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<tr>
<td>SH-3</td>
<td>+7</td>
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TEST INSTRUCTIONS

SPEECH INTELLIGIBILITY TESTS
NASA
November 1976
Langley

Subject No. _____ Group No. _____ Noise No. ______
Name ________________________________ (S) _____ (N) ______

I. RATING RESPONSE SHEET

After you hear each noise, please rate its quality on the scale below. Remember to imagine that you are hearing this background noise while on an airplane when you make your rating.

The background noise was

Not at all Annoying 0
Slightly Annoying 1 (Circle the number that best corresponds to how you feel)
Moderately Annoying 2
Very Annoying 3
Extremely Annoying 4

II. RATING RESPONSE SHEET

Now rate the annoyance of the level of the background noise. Remember to imagine that you are hearing this background noise while on an airplane. You should base your evaluation on whether you could communicate comfortably with the passenger sitting next to you while aboard an aircraft.

This background level for communicating with someone is

Not at all Annoying 0
Slightly Annoying 1 (Circle the number that best corresponds to how you feel)
Moderately Annoying 2
Very Annoying 3
Extremely Annoying 4
INSTRUCTIONS

You are about to listen to some words that you will hear in a background noise. The words will be presented in groups of 50; one word spoken every two seconds. The background noise will be heard continuously throughout each presentation. The words that you are listening for will not always be of identical loudness each time you hear them. Thus, sometimes you will be quite sure which word was spoken, but at other times you may have considerable difficulty. You should therefore listen carefully throughout the experimental session, which will last approximately one-half hour.

Your TASK will be to write down the word that you thought you heard. The answer sheet in front of you is divided into two columns, each column corresponding to a word list. Start each word list at the top of a new column. If you cannot immediately identify the word when it is presented, draw a line through the corresponding line number and go on. However, if you recall the correct word later you may go back and write it in the appropriate space. When the word list is finished the last word presented should correspond with line number 50.

After you have completed the task, follow the instructions on the Rating Response sheet in front of you and evaluate whether you think the background noise was annoying.
### List 1A

<table>
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<td>day</td>
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<td>knees</td>
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<td>high</td>
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<td>tear (tare)</td>
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<td>31</td>
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<td>31</td>
<td>that</td>
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<td>them</td>
<td>32</td>
<td>die (dye)</td>
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<td>33</td>
<td>give</td>
<td>33</td>
<td>show</td>
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<td>true</td>
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<td>hurt</td>
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<td>isle (aisle)</td>
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<td>own</td>
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<td>36</td>
<td>or (oar)</td>
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<td>37</td>
<td>law</td>
<td>37</td>
<td>oak</td>
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<td>me</td>
<td>38</td>
<td>new (knew)</td>
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<td>none (nun)</td>
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<td>ache</td>
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### List 2A

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<td>by (buy)</td>
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<td>ail (ale)</td>
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Percent Correct: _____  Percent Correct: _____
**LIST 3A**

1. bill
2. add (ad)
3. west
4. cute
5. start
6. ears
7. tan
8. nest
9. say
10. is
11. out
12. lie (lye)
13. three
14. oil
15. king
16. pie
17. he
18. smooth
19. farm
20. this
21. done (dun)
22. use (vews)
23. camp
24. wool
25. are
26. aim
27. when
28. book
29. tie
30. do
31. hand
32. end
33. shove
34. have
35. owes
36. jar
37. no (know)
38. may
39. knit
40. on
41. if
42. raw
43. glove
44. ten
45. dull
46. though
47. chair
48. we
49. ate (eight)
50. year

