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Effects of the Advanced Combat Helmet (ACH) and Selected Communication and Hearing Protection Systems (C&HPSs) on Speech Communication: Talk-Through Systems

by Rachel A. Weatherless, Rhoda M. Wilson, Lamar Garrett, Tomasz R. Letowski, and Mary S. Binseel

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14. ABSTRACT
Communication in military settings must be clear and understandable to avoid possible fatal accidents and mistakes. Speech intelligibility is the overall quality of speech that makes it comprehensible. Intelligibility of speech depends on the properties of the talker, transmission channel, and the listener. The purpose of the reported study was to evaluate intelligibility of speech provided by five communication and hearing protection systems (C&HPSs) operating in talk-through mode. The systems evaluated in this study were the Product Improved-Combat Vehicle Crewman's (PI-CVC) helmet, Bose Improved Tactical Headset (ITH), Mine Safety Appliances-Sordin "Gen II" headset (Gen II), Communications Enhancement and Protection System (CEPS), and Combat Arms Earplugs (CAE). All systems except for the first one were worn with the Advanced Combat Helmet (ACH). The baseline conditions for assessing the communication data were bare head and the ACH worn alone. Results show that the ACH only, PI-CVC, and Gen II conditions provided significantly better speech intelligibility than the CAE and CEPS for the listeners participating in the study. Performance data for the ITH condition fell between the two groupings. Overall, the earplug-based communication systems (CAE and CEPS) resulted in lower performance and larger data variability than the earmuff-based systems. This larger variability could be attributed to poor repeatability in earplug insertion, which may be limited through more extensive training.

15. SUBJECT TERMS
ACH; CEPS; communication hearing protection; dismounted; Gen II; human factors; ITH; PI-CVC; speech intelligibility

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1. Introduction

1.1 Speech Intelligibility

Communication is the exchange of thoughts, messages, and information by speech, writing, behavior, or signals (Webster, 2002). Communication in military settings as well as in any other operational environment must be clear and understandable to avoid possible fatal accidents and mistakes.

Speech intelligibility is the overall quality of speech that makes it comprehensible. Speech intelligibility can be predicted to a limited extent by various technical measures of speech, but the ultimate criterion of speech intelligibility is the number of speech units correctly identified by the listener with normal hearing during specific operational conditions. The speech units can be phonemes, syllables, words, phrases, sentences, or passages (speech comprehension). The most common speech units used in testing transmission systems are words, and the transmission effectiveness of a system is scored as a percentage of words that are correctly identified by the listener (Syrdal, Bennet, & Greesnpan, 1994).

Overall effectiveness of speech communication depends on the properties of the talker, transmission channel, and the listener. Effective communication via speech requires clear speech by the talker, a non-restrictive transmission channel or medium, and good hearing and speech comprehension by the listener. These properties can be assessed individually or jointly and tested by various speech intelligibility tests. When they are considered individually, these properties are typically referred to as *speech articulation* (talker), *speech transmission* effectiveness (channel), and *speech recognition* (listener). Speech articulation and speech transmission effectiveness contribute to speech intelligibility by the listener. The main effects of the transmission system on speech intelligibility in the space are noise, reverberation, weather conditions (outdoors), and the effective distance between the talker and the listener (Rettinger, 1973; Harris & Swenson, 1990). In the case when speech communication is made through a radio channel, speech intelligibility is affected by the technical parameters of the channel (e.g., bandwidth, dynamic range), conditions of the electromagnetic wave propagation, and acoustic conditions on both sides of the channel.

In order to measure the effects of the transmission channel on speech intelligibility with the use of speech units, the potential effects of the talker and listener on the speech recognition scores need to be minimized. A common method of minimizing these effects is averaging transmission scores obtained with a number of talkers and listeners who have normal speech and normal hearing. The American National Standards Institute (ANSI) standard S3.2-1989 (R1999) (ANSI, 1999) specifies that at least five talkers and five listeners be used in such an evaluation, with the number of talkers being equal to or greater than the number of listeners. To minimize the natural differences in pronunciation and perception of words by talkers and listeners representing a diversified population, each listener needs to listen to each talker participating in the study.

1.2 Talk-Through Systems

A talk-through system is defined in this report as an element of a communications and hearing protection system (C&HPS) that allows the user to hear external sounds while wearing the C&HPS. The typical talk-through system is an electronic amplification system (active system) with an external microphone situated outside the hearing protector and a small loudspeaker situated inside the earmuff or in the ear canal of the listener. When the system is turned off, the hearing protection system is fully operational. When the system is turned on, sounds in the surrounding acoustic environment, which are not at levels that would cause hearing damage, are passed through the microphone and loudspeaker system to the ears of the listener. When the sounds in the environment exceed a predetermined safe level, the system is automatically shut off and hearing protection is fully engaged. Thus, the talk-through system can be considered a level-dependent (nonlinear) hearing protector that provides minimal attenuation in quiet environments and satisfactory hearing protection when sound intensity exceeds some safe limit. Soldiers use the talk-through capability of headset systems to hear their surroundings and to enhance auditory awareness.

The study involved comparison of five helmet-C&HPS combinations. Four electronic talk-through systems were evaluated. Three of the electronic systems were an earmuff-type (Product Improved-Combat Vehicle Crewman's (CVC) helmet, Bose improved tactical headset, and Mine Safety Appliances-Sordin "Gen II"), and one was an earplug-type system (Communications Enhancement and Protection System). The combat arms earplug (CAE), a passive talk-through system, was also evaluated in the current study. Such a system does not need signal amplification by an electronic device. The CAE is a nonlinear earplug with a small opening that allows sound to pass through when the sound level is relatively low (e.g., human voices), yet blocks high intensity impulse sounds, which are then attenuated by the earplug.

