Bone Conduction Microphone: A Head Mapping Pilot Study

Rafael N. Patrick
Embry-Riddle Aeronautical University

Follow this and additional works at: https://commons.erau.edu/mcnair

Recommended Citation
Available at: https://commons.erau.edu/mcnair/vol1/iss1/11

This Article is brought to you for free and open access by the Journals at Scholarly Commons. It has been accepted for inclusion in McNair Scholars Research Journal by an authorized administrator of Scholarly Commons. For more information, please contact commons@erau.edu, wolfe309@erau.edu.
Rafael N. Patrick

Mr. Rafael N. Patrick currently has a degree in Human Factors and Psychology and is expected to complete a M.S. in Human Factors and Systems in May 2010 from Embry-Riddle Aeronautical University. After completing his M.S., he plans to gain valuable hands-on experience working in the Aerospace Industry prior to pursuing a Ph. D. in Industrial and Organizational Psychology with a concentration in training and simulation