**LIST 4A**

1. all (awl)
2. wood (would)
3. at
4. where
5. chin
6. they
7. dolls
8. so (sew)
9. nuts
10. ought (ought)
11. in (inn)
12. net
13. my
14. leave
15. of
16. hang
17. save
18. ear
19. tea (tee)
20. cook
21. tin
22. bread (bred)
23. why
24. arm
25. yet
26. darn
27. art
28. will
29. dust
30. toy
31. aid
32. than
33. eyes (ayes)
34. shoe
35. his
36. our
37. men
38. near
39. few
40. jump
41. pale (pail)
42. go
43. stiff
44. can
45. through (thru)
46. clothes
47. who
48. bee (be)
49. yes
50. am

Percent Correct _______ Percent Correct _______
INSTRUCTIONS

You will hear a set of English sentences. Your job is to listen carefully to each sentence and to write down just the last word of each one. Your answer sheet has numbered blank spaces, one for each of the sentences. Before each sentence you will hear the number of the answer blank you should use for your answer. Pay close attention to this number because if you put your answer in the wrong blank you will not get credit for it. You will have plenty of time to write in the last word of one sentence before the next sentence starts, so write legibly, check your spelling, and don't rush. The last word of each sentence will be a common word that you have heard many times. You will probably find it easier to understand the last words of some sentences than of others. We encourage you to guess. There is nothing at all wrong with putting in a word that you are not sure of. Please write down any word that you think has a chance of being right. Before we start the real test you will have a chance to ask any questions you wish. Do you have any questions before the practice?
SPEECH PERCEPTION IN NOISE TEST (SPIN)

SCRIPT SHEET GIVING SENTENCES AND PREDICTABILITY LEVEL, FORM 1 (AHBL)

1. THE WATCHDOG GAVE A WARNING GROWL.
2. SHE MADE THE BED WITH CLEAN SHEETS.
3. THE OLD MAN DISCUSSED THE DIVE.
4. BOB HEARD PAUL CALLED ABOUT THE STRIPS.
5. I SHOULD HAVE CONSIDERED THE MAP.
6. THE OLD TRAIN WAS POWERED BY STEAM.
7. HE CAUGHT THE FISH IN HIS NET.
8. MISS BROWN SHOULDN'T DISCUSS THE SAND.
9. CLOSE THE WINDOW TO STOP THE DRAFT.
10. MY T.V. HAS A TWELVE-INCH SCREEN.

1. GROWL
2. SHEETS
3. DIVE
4. STRIPS
5. MAP
6. STEAM
7. NET
8. SAND
9. DRAFT
10. SCREEN

11. THEY MIGHT HAVE CONSIDERED THE HIVE.
12. DAVID HAS DISCUSSED THE DENT.
13. THE SANDAL HAS A BROKEN STRAP.
14. THE BOAT SAILED ALONG THE COAST.
15. CHOCOLATES LIVE IN MUDDY SWAMPS.
16. HE CAN'T CONSIDER THE CRIB.
17. THE FARMER HARBORSED HIS CROP.
18. ALL THE FLOWERS WERE IN BLOOM.
19. I AM THINKING ABOUT THE KNIFE.
20. DAVID DOES NOT DISCUSS THE HUG.
21. SHE WORE A FEATHER IN HER CAP.
22. WE'VE BEEN DISCUSSING THE CRATES.
23. MISS BLACK KNEW ABOUT THE DOLL.
24. THE ADMIRAL COMMANDS THE FLEET.
25. SHE COULDN'T DISCUSS THE PINE.
26. MISS BLACK THOUGHT ABOUT THE LAP.
27. THE BEER DRINKERS RAISED THEIR HUGS.
28. HE WAS HIT BY A POISONED DART.
29. THE BREAD WAS MADE FROM WHOLE WHEAT.
30. MR. BLACK KNEW ABOUT THE PAD.
31. YOU HEARD JANE CALLED ABOUT THE VAN.
32. I MADE THE PHONE CALL FROM A BOOTH.
33. TOM WANTS TO KNOW ABOUT THE CAKE.
34. SHE'S SPOKEN ABOUT THE BOMB.
35. THE CUT ON HIS KNEE FORMED A SCAB.
36. WE HEAR YOU CALLED ABOUT THE LOCK.
37. THE OLD MAN DISCUSSED THE YELL.
38. HIS BOSS MADE HIM WORK LIKE A SLAVE.
39. THE FARMER BALED THE HAY.
40. THEY'RE GLAD WE HEARD ABOUT THE TRACK.
41. A TERMITAE LOOKS LIKE A ANT.
42. AIR MAIL REQUIRES A SPECIAL STAMP.
43. FOOTBALL IS A DANGEROUS SPORT.
44. SHE WAS INTERESTED IN THE BRUISE.
45. RUTH WILL CONSIDER THE HERD.
46. WE SAW A FLOCK OF WILD GEESE.
47. THE GIRL TALKED ABOUT THE GIN.
48. PAUL CAN'T DISCUSS THE WAX.
49. DROP THE COIN THROUGH THE SLOT.
50. I HOPE PAUL ASKED ABOUT THE MATE.