2. Objective

The goal of the present study was to determine the effects of various communication systems on speech communication effectiveness. This study was conducted at Fort Benning, Georgia, and was an extension of a study conducted by the U.S. Army Infantry Center to determine whether it was feasible for the Advanced Combat Helmet (ACH) with a tactical headset to replace (entirely or partly) the current CVC helmet for mounted Soldiers (Garrett et al., 2007). The goal of the present study was to evaluate the impact of all the systems tested in the U.S. Army Infantry Center study and the CAE on the Soldier's ability to communicate in a dismounted environment via live voice and the talk-through capability of the investigated communication systems.

3. Methodology

3.1 Participants

A group of five participants between 18 and 30 years of age served as talkers and listeners during the study. Participants were recruited from active duty military personnel from Fort Polk, Louisiana. All participants spoke American English and had normal hearing sensitivity defined as pure-tone air conduction threshold levels that were no poorer than 20 dB HL (hearing level) and no better than -10 dB HL at audiometric frequencies from 250 through 8000 Hz (ANSI, 1999). None of the participants had a history of speech or hearing pathology.

Audiometric testing was performed by a certified audiologist assigned to the test site. The test involved standardized clinical equipment and procedure. After completion of the hearing test, the volunteers whose hearing met the study criteria were invited to participate in the study and were asked to sign the volunteer agreement affidavit (VAA) (see appendix A). All questions and concerns of the participants were addressed before they signed the VAA. The participants were informed that they could withdraw from the study at any time.

3.2 Modified Rhyme Test

The speech intelligibility test used in this study was the Modified Rhyme Test (MRT). The MRT is one of three standardized word tests recommended by ANSI for measuring the intelligibility of speech over communication systems (ANSI, 1999). The MRT scores have been demonstrated to be highly correlated with results obtained with vocabularies representative of operational military communications (ANSI, 1999).

The MRT consists of 300 words divided into 50 six-word groups of monosyllabic consonant-vowel-consonant English words (House, Williams, Hecker, & Kryter, 1965). The words in each group sound very similar and differ only by initial or final phoneme. The first 25 groups differ by the initial phoneme and the remaining 25 groups by the final phoneme. The total number of words in the test is 275, with 25 words repeated in initial and final phoneme groups. A single administration of the test consists of a list of 50 target items—one word from each group. The words are spoken in a carrier phrase; the carrier phrase used in this study was "Mark the ____ now". During a single test trial, a target word is spoken by the talker and the listener selects which of the given six words in the group was the one that was spoken. Complete administration of the test includes six lists in which each of the 300 words is used as a target word. It is a closed set test with the probability of a correct guess equal to 1/6 (16.7%).

The goal of the MRT is to reveal the type of errors in discrimination of initial and final consonant sounds that the listeners make during specific test conditions. Listener responses can be scored as the fraction (percentage) of words heard correctly, the fractions (percentages) of initial and final phonemes heard correctly, or the frequencies of particular confusions of consonant sounds.

3.3 Tested Systems and Instrumentation

The study involved comparison of five communications systems:

1. Product Improved-CVC (PI-CVC) helmet;
2. ACH worn with Bose improved tactical headset (ITH);
3. ACH worn with Mine Safety Appliances (MSA)-Sordin “Gen II” (“Ranger Comms”) headset (Gen II);
4. ACH worn with Communications Enhancement and Protection System (CEPS);
5. ACH worn with CAE.

The systems listed were also compared to the ACH worn alone and to the bare head condition.

The PI-CVC (see figure 1) is an earmuff-type tanker helmet that provides hearing protection, radio communication, and ballistic protection (separate shell) for Soldiers in tracked vehicles. The ear cups house a talk-through system with forward oriented external microphones and earphones and provide passive and active noise reduction exceeding 30 dB across a wide frequency range.

The ACH (see figure 2) is the current infantry helmet of the U.S Army. It is manufactured by the MSA Company. It provides ballistic protection against fragmentation and 9-mm bullets. The physical extent of the helmet on the sides allows the wearer’s ear canals to be unoccluded and exposed to the direct sound. Its suspension systems consist of five to seven adjustable foam pads inside the helmet and a four-point harness with a nape strap as the retention system (McCarter, 2006).

The Bose ITH (see figure 3) is an earmuff-type communication system designed to protect Soldiers’ hearing (to 95+ dB A). The ITH has two (left and right) forward facing pass-through microphones and is designed to fit under the ACH. It provides hearing protection through active and passive noise reduction of about 25 dB (Larson, 2005). The ITH system is compatible with most common Army radio systems such as the Icom F43GS, the Motorola XTS 5000, and the multiband inter/intra-team radio.

The MSA-Sordin “Gen II” (see figure 4) earmuff-type headset provides attenuation of approximately 20 dB. The headset has talk-through capability with a volume control and two (left and right) forward oriented pass-through microphones.

Figure 1. PI-CVC helmet.

Figure 2. ACH.

Figure 3. Bose ITH.

Figure 4. MSA Sordin Gen II headset.

The CEPS (see figure 5) is an earplug-type C&HPS that provides talk-through capability through external microphones slightly extending from the ear canals and facing outward. It has a volume control and provides noise attenuation exceeding about 25 dB. An internal amplifier provides attenuation of about 12 dB.

The CAE (see figure 6) is a double-sided nonlinear hearing protection system that consists of two different types of earplugs, one for impulse sound (yellow plug) and one for continuous noise (olive drab plug) protection. The yellow side of the earplug attenuates impulse noise as high as 190 dB sound pressure level (SPL) peak while allowing most low volume speech communication to pass through. The olive drab side of the earplug attenuates steady state noises by about 25 dB. The CAE is the recommended hearing protection device for dismounted U.S. Army infantry troops (Navy Environmental Health Center, 2006).

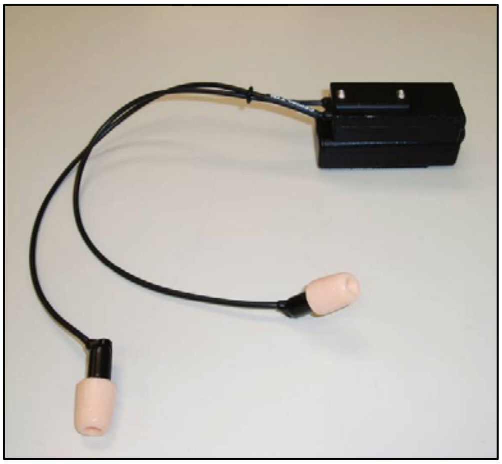

Figure 5. CEPS.

