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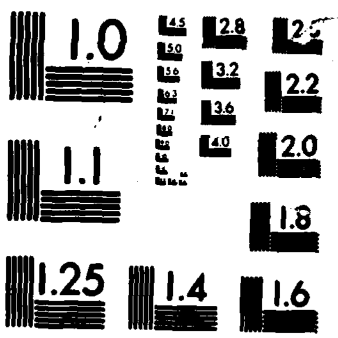

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USAARL Report No. 86-3

A COMPARISON OF SPEECH INTELLIGIBILITY CHARACTERISTICS FOR EARCUPS INTENDED FOR USE IN THE SPH-4 HELMET

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SENSORY RESEARCH DIVISION

March 1986

USAARL

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Studies at USAARL have demonstrated significant problems with impact protection in the area of the earcup of the SPH-4 aviator helmet. Efforts to develop a crushable earcup that will attenuate impact have resulted in development of two candidate earcups. This study compares the speech intelligibility characteristics of the two prototypes to those of the standard SPH-4 earcup and a proposed replacement earcup identified as the MK-1564. The results indicate that both crushable cups will provide speech intelligibility equal to or better than the standard cup.

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INTRODUCTION

The development of the SPH-4 aviator helmet has been recognized as a significant improvement in providing hearing protection and impact absorption for aviation personnel. However, it has been determined that impact protection is compromised significantly in the region of the earcup (Haley et al., 1983). In 1977, USAARL contracted with Simula Incorporated to develop an earcup capable of providing improved impact energy absorption while maintaining sound attenuation equal to or better than that required by the specification for the SPH-4. Sound attenuation results for that effort are reported in USAARL Report No. 84-2. Efforts to identify better and more economical "crushable" earcups have continued. Currently, there are two candidates, one made of aluminum and one made of Cycolac plastic.

Development also has been proceeding on an "improved" conventional earcup for the aviation community, the MK-1564 project. MK-1564 earcups are constructed from hard plastic as are the standard SPH-4 cups, but with different physical dimensions. These earcups were included in this evaluation.

This study focuses on the issue of speech intelligibility (the ability of the aviator to understand oral communication) with the experimental earcups. Recent studies (Mozo and Peters, 1984; and Nelson and Mozo, 1985) have demonstrated the impact of individual components on the overall performance of communications systems in difficult listening situations. The possibility was raised that changing the earcup could degrade the speech communications capability of the SPH-4 helmet. The effects on communications of the three experimental earcups when installed in the SPH-4 aviator helmet were compared to the current SPH-4 earcup.

METHODS AND MATERIALS

Twelve warrant officers with normal hearing were selected as listeners. They were required to have hearing thresholds for each ear no greater than 20 dB at the seven pure tone test frequencies. Listeners were evaluated for acceptability on a standard clinical audiometer (ANSI S3.6-1969). All listeners were used for each of the test conditions of the intelligibility evaluation.

The parameter of speech intelligibility of interest was the ability of the listener to understand speech while in a noise environment. The listeners wore the SPH-4 helmet fitted with the various earcups as described in Table 1. Speech intelligibility of each test condition was measured using lists of 50 phonetically balanced (PB) words. The lists of words used in this experiment are described in ANSI S3.2-1960 (R1971). A different PB word list was used for each of the four experimental conditions. All speaker conditions used words recorded by the same narrator who was seated in a simulated UH-60A helicopter noise environment. An octave band analysis of the noise spectrum is shown in Table 2. The listeners were required to listen to and transcribe the PB words while subjected to the same simulated background noise.