11. HIVE
12. DENT
13. STRAP
14. COAST
15. SHAMPS
16. CRIB
17. CROP
18. BLOOM
19. KNIFE
20. HUG
21. CAP
22. CRATES
23. DOLL
24. FLEET
25. PINE
26. LAP
27. HUGS
28. DART
29. WHEAT
30. PAD
31. VAN
32. BOOTH
33. CAKE
34. BOMB
35. SCAB
36. LOCK
37. YELL
38. SLAVE
39. HAY
40. TRACK
41. ANT
42. STAMP
43. SPORT
44. BRUISE
45. HERD
46. GEESE
47. GIN
48. WAX
49. SLOT
50. MATE
1. YOU'RE GLAD THEY HEARD ABOUT THE SLAVE.
2. THE GIRL KNOWS ABOUT THE SWAMPS.
3. HOLD THE BABY ON YOUR LAP.
4. FOR YOUR BIRTHDAY I BAKED A CAKE.
5. THE RAILROAD TRAIN RAN OFF THE TRACK.
6. THEY DID NOT DISCUSS THE SCREEN.
7. THEY WERE INTERESTED IN THE STRAP.
8. TEAR OFF SOME PAPER FROM THE PAD.
9. I HAD A PROBLEM WITH THE BLOOM.
10. PETER SHOULD SPEAK ABOUT THE MUGS.
11. THE FRUIT WAS SHIPPED IN WOODEN CRATES.
12. THE RANCHER ROUNDED UP HIS HERD.
13. SHE WANTS TO SPEAK ABOUT THE ANT.
14. WE'RE DISCUSSING THE SHEETS.
15. THE BOY WOULD DISCUSS THE SCAB.
16. THE LONELY BIRD SEARCHED FOR ITS MATE.
17. TOM COULD HAVE THOUGHT ABOUT THE SPORT.
18. YOU'D BEEN CONSIDERING THE GEESE.
19. THEY DRANK A WHOLE BOTTLE OF GIN.
20. ON THE BEACH WE PLAY IN THE SAND.
21. MR. BLACK CONSIDERED THE FLEET.
22. THE AIRPLANE WENT INTO A DIVE.
23. WE'RE LOST SO LET'S LOOK AT THE MAP.
24. I WANT TO KNOW ABOUT THE CROP.
25. HOUSEHOLD GOODS ARE MOVED IN A VAN.
26. THE HONEY BEES SWARMED ROUND THE HIVE.
27. BETTY HAS TALKED ABOUT THE DRAFT.
28. TOM DISCUSSED THE HAY.
29. JANE WAS INTERESTED IN THE STAMP.
30. THE AIRPLANE DROPPED A BOMB.
31. CUT THE BACON INTO STRIPS.
32. I HAD NOT THOUGHT ABOUT THE GROWL.
33. THE DROWNING MAN LET OUT A YELL.
34. I GAVE HER A KISS AND A HUG.
35. PAUL SHOULD KNOW ABOUT THE NET.
36. I CUT MY FINGER WITH A KNIFE.
37. THE CANDLE FLAME MELTED THE WAX.
38. TOM HEARD JANE CALLED ABOUT THE BOOTH.
39. WE CAN'T CONSIDER THE WHEAT.
40. THIS KEY WON'T FIT IN THE LOCK.
41. WE HAVE NOT DISCUSSED THE STEAM.
42. MISS BROWN NIGHT CONSIDER THE COAST.
43. MR. BROWN CAN'T DISCUSS THE SLOT.
44. THE LITTLE GIRL CUDDLED HER DOLL.
45. TOM FELL DOWN AND GOT A BAD BRUISE.
46. HE HADN'T CONSIDERED THE DART.
47. THE FURNITURE WAS MADE OF PINE.
48. HOW DID YOUR CAR GET THAT DENT?
49. MR. SMITH THINKS ABOUT THE CAP.
50. THE BABY SLEPT IN HIS CRIB.