Figure 6. CAE.

All systems were tested in a background noise of a typical Baghdad urban environment noise ("Baghdad noise"), recorded in Baghdad in 2004. The noise was played from six small loud-speakers (Kloss, Lowe, and Hoffman Model No. 970A) situated behind the head of each of the four listeners and the talker. The noise level at each participant's location (with participant absent) was 60 dBA.

The instrumentation used during the study included

1. a timing device (flashing light) to aid the talker in maintaining a constant rate of speech (used during training);
2. a sound level meter (Radio Shack Model No. 33-205) to monitor the noise level in the testing room and help the talker maintain the same speech level during speaking;
3. a surround noise system including five loudspeakers with amplifiers and a CD player with a recording of the "Baghdad noise";
4. four listener stations (seats with small writing tables) and a talker station;
5. writing tablets, pens, and response sheets.

3.4 Anthropometrics and Fitting

In order to assign and appropriately fit the ACH and PI-CVC helmets to each of the participants of the study, several basic anthropometric measurements were taken. They included measures of head circumference, head length, head breadth, and bitragion coronal arc (measurement from ear to ear over the top of the head) (see figures 7 and 8). These measurements were made in accordance with Gordon et al. (1989). The anthropometric data were used to issue appropriate helmets for each participant. The participants were also instructed how to fit and wear both helmets correctly.

Figure 7. Anthropometric measurement of Soldier head circumference.

Figure 8. Anthropometric measurement of Soldier head breadth.

3.5 Orientation and Training

At the beginning of the study, all participants received an orientation about the testing procedure and the required task. The main goal of the training was to familiarize the participants with the MRT words and the way in which individual participants spoke these words. The ANSI S3.2-1989 (R1999) standard requires training of the talkers and the listeners. "Talkers must be trained until they have attained facility in synchronizing their utterance of the test words with the timing signals" (ANSI, 1999) and until they are thoroughly familiar with all the words. Participants were also thoroughly familiarized with the listener response sheets and response methodology (see section 3.6).

All the participants in this study performed as talkers and listeners, so training for both functions was combined into a two-day training session for all five participants. During the training, the participants were familiarized with the MRT words and gained the required level of proficiency in saying and recognizing MRT words in a quiet environment. Each talker and each listener participated in several MRT procedures and completed several MRT response forms. The talkers were trained to speak all the words at a consistent level and at a constant speech rate of about 10 to 12 words per minute. The precise voice level was not specified and the talkers were asked to talk at their most comfortable voice level across all compared devices. All major pronunciation errors made by the talkers were corrected by the trainers. In addition, talkers and listeners received feedback on each test item.

The average listeners' scores for each test item were calculated and this information was provided to the participants. In this way, talkers could improve diction for those words that were less intelligible to the listeners. The MRT training was completed when all listeners could score 90% or better on MRT lists pronounced by each talker in a quiet environment (background noise level below 35 dBA). The percent correct score obtained by each participant at the end of the training session was used as the baseline no-headgear no-noise condition (bare head). The final test included all 300 MRT words as the target words. The participants were also trained until proficient in the use of all the communication systems evaluated in the study.

3.6 Procedure

The study was conducted in an open area of the Conduct of Fire Trainer simulator room at Fort Benning. For any single condition, one Soldier served as a talker (see figure 9), and four Soldiers served as listeners (see figure 10). The four listeners sat in an arc facing the talker (see figure 11). The talker was seated in the center of the circle. The distance between the talker and the listeners was 3.75 m and the distance between each listener was approximately 0.5 m. During testing, the background noise was played from six small loudspeakers described in section 3.3.

Figure 9. Talker station.

Figure 10. Listener stations.

All systems were evaluated each day through six days of data collection. The talk-through mode of the systems was used for the PI-CVC (without ballistic shell) and the ACH with C&HPS. In the CAE condition, the yellow side of the CAE was used since it is analogous to the talk-through mode of the powered systems. The CEPS and Gen II talk-through systems have volume control capability. Participants were asked to adjust their own volume to the most comfortable listening level while an experimenter read a sample of words. The study was conducted via the pen-and-paper method of data collection. Examples of the MRT forms used by the listeners and the talker are included in appendices B and C.

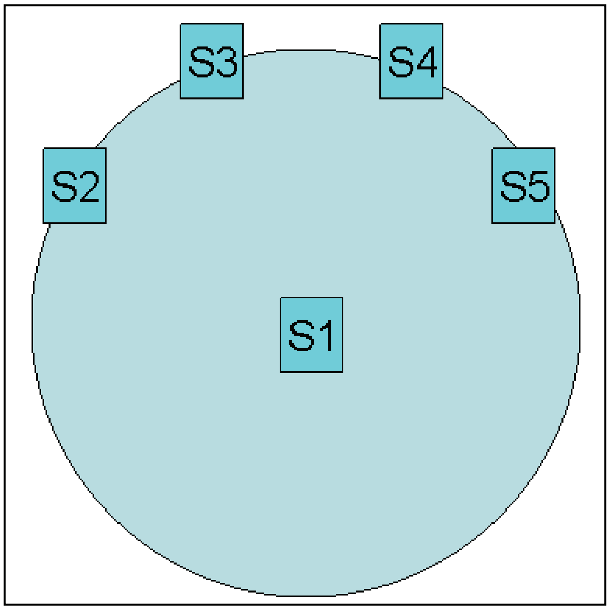

Figure 11. Spatial arrangement of the talker's position (S1) and listeners' positions (S2 through S5) in the study.