TABLE 1

CONDITIONS USED IN THE EVALUATION OF SPEECH INTELLIGIBILITY

Test condition	Listener condition	Speaker condition
1	Standard SPH-4 cup	SPH-4 microphone
2	Aluminum crushable	SPH-4 microphone
3	Cycolac crushable	SPH-4 microphone
4	MK-1564 prototype	SPH-4 microphone

TABLE 2

OCTAVE-BAND SOUND PRESSURE LEVEL OF THE SIMULATED UH-60A NOISE ENVIRONMENT

Octave-band center frequencies in Hertz

63	125	250	500	1K	2K	4K	8K	16K
97	97	98	95	89	88	82	83	80

The speech samples used in the experiment were recorded on a Nagra Model IV-SJ* magnetic tape recorder. Each sample list was reproduced and the output recorded on a Bruel and Kjaer (BK) Type 2307* graphic level recorder. From the level recordings, the signal intensity was determined and a 1000 Hertz (Hz) calibration tone was placed at the beginning of each list. Each subject was seated in the simulated noise environment during the test. The speech reception threshold (SRT) for each listening condition was determined to be the signal intensity at which a 50 percent correct response to spondee words was obtained under that test condition. All SRT presentations were made using commercially recorded speech samples. The SRT procedure was used to establish a consistent level of speech signal at the listener's ear for all test subjects. The PB word lists were presented through the test earphones at a level 10 dB above his SRT. This allowed an estimate of speech intelligibility for each condition relative to every other condition at equalized listener levels. The order of presentation of the test conditions was fully crossed.

It must be understood that the intelligibility estimates obtained may not represent scores achievable under conditions different from those tested. Since the test environment was a simulated condition, important variables which influence intelligibility could not be included such as stress, heat, competing tasks, vibration, and others.

The instrumentation used to present the PB words is shown in Figure 1. The Hewlett-Packard (HP) Model 239A* oscillator was used to generate a calibration tone at 1000