SLAVE
SWAMPS
LAP
CAKE
TRACK
SCREEN
STRAP
PAD
BLOOM
MUGS
CRATES
HERD
ANT
SHEETS
SCAB
MATE
SPORT
GEESE
GIN
SAND
FLEET
DIVE
MAP
CROP
VAN
HIVE
DRAFT
STAMP
BOMB
STRIPS
GROWL
YELL
HUG
WAX
BOOTH
WHEAT
LOCK
STEAM
COAST
SLOT
DOLL
BRUISE
DART
PINE
CAP
CRIB
1. I WANT TO SPEAK ABOUT THE CRASH.
2. HARRY SLEPT ON THE FOLDING COT.
3. SHE'S GLAD JANE ASKED ABOUT THE DRAIN.
4. THE DOCTOR CHARGED A LOW FEE.
5. HE HAD CONSIDERED THE ROBE.
6. I HAVEN'T DISCUSSED THE SPONGE.
7. THE GUILTY ONE SHOULD TAKE THE BLAME.
8. YOU CANNOT HAVE DISCUSSED THE GREASE.
9. THE COOKIES WERE KEPT IN A JAR.
10. LET'S INVITE THE WHOLE GANG.
11. MR. WHITE DISCUSSED THE CRUISE.
12. THE SPORT SHIRT HAS SHORT SLEEVES.
13. THEY KNEW ABOUT THE FUR.
14. WE'VE SPOKEN ABOUT THE TRUCK.
15. THE CUSHION WAS FILLED WITH FOAM.
16. HOW LONG CAN YOU HOLD YOUR BREATH?
17. SHE WANTS TO TALK ABOUT THE CREW.
18. THE COW WAS MILKED IN THE BARN.
19. THAT ACCIDENT GAVE ME A SCARE.
20. THE KITTEN CLIMBED OUT ON A LIMB.
21. YOU'RE GLAD SHE CALLED ABOUT THE BOWL.
22. THE MAN COULD NOT DISCUSS THE HOUSE.
23. HE TOSSSED THE DROWNING MAN A ROPE.
24. YOU HOPE THEY ASKED ABOUT THE VEST.
25. YOU WANT TO TALK ABOUT THE DITCH.
26. STIR YOUR COFFEE WITH A SPOON.
27. WE HEAR SHE CALLED ABOUT THE DRUM.
28. BOB STOOD WITH HIS HANDS ON HIS HIPS.
29. THE TEACHER SAT ON A SHARP TACK.
30. SHE MIGHT HAVE DISCUSSED THE APE.
31. THE STORM BROKE THE SAILBOAT'S MAST.
32. AT BREAKFAST HE DRANK SOME JUICE.
33. HE HIT ME WITH A CLENCHED FIST.
34. PETER KNOWS ABOUT THE RAFT.
35. THE OLD MAN CONSIDERED THE KICK.
36. WE HAVE NOT THOUGHT ABOUT THE HINT.
37. THE TEAM WAS TRAINED BY THEIR COACH.
38. BILL HOPES PAUL HEARD ABOUT THE MIST.
39. THE KING WORE A GOLDEN CROWN.
40. THE SAND WAS HEAPED IN A PILE.
41. THE BOY CAN'T TALK ABOUT THE THORNS.
42. MISS BROWN WILL SPEAK ABOUT THE GRIN.
43. THE DUCK SWAM WITH THE WHITE SWAN.
44. LET'S DECIDE BY TOSSING A COIN.
45. SHE HAS A PROBLEM WITH THE GOAL.
46. JANE DIDN'T THINK ABOUT THE BROOK.
47. HE HEARS SHE ASKED ABOUT THE DECK.
48. HE GOT DRUNK IN THE LOCAL BAR.
49. THE GIRL SWEP TED THE FLOOR WITH A BROOM.
50. THE CLASS WILL CONSIDER THE BLAST.
MISS WHITE WOULD CONSIDER THE MOLD.
RUTH HAS A PROBLEM WITH THE JOINTS.
THE BOY MIGHT CONSIDER THE TRAP.
TO STORE HIS WOOD HE BUILT A SHED.
THE LION GAVE AN ANGRY ROAR.
HE IS CONSIDERING THE THROAT.