During a single test presentation, a talker read one of the lists of 50 words. Each participant of the study was rotated to serve as a talker as well as a listener in subsequent test presentations. The four non-talkers acted as listeners for all trials. Each list of 50 words took 3 to 4 minutes. After a single list was read, a different participant served as the talker. After all five participants had served as the talker, the participants were given a 15-minute break and then the same talker rotation was repeated with a different C&HPS. The daily session lasted 3 to 4 hours during which 30 individual tests were completed. Data collection was completed in six days during which each talker read all 300 MRT words through each of the communication systems.

4. Experimental Design

The study used a single factor (six equipment conditions) repeated measures design. The order of all presentations was counterbalanced. The independent variables were the communication systems. The dependent variable was the listener's percentage of correct responses (percent) in the MRT task. Because of the closed set nature of the MRT, all individual scores were adjusted for the probability of getting a correct response by chance according to the formula (ANSI, 1999)

$$R_A = R - \frac{W}{n-1} = R - \frac{W}{5},$$

in which R_A is the number of correct responses adjusted for chance, R is the number of correct responses, W is the number of incorrect responses, and n is the number of alternate choices per item (for the MRT, $n = 6$).

5. Results and Discussion

The effect of various communication systems assessed in this study was measured by the percentage of correctly identified MRT words for the entire 300-item word set. The average percent correct scores obtained by all participants with the individual systems are listed in table 1. The individual averages for talkers and listeners are shown in appendix D.

Table 1. Means and standard deviations for MRT word recognition scores obtained for all conditions evaluated in this study.

Test Conditions	Word Recognition Score		Environment
	Mean Score (percent)	**Standard Deviation (percent)**	
ACH with CEPS	65	12	Baghdad Noise
ACH with CAE	67	14	Baghdad Noise
ACH with ITH	70	13	Baghdad Noise
ACH with Gen II	75	10	Baghdad Noise
PI-CVC	76	12	Baghdad Noise
ACH only	80	10	Baghdad Noise
Bare head	90	6	Quiet

All tested helmet-C&HPSs combinations degraded speech intelligibility as compared to the best case no-headgear no-noise condition. The average speech intelligibility score obtained for the no-headgear no-noise (bare head in quiet) condition was 90%, whereas the best score obtained for any other condition was 80%. It is important to note that the bare head condition was performed in an ambient (quiet) noise condition, whereas all other conditions were evaluated in Baghdad noise.

5.1 Conditions

The differences in speech recognition scores between conditions tested in the study were analyzed with a mixed linear model analysis of variance (ANOVA) with repeated measures with the statistical package SPSS[1] 12.0 (SPSS, Inc., 2003). The data collected over the six-day period were combined since the initial analysis including "Day" did not show a significant effect on performance data (see section 5.2). To avoid potential ceiling effects, the data were transformed into rationalized arcsine units (raus) for the ANOVA (Studebaker, 1985). The effect of "Condition"

[1]SPSS (Statistical Package for the Social Sciences) is a registered trademark of SPSS, Inc.

was analyzed in a single factor ANOVA on seven conditions including the no-headgear no-noise condition. Two analyses were performed, one for talker and the other for listeners as the random effects. The "Condition" factor was significant in both the talker (F = 5.659, df = 6/30, $p = 0.001$) and the listener (F = 12.485, df = 6/30, $p = 0.0001$) analyses. The results of a *post hoc* pairwise analysis are shown in table 2. The difference between bare head and all other conditions was statistically significant at $p = 0.041$ for the talker random effect and at $p = 0.004$ for the listener random effect. In addition, the differences between systems are more distinct when averaged across listeners than across talkers. This seems to indicate that the differences among listeners were much smaller than the differences among talkers for the participants in this study. These differences were largely attributable to differences in voice quality and pitch since major differences in pronunciation were eliminated during training.

Table 2. Results of pairwise comparisons between various systems. (Listener data are shown in the upper right half of table. Talker data are shown in the lower left half of table. The symbol indicates statistically significant difference at the $p < 0.05$ level.)

	Bare head	**ACH**	**CVC**	**GEN II**	**ITH**	**CAE**	**CEPS**
Bare head		+	+	+	+	+	+
ACH	*				+	+	+
CVC	*					+	+
GEN II	*					+	+
ITH	*						
CAE	*	*					
CEPS	*	*	*	*			

No natural grouping of the six systems was evaluated in the study. However, for the listener analysis, ACH only, PI-CVC, and ACH with Gen II provided significantly better speech intelligibility than ACH with CAE and ACH with CEPS for the listeners participating in the study. Variability among talkers was too large to reveal groupings among the compared systems.

5.2 Day

A two-factor ANOVA on Condition (six systems) and Day (six days) with listener as the random variable was conducted to determine if the data collected for all systems were consistent across all six days. The results of the analysis confirmed a significant effect of Condition (F = 15.349, df = 5/20, $p = 0.0001$) but no significant effect of the Day (F = 1.771, df = 5/660, $p = 0.117$). This analysis validated summing of all the data across the entire study in condition analysis.

As discussed previously, there was no significant effect of Day on collected data. In addition, detailed analysis of day-by-day results for various systems did not reveal any clear pattern across the six-day data collection period. There was neither gradual improvement in speech recognition during initial days of data collection nor decrease in participant performance during the final days of data collection. The data for earmuff-based communication systems were very consistent across the test days. However, the data for both earplug-based communication systems showed much larger day-to-day variability. This indicates greater difficulty of the participant in fitting the earplug systems in a uniform manner and could have added some instability in earplug placement during the test sessions.

5.3 Listener

The speech recognition data obtained by individual listeners for specific talkers and systems are presented in figure 12. The individual scores vary from 52% to about 89%. The data shown in figure 12 show the large effect of the talker on the listener performance. All the listeners performed similarly across all the talkers and all the systems except for Listener 1 who performed better than the average on all the systems except for CEPS.