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*See Appendix A

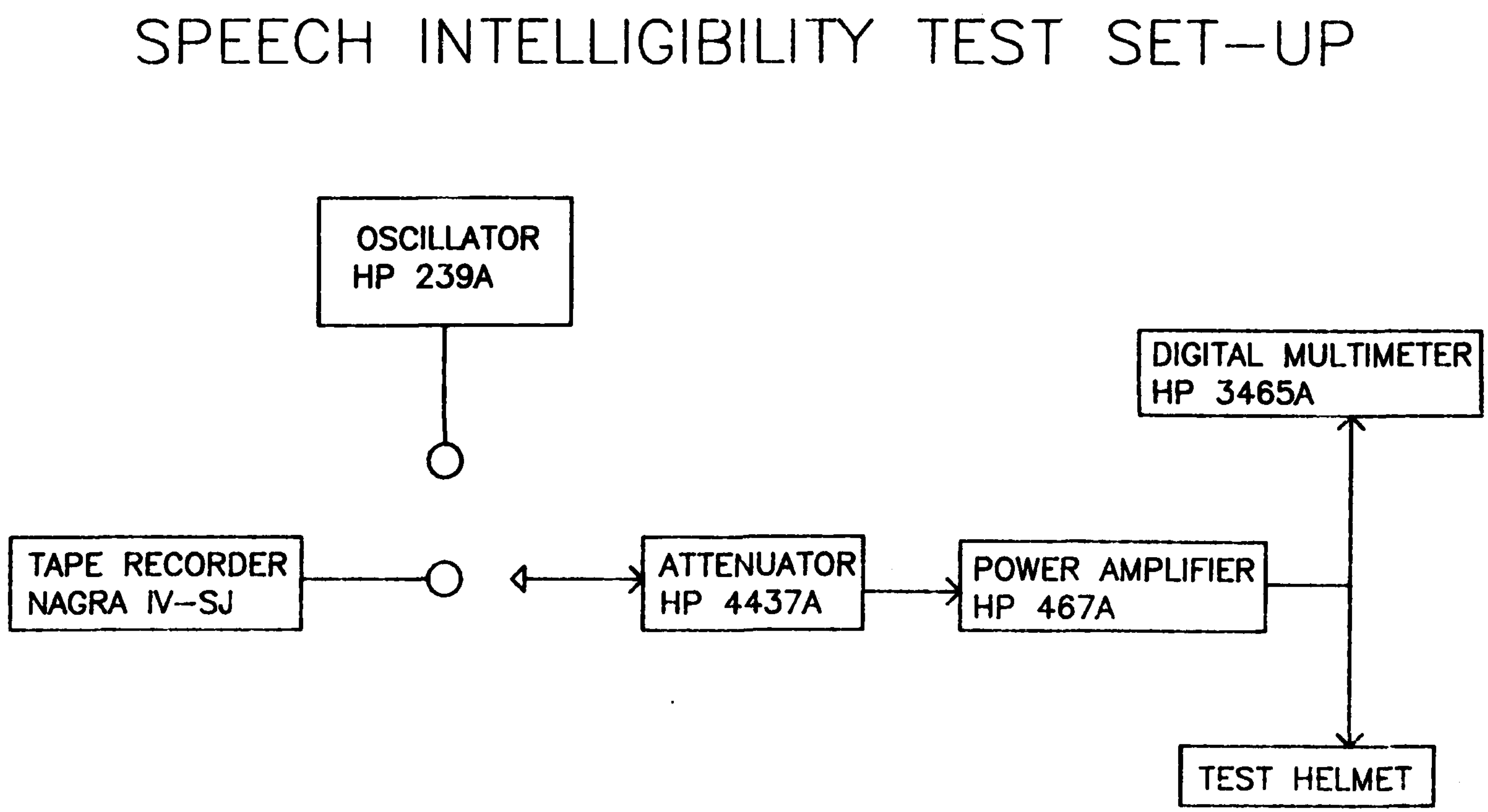

FIGURE 1. Speech intelligibility test setup.

Hertz. The HP Digital Multimeter, Model 3465A*, was used to set and monitor intensity. The word lists were reproduced using the same Nagra tape recorder specified. The intensity of the signal presented to the listeners was controlled by an HP Attenuator, Model 4437A*, and an HP Power Amplifier, Model 467A.

RESULTS AND DISCUSSION

The results of the evaluations are shown in Table 3.

TABLE 3

PERCENT CORRECT RESPONSES FOR EXPERIMENTAL LISTENER'S CONDITIONS, TALKER USING THE SPH-4 MICROPHONE

Earcup Test condition	Mean	Standard deviation
Standard SPH-4	55.2	11.10
Aluminum crushable	63.0	6.52
Cycolac crushable	55.7	11.59
MK-1564	47.7	12.03

Table 3 shows a comparison of the average percent correct responses of the listeners for each test condition while the speaker condition was held constant. A repeated measures one-way analysis of variance (ANOVA) as described by Winer (1962) was completed on the listener results. An a priori Type 1 error rate (α) of .05 was selected. The result of this analysis indicates a significant difference exists between the listener conditions ($F(3,44)=4.23$, $p<.010$).

A multiple comparison analysis was run using the Honestly Significant Difference (HSD) method described by Tukey (1949). An (α) of .05 was used with 44 degrees of freedom. The result was a Studentized range equal to 3.79 and an HSD value of 11.54. Table 4 contains a comparison of levels of significant differences between the experimental earcups. The letters represent factor levels which statistically are different from one another. The lowest level or mean is represented by the letter "A," with subsequent letters representing higher levels or means with statistically significant differences. As shown in Table 4, the standard SPH-4 and the Cycolac earcups are grouped together, but overlap both the aluminum and MK-1564, while the aluminum is significantly better than the MK-1564.

TABLE 4

TUKEY'S (HSD) MULTIPLE COMPARISON OF LISTENER'S INTELLIGIBILITY USING ALPHA = .05

	TEST CONDITION			
	Standard SPH-4	Aluminum crushable	Cycolac crushable	MK-1564
Level of separation	AB	B	AB	A

CONCLUSION AND RECOMMENDATION

It may '. concluded from this study that both the aluminum and cycolac crushable earcups provide as good or better speech communication capability as the standard SPH-4 earcup. Further, the MK-1564 provides significantly less communication capability than the aluminum earcup.

It is recommended that a cost analysis and selection process proceed immediately and that a crushable earcup be made standard for all aviator helmets used by DA personnel.

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