THEY HOPE HE HEARD ABOUT THE RENT.
THE CAR WAS PARKED AT THE CURB.
PETER SHOULD CONSIDER THE HOW. (AS IN "NO")
THE OLD WOMAN DISCUSSED THE THIEF.
A ROUND HOLE WON'T TAKE A SQUARE PEG.
YOU'RE DISCUSSING THE PLOT.
THE WOMAN KNEW ABOUT THE LID.
PETER DROPPED IN FOR A BRIEF CHAT.
YOU WERE INTERESTED IN THE SCREAM.
THE GAMBLER LOST THE BET.
THE BURGLAR ESCAPED WITH THE LOOT.
HE COULD DISCUSS THE BREAD.
HE WAS SCARED OUT OF HIS WITS.
HE DOESN'T DISCUSS THE HOP.
EVE WAS MADE FROM ADAM'S RIB.
GET THE BREAD AND CUT ME A SLICE.
BILL WON'T CONSIDER THE BRAT.
WE HEARD THE TICKING OF THE CLOCK.
GREET THE HEROES WITH LOUD CHEERS.
THIS CAMERA IS OUT OF FILM.
RUTH WANTS TO SPEAK ABOUT THE SLING.
MY JAW ACHES WHEN I CHEW GUM.
THE MAN COULD CONSIDER THE SPOOL.
THE DOCTOR PRESCRIBED THE DRUG.
HE RODE OFF IN A CLOUD OF DUST.
HE WAS INTERESTED IN THE HEDGE.
RUTH HOPES SHE CALLED ABOUT THE JUNK.
PLAYING CHECKERS CAN BE FUN.
WE'RE GLAD ANN ASKED ABOUT THE FUDGE.
THE SUPER HIGHWAY HAS SIX LANES.
UNLOCK THE DOOR AND TURN THE KNOB.
RUTH IS SPEAKING ABOUT THE MEAL.
MAPLE SYRUP IS MADE FROM SAP.
BILL CANNOT CONSIDER THE DEN.
WE ARE SPEAKING ABOUT THE PRIZE.
THE CAR DROVE OFF THE STEEP CLIFF.
MISS SMITH COULDN'T DISCUSS THE ROW. ("NO")
THE GLASS HAD A CHIP ON THE RIM.
OLD METAL CANS WERE MADE WITH TIN.
MISS WHITE THINKS ABOUT THE TEA.
MISS WHITE DOESN'T DISCUSS THE CRAMP.
THAT JOB WAS AN EASY TASK.
THROW OUT ALL THIS USELESS JUNK.
SHE COOKED HIM A HEARTY MEAL.
HER ENTRY SHOULD WIN FIRST PRIZE.
RUTH COULD HAVE DISCUSSED THE WITS.
WE COULD DISCUSS THE DUST.
THE STALE BREAD WAS COVERED WITH MOLD.
THE FIREFIGHTER HEARD HER FRIGHTENED SCREAM.
WE SPOKE ABOUT THE KOBJ.
YOUR KNEES AND YOUR ELBOWS ARE JOINTS.
I ATE A PIECE OF CHOCOLATE FUDGE.
PAUL HOPES WE HEARD ABOUT THE LOOT.
INSTEAD OF A FENCE, PLANT A HEDGE.
THE STORY HAD A CLEVER PLOT.
DAVID MIGHT CONSIDER THE WITS.
WE COULD DISCUSS THE DUST.
THE FIREMEN HEARD HER FRIGHTENED SCREAM.
WE SPOKE ABOUT THE KOBJ.
YOUR KNEES AND YOUR ELBOWS ARE JOINTS.
I ATE A PIECE OF CHOCOLATE FUDGE.
PAUL HOPES WE HEARD ABOUT THE LOOT.
INSTEAD OF A FENCE, PLANT A HEDGE.
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THE STORY HAD A CLEVER PLOT.
DAVID MIGHT CONSIDER THE WITS.
WE COULD DISCUSS THE DUST.
THE FIREMEN HEARD HER FRIGHTENED SCREAM.
WE SPOKE ABOUT THE KOBJ.
YOUR KNEES AND YOUR ELBOWS ARE JOINTS.
INSTRUCTIONS