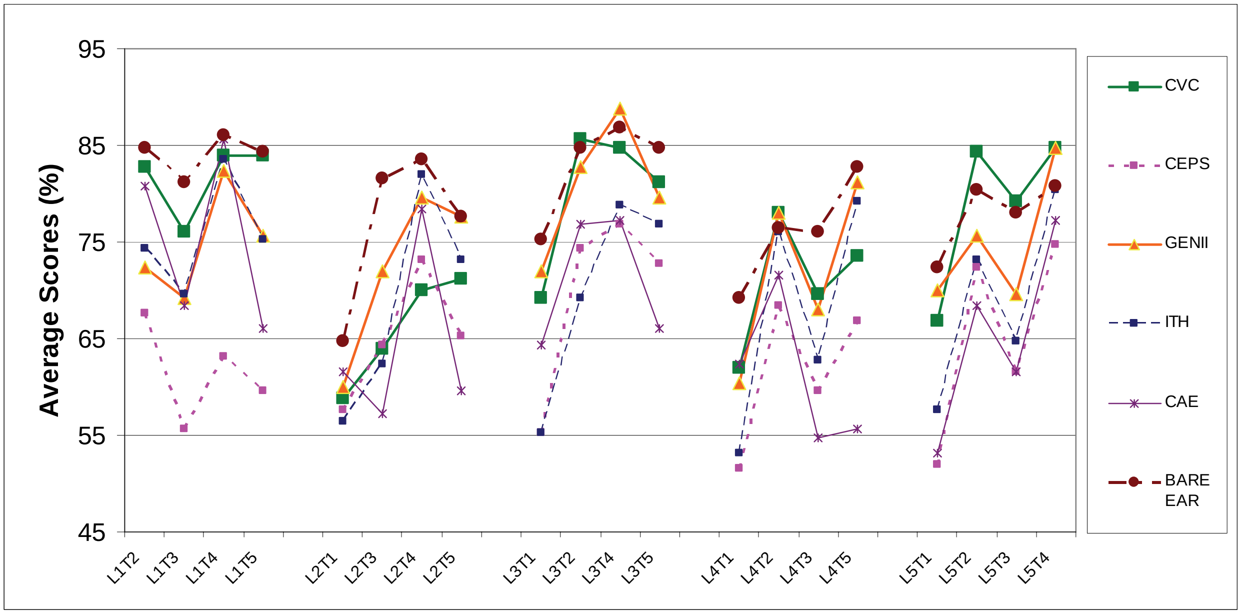

Figure 12. Listener-dependent scores (percent) for various talkers and communication systems.

5.4 Talker

The speech recognition data obtained with individual talkers for specific listeners and systems are presented in figure 13. The variability of data shown in figure 13 is much larger than variability of the data for the listeners shown in figure 12. Talkers 2 and 4 were more intelligible than the remaining talkers, with Talker 1 being the least intelligible. We assume that these differences were attributable to the natural variations in voice quality among the talkers, although some variations in pronunciation were not eliminated during the training. For example, Talker 1 had a very heavy local accent that affected intelligibility of his speech even when all his pronunciation errors were corrected during training. These data also indicate that very intelligible and very poor talkers make it difficult to reveal the differences between communication systems. Therefore, presented results support the need for using a variety of talkers in communication system evaluation.

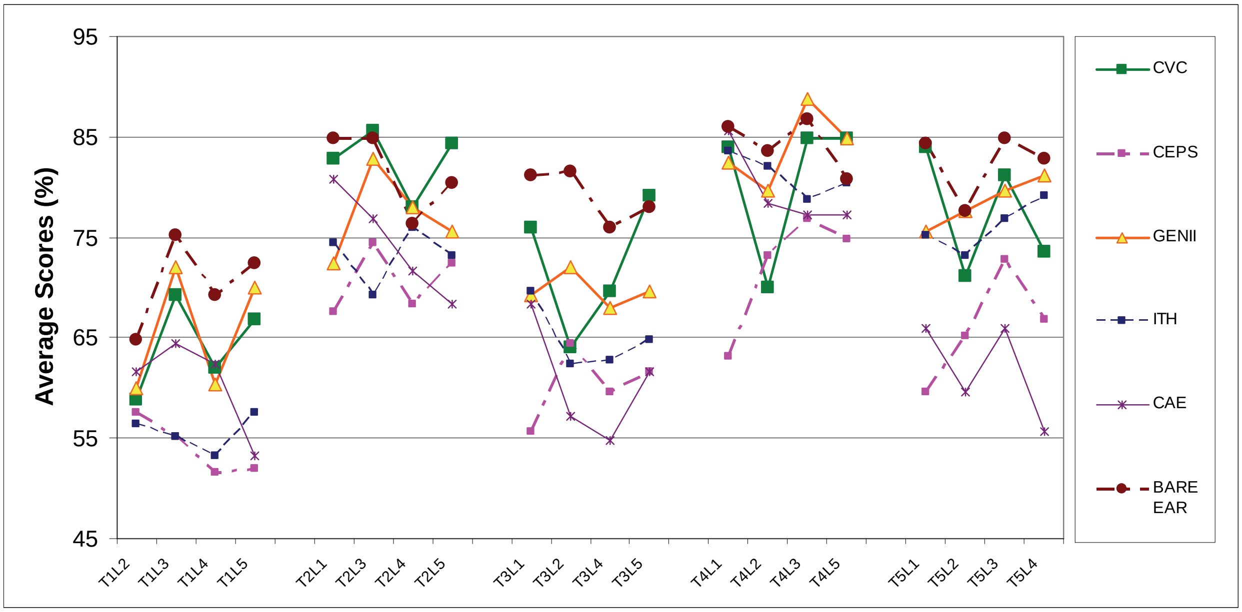

Figure 13. Talker-dependent scores (percent) for various listeners and communication systems.

6. Debriefing Session

Subjective comments were solicited from the participants in a debriefing session at the end of the study. Questions were asked about the positive and negative aspects of the individual communication systems on the speech intelligibility study and wearer comfort. Soldiers were also questioned about the changes they would like to see for improved performance and usability of the tested systems. Overall, the Soldiers considered the Gen II to be the best C&HPS system for reasons including comfort, fit, volume control capability, and clarity of the talk-through operation. The Gen II preference was consistent with performance data collected during the study. The CEPS was the least preferred system for reasons including poor talk-through operation and design issues. The specific comments provided by the Soldiers about the investigated systems are listed in table 3.

Table 3. Participants' debriefing comments.

Headgear	Positive	Negative	Recommended Changes
PI-CVC	Very comfortable Fits head well Easy to operate Clear communication	No comments	Needs volume control
ACH with ITH	Probably better suited for mounted situation	Difficulty donning and doffing Too fragile Not ideal for a combat situation	Change the Velcro[2] to provide a tighter secure fit with ACH Add a volume control knob Make more durable straps and toggle switch
ACH with Gen II	Easy to use and put on Comfortable fit Good communication and talk-through capability	Learning curve associated with properly donning the headset	Reduce the headset band Reduce earmuff size
ACH with CEPS	Good fit	Flimsy construction Difficulty securing to clothing and head Did not block background noise well Would be uncomfortable with double hearing protection	Too many wires Reduce the number of components for the system
CAE	More comfortable than previously issued earplugs	Somewhat uncomfortable for smaller ear canals	Should come in different sizes

7. Conclusions

The present study had several limitations related to the sample size, participant selection, and the duration of the training. However, within the constraints of the study, the following conclusions and observations can be made:

1. All investigated systems significantly affected speech intelligibility when compared to the baseline condition. However, this result may be because the baseline condition data were collected in a quiet environment whereas the other data were collected in the presence of noise.

2. The ACH only, PI-CVC, and ACH with Gen II conditions provided significantly better speech intelligibility than the ACH with CAE and ACH with CEPS conditions for the listeners participating in the study.

3. The participants' performance did not significantly change from one day to another across the six-day period of testing.

[2]Velcro is a registered trademark of Velcro USA, Inc.

4. The earplug-based communication systems (CAE and CEPS) resulted in larger data variability that the earmuff-based systems. This larger variability could be attributed to poor repeatability in earplug insertion.

5. Data variability across individual talkers was much larger than the data variability across listeners. Therefore, it is recommended that future studies include a diversified group of talkers and a more extensive training period.

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[3]CRC = Chemical Rubber Company

Appendix A. Volunteer Agreement Affidavit

VOLUNTEER AGREEMENT AFFIDAVIT:
ARL-HRED Local Adaptation of DA Form 5303-R. For use of this form, see AR 70-25 or AR 40-38

The proponent for this study is:	**U.S. Army Research Laboratory Human Research and Engineering Directorate Aberdeen Proving Ground, MD 21005**

Authority:	Privacy Act of 1974, 10 U.S.C. 3013, [Subject to the authority, direction, and control of the Secretary of Defense and subject to the provisions of chapter 6 of this title, the Secretary of the Army is responsible for, and has the authority necessary to conduct, all affairs of the Department of the Army, including the following functions: (4) Equipping (including research and development), 44 USC 3101 [The head of each Federal agency shall make and preserve records containing adequate and proper documentation of the organization, functions, policies, decisions, procedures, and essential transactions of the agency and designed to furnish the information necessary to protect the legal and financial rights of the Government and of persons directly affected by the agency's activities]
Principal purpose:	To document voluntary participation in the Research program.
Routine Uses:	The SSN and home address will be used for identification and locating purposes. Information derived from the project will be used for documentation, adjudication of claims, and mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State, and local agencies.
Disclosure:	The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this data collection.

Part A • Volunteer agreement affidavit for subjects in approved Department of Army research projects

Note: Volunteers are authorized medical care for any injury or disease that is the direct result of

participating in this project (under the provisions of AR 40-38 and AR 70-25).

Title of Research Project:	Speech Intelligibility Impact on Soldiers Wearing Various Helmets with Hearing Protection and Communication Equipment	
Human Use Protocol Log # Number:	**ARL-20098-06019**	
Principal Investigator:	Tomasz Letowski	Phone: (410) 278-5968 E-Mail: trl2@arl.army.mil
Associate Investigator(s)	Lamar Garrett Mary Binseel	Phone: (410) 278-3413 E-Mail: lgarrett@arl.army.mil Phone: (410) 278-5985 E-Mail: mbinseel@arl.army.mil
Location of Research:	Ft. Benning (GA), Ft.Knox (KY), or APG (MD)	
Dates of Participation:	3 April 2006 – 28 April 2006	

Part B • To be completed by the Principal Investigator

Note: Instruction for elements of the informed consent provided as detailed explanation in accordance with Appendix C, AR 40-38 or AR 70-25.

Purpose of the Study

This study will evaluate the intelligibility of speech transmitted through four communication systems used in Mounted and Dismounted conditions of operation.

Procedures

There are two operational scenarios used in the study: Mounted and Dismounted. You will be assigned to one of them. In the Mounted Scenario you will be seated in a moving M2 Bradley Infantry Fighting Vehicle (IFV) and in the Dismounted Scenario you will be seated in a room with background noise of 65 dB A level. In both scenarios you will work together with four other participants wearing various communication systems listening to the speech signals transmitted through the systems..

Your task will be to listen to speech test signals presented by a talker through communication systems and circle your answers on a paper form. The talker will be your colleague participating in the study. In some cases you will be asked to serve as a talker. You will conduct your task in a certain amount of a surrounding noise. Prior to the study you will participate in a two-day long training in pronouncing speech material and the used of the communication equipment being evaluated.

During the test, you will be the talker or one of the four listeners. Each single test will consist of 50 words presented by the talker in the carrier phrase “Mark the word ____, now”. The test item on the form will be indicated be a block of 6 words which are your possible choices. You will need to select and circle the word that you heard. If you are unsure of what you heard, make your best guess.