For this speech test, you will be listening to the speaker say three words sequentially in a background of aircraft noise. Listen carefully as the speaker first says the number of the trial; then a standard phrase which will include the three target words. He will indicate he has finished the sample by saying the word 'over'. The example at the top of your answer sheet shows exactly what he will say.

Your TASK is to circle the one word you think you hear in each group of six words. If for a given trial you are not sure what word the speaker has said, make a best estimate. There is no penalty for guessing.

After you have completed this task, follow the instructions on the Rating Response Sheet in front of you and evaluate whether you think the background noise was annoying.
**TRI-RHYME TEST**

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Group No.</th>
<th>Noise No.</th>
<th>Form AX</th>
<th>Test No.</th>
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**Score**

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<tr>
<th>(S)</th>
<th>(N)</th>
<th>Name</th>
<th>Date</th>
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**Example:**

Zero, do you read saw, safe, hold Over.

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<tr>
<th>saw</th>
<th>thaw</th>
<th>jaw</th>
<th>sale</th>
<th>same</th>
<th>same</th>
<th>told</th>
<th>fold</th>
<th>cold</th>
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<tbody>
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<td>safe</td>
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<td>rent</td>
<td>dud</td>
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<th>bad</th>
<th>din</th>
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<th>dim</th>
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<td>dig</td>
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<th>sun</th>
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### TRI-RHYME TEST

**Subject No.** | **Group No.** | **Noise No.** | **Form BX** | **Test No.** | **Score** | **(S)** | **(N)** | **Name** | **Date**
---|---|---|---|---|---|---|---|---|---

**EXAMPLE:**

Zero, do you read **saw**, **safe**, **hold** Over.

<table>
<thead>
<tr>
<th>Saw</th>
<th>Thaw</th>
<th>Jaw</th>
<th>Sale</th>
<th>Sane</th>
<th>Same</th>
<th>Told</th>
<th>Fold</th>
<th>Cold</th>
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<tbody>
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<td>Safe</td>
<td>Save</td>
<td>Sake</td>
<td>Gold</td>
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<td>Sip</td>
<td>Rip</td>
<td>Tip</td>
<td>Hen</td>
<td>Ten</td>
<td>Then</td>
</tr>
<tr>
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<td>Fold</td>
<td>&quot;Cold&quot;</td>
<td>Lip</td>
<td>Hip</td>
<td>Dip</td>
<td>Den</td>
<td>Men</td>
<td>Pen</td>
</tr>
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<td>Mat</td>
<td>Math</td>
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### Example: TRI-RHYME TEST

Zero, do you read **saw**, **safe**, **hold** Over.