After presentation of 50 words by a talker, the test will be interrupted for a few minutes (e.g., the vehicle will be stopped) and another person becomes a talker. This procedure will be repeated five times, that is, until each of five people in your group serves as a talker. This block of tests will be followed by a longer break during which all participants change the communication equipment that they use and a new block of test will be run. There will be four blocks of tests per a daily session. The sessions will last about 6-7 hours in Mounted Scenario and 6-7 hours in Dismounted Scenario with ample time provided for breaks between individual tests. There will be 6 test sessions conducted--one session per day for 6 days.

Benefits

You will receive a free hearing test for participation in the study. No additional benefits other than satisfaction from participating in the study addressing well-being of the future U.S. Soldiers will be provided.

Participant’s Rights

Any published data will not reveal your identity. Your participation in this evaluation is voluntary. If you choose not to participate in this evaluation, or if later you wish to withdraw from any portion of it, you may do so without penalty. Military personnel are not subject to punishment under the Uniform Code of Military Justice for choosing not to take part as human subjects. No administrative sanctions can be taken against military or civilian personnel for choosing not to participate as human subjects. The furnishing of your social security number and home address is mandatory and necessary for identification and locating purposes to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this study.

Under the provisions of AR 40-38 and AR 70-25, volunteers are authorized all necessary medical care for injury or disease which is the proximate result of their participation in this study.

Risks

This study is of minimal risk to your health. The communication systems and other equipment you will use in this data collection are commonly encountered and in wide use. Under no circumstance, will you experience hazardous listening levels that exceed the limits determined by OSHA and the U.S. Army. If you feel uncomfortable during the study you may interrupt it or terminate your participation at any time.

Confidentiality

All data and information obtained about you will be considered privileged and held in confidence. Photographic or video images of you taken during this data collection will not be identified with any of your personal information (name, rank, or status). Complete confidentiality cannot be promised, particularly if you are a military service member, because information bearing on your health may be required to be reported to appropriate medical or command authorities. In addition, applicable regulations note the possibility that the U.S. Army Medical Research and Materiel Command (MRMC-RCQ) officials may inspect the records. At the end of the data collection, you will be debriefed on your results.

Disposition of Volunteer Agreement Affidavit

The Principal Investigator will retain the original signed Volunteer Agreement Affidavit and forward a photocopy of it to the Chair of the Human Use Committee after the data collection. The Principal Investigator or Associate Investigator will provide a copy of the signed and initialed Affidavit to you.

Contacts for Additional Assistance

If you have questions concerning your rights on research-related injury, or if you have any complaints about your treatment while participating in this study, you can contact:

Chair, Human Use Committee	OR	Office of the Chief Counsel
U.S. Army Research Laboratory		U.S. Army Research Laboratory
Human Research and Engineering Directorate		2800 Powder Mill Road
Aberdeen Proving Ground, MD 21005		Adelphi, MD 20783-1197
(520) 538-4705 or (DSN) 875-4705		(301) 394-1070 or (DSN) 290-1070

I do hereby volunteer to participate in the study described in this document. I have full capacity to consent and have attained my 18th birthday. The implications of my voluntary participation, duration, and purpose of the study, the methods and means by which it is to be conducted, and the inconveniences and hazards that may reasonably be expected have been explained to me. I have been given an opportunity to ask questions concerning this study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights or project related injury, I may contact the **ARL-HRED Human Use Committee Chairperson at Aberdeen Proving Ground, Maryland, USA by telephone at (520) 538-4705 or (DSN) 875-4705.** I understand that any published data will not reveal my identity. If I choose not to participate, or later wish to withdraw from any portion of it, I may do so without penalty. I understand that military personnel are not subject to punishment under the Uniform Code of Military Justice for choosing not to take part as human volunteers and that no administrative sanctions can be given me for choosing not to participate. I may at any time during the course of the project revoke my consent and withdraw without penalty or loss of benefits. However, I may be required (military volunteer) or requested (civilian volunteer) to undergo certain examinations if, in the opinion of an attending physician, such examinations are necessary for my health and well being.

Printed Name of Volunteer (First, MI., Last)	
Social Security Number (SSN)	**Permanent Address of Volunteer**
Date of Birth (Month, Day, Year)	
Today's Date (Month, Day, Year)	**Signature of Volunteer**
Signature of Administrator	

Appendix B. Example of Modified Rhyme Test Answer Form

Modified Rhyme Test (MRT) Answer Form

Listener: ______________________ Word List: __________ Date: _______________

1	bat	bad	back	bass	ban	bath
2	bean	beach	beat	beam	bead	beak
3	bub	bus	but	buff	buck	bug
4	came	cape	cane	cake	cave	case
5	cut	cub	cuff	cup	cud	cuss
6	dig	dip	did	dim	dill	din
7	duck	dud	dung	dub	dug	dun
8	fill	fig	fin	fizz	fib	fit
9	hear	heath	heal	heave	heat	heap
10	kick	king	kid	kit	kin	kill
11	late	lake	lay	lace	lane	lame
12	map	mat	math	man	mass	mad
13	page	pane	pace	pay	pale	pave
14	pass	pat	pack	pad	path	pan
15	peace	peas	peak	peal	peat	peach
16	pill	pick	pip	pig	pin	pit
17	pun	puff	pup	puck	pus	pub
18	rave	rake	race	rate	raze	ray
19	sake	sale	save	sane	safe	same
20	sad	sass	sag	sack	sap	sat
21	seep	seen	seethe	seed	seem	seek
22	sing	sit	sin	sip	sick	sill
23	sud	sum	sub	sun	sup	sung
24	tab	tan	tam	tang	tack	tap
25	teach	tear	tease	teal	team	teak
26	led	shed	red	bed	fed	wed
27	sold	told	hold	fold	gold	cold
28	dig	wig	big	rig	pig	fig
29	kick	lick	sick	pick	wick	tick
30	book	took	shook	cook	hook	look
31	hark	dark	mark	lark	park	bark
32	gale	male	tale	bale	sale	pale
33	peel	reel	feel	heel	keel	eel
34	will	hill	kill	till	fill	bill
35	foil	coil	boil	oil	toil	soil
36	fame	same	came	name	tame	game
37	ten	pen	den	hen	then	men
38	pin	sin	tin	win	din	fin
39	sun	nun	gun	fun	bun	run
40	rang	fang	gang	bang	sang	hang
41	tent	bent	went	dent	rent	sent
42	sip	rip	tip	dip	hip	lip
43	top	hop	pop	cop	mop	shop
44	meat	feat	heat	seat	beat	neat

45	kit	bit	fit	sit	wit	hit
46	hot	got	not	pot	lot	tot
47	nest	vest	west	test	best	rest
48	bust	just	rust	must	gust	dust
49	raw	paw	law	jaw	thaw	saw
50	way	may	say	day	day	pay

Appendix C. Example of Modified Rhyme Test Talker Form

Modified Rhyme Test (MRT) Talker Form

Talker: __________________________ Word List: __________ Date: _______________

1	bat
2	beak
3	buck
4	cape
5	cuff
6	did
7	dud
8	fig
9	heat
10	kick
11	lace
12	map
13	pay
14	pan
15	peak
16	pick
17	puck
18	race
19	sake
20	sat
21	seem
22	sick
23	sung
24	tam
25	teach

26	fed
27	hold
28	rig
29	sick
30	took
31	lark
32	pale
33	reel
34	will
35	soil
36	name
37	then
38	din
39	nun
40	rang
41	sent
42	dip
43	top
44	seat
45	hit
46	not
47	best
48	gust
49	paw
50	way

INTENTIONALLY LEFT BLANK

Appendix D. Individual Average Scores for Talker and Listener

Individual average scores for Talker and Listener for all C&HPSs.

	CVC				
Talker	L1	L2	L3	L4	L5
T1	X	58.8	69.2	62	66.8
T2	82.8	X	85.6	78	84.4
T3	76	64	X	69.6	79.2
T4	84	70	84.8	X	84.8
T5	84	71.2	81.2	73.6	X

	GEN II				
Talker	L1	L2	L3	L4	L5
T1	X	60	72	60.4	70
T2	72.4	X	82.8	78	75.6
T3	69.2	72	X	68	69.6
T4	82.4	79.6	88.8	X	84.8
T5	75.6	77.6	79.6	81.2	X

	CAE				
Talker	L1	L2	L3	L4	L5
T1	X	61.6	64.4	62.4	53.2
T2	80.8	X	76.8	71.6	68.4
T3	68.4	57.2	X	54.8	61.6
T4	85.6	78.4	77.2	X	77.2
T5	66	59.6	66	55.6	X

	CVC				
Listener	T1	T2	T3	T4	T5
L1	X	82.8	76	84	84
L2	58.8	X	64	70	71.2
L3	69.2	85.6	X	84.8	81.2
L4	62	78	69.6	X	73.6
L5	66.8	84.4	79.2	84.8	X

	GEN II				
Listener	T1	T2	T3	T4	T5
L1	X	72.4	69.2	82.4	75.6
L2	60	X	72	79.6	77.6
L3	72	82.8	X	88.8	79.6
L4	60.4	78	68	X	81.2
L5	70	75.6	69.6	84.8	X

	CAE				
Listener	T1	T2	T3	T4	T5
L1	X	80.8	68.4	85.6	66
L2	61.6	X	57.2	78.4	59.6
L3	64.4	76.8	X	77.2	66
L4	62.4	71.6	54.8	X	55.6
L5	53.2	68.4	61.6	77.2	X

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	CEPS				
Talker	L1	L2	L3	L4	L5
T1	X	57.6	55.2	51.6	52
T2	67.6	X	74.4	68.4	72.4
T3	55.6	64.4	X	59.6	61.6
T4	63.2	73.2	76.8	X	74.8
T5	59.6	65.2	72.8	66.8	X

	ITH				
Talker	L1	L2	L3	L4	L5
T1	X	56.4	55.2	53.2	57.6
T2	74.4	X	69.2	76	73.2
T3	69.6	62.4	X	62.8	64.8
T4	83.6	82	78.8	X	80.4
T5	75.2	73.2	76.8	79.2	X

	ACH ONLY (BARE EAR)				
Talker	L1	L2	L3	L4	L5
T1	X	64.8	75.2	69.2	72.4
T2	84.8	X	84.8	76.4	80.4
T3	81.2	81.6	X	76	78
T4	86	83.6	86.8	X	80.8
T5	84.4	77.6	84.8	82.8	X

	CEPS				
Listener	T1	T2	T3	T4	T5
L1	X	67.6	55.6	63.2	59.6
L2	57.6	X	64.4	73.2	65.2
L3	55.2	74.4	X	76.8	72.8
L4	51.6	68.4	59.6	X	66.8
L5	52	72.4	61.6	74.8	X

	ITH				
Listener	T1	T2	T3	T4	T5
L1	X	74.4	69.6	83.6	75.2
L2	56.4	X	62.4	82	73.2
L3	55.2	69.2	X	78.8	76.8
L4	53.2	76	62.8	X	79.2
L5	57.6	73.2	64.8	80.4	X

	ACH ONLY (BARE EAR)				
Listener	T1	T2	T3	T4	T5
L1	X	84.8	81.2	86	84.4
L2	64.8	X	81.6	83.6	77.6
L3	75.2	84.8	X	86.8	84.8
L4	69.2	76.4	76	X	82.8
L5	72.4	80.4	78	80.8	X

Individual average scores for baseline bare head condition by Talker and Listener

	Listener				
Talker	L1	L2	L3	L4	L5
T1	X	92.2	85.2	84.8	85.2
T2	90.8	X	94.8	92.4	90
T3	91.2	88	X	90	86.8
T4	92.8	92.8	94.8	X	94.8
T5	87.2	90.8	92.4	92.4	X

	Talker				
Listener	T1	T2	T3	T4	T5
L1	X	90.8	91.2	92.8	87.2
L2	92.2	X	88	92.8	90.8
L3	85.2	94.8	X	94.8	92.4
L4	84.8	92.4	90	X	92.4
L5	85.2	90	86.8	94.8	X

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