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INSTRUCTIONS

In this part of the experiment you will be listening to speech in an aircraft background noise. Listen carefully, because you will be asked questions about the subject matter at the end of the presentation.

Your TASK is to answer the questions about the speech material on your response sheet in front of you. You will have the questions in front of you at all times. You may answer these questions at any time while listening to the speech.

After you have completed the task, follow the instructions on the Rating Response sheet in front of you and evaluate whether you think the background noise was annoying.
Please answer the brief questions concerning the content the speech message just presented.

1. What hobby has a new found popularity with the horsey set?

2. What is the primary prerequisite for starting a collection with this hobby?

3. What is livery?
Please answer the brief questions concerning the content the speech message just presented.

1. How long have they been friends?

2. What is the dying man's name?

3. What does the other man (the priest) notice in the room?
Subject No. ___________ Group No. _______ Noise No. _______

Name ____________________ (G) 4 (H) _______

Please answer the brief questions concerning the content the speech message just presented.

1. What did the doctor say was the cause of the old lady's death?

2. What is suspicious about the lady's bank book?

3. Why does the man feel that he has special expertise about the behavior of old people?
Please answer the brief questions concerning the content the speech message just presented.

1. Whose life is discussed?

2. Name one of his earlier jobs?

3. How is the man's style of delivery unique from his rivals?
It's 7 a.m. on a dewy morning, and the ground fog of auto emission is just beginning to collect over the nearby Garden State Parkway. All at once, the outline of a 19th Century carriage drawn by two horses emerges on the horizon with a bulky coachman at the reins.

Relax, bleary-eyed commuters, it isn't an apparition. It's just the board chairman of Johnson & Johnson out for his morning carriage ride. The jaunt is an essential part of Philip Hofmann's morning routine as he describes it:

"Up at a quarter-to-seven, out to the barn. Ride horseback from seven to seven-thirty. Then I've got either two or four horses hitched and ready to go, and I'm off. Drive around the grounds, back to the house, breakfast on the table. Shower at eight-fifteen, in the car and on the way to the office by eight-thirty."

Mr. Hofmann, head man of a $1.14 billion-a-year Band-Aid empire, owns 17 carriages. He is registered with the Carriage Association of America, a Staten Island-based organization whose 2,000 members spend a fair-sized hunk of their time and furtunes hunting down old carriages, fixing them up and driving them no particular place at all. Just 10 years ago, the fledgling association had 200 members. Part of the reason for its astounding growth can be found in the answer to this question: What do you do with an aging horseman?

The 64-year-old Mr. Hofmann's story is typical. "I found that in fox hunting I'd lost my timing at a fence, and it was getting too dangerous," he says. "I was a bit like a baseball player losing his eye at batting, so I decided to shift to driving."

What that shift means for those who make it is an investment of up to $5,000 for a restored coach that grandpa may have paid $50 for in 1890. To really get rolling, carriage buffs also need a few coach-trained horses, which can run up to $1,500 apiece. Mr. Hofmann, whose wife sometimes takes a carriage and footman to the theater, even traveled to Germany to buy six registered Holstein horses for a total of $30,000. "I'm not fooling," he says, "They're Holstein horses, not cows."
Why such a big fuss just to take yourself for a ride? "To sit up on a coach and drive four horses is the ultimate in authority," explains Tom Ryder, a retired British cavalryman and author of a standard reference work on carriage driving. Mr. Ryder, with his wife, manages the stables of IU International Corp.
REFERENCES

1. Gasaway, Donald, "Noise Within Fixed Wing Utility Aircraft Used by the Military", USAF School of Aerospace Medicine, Aerospace Medical Division (AFSC), Brooks Air Force Base, Texas, December, 1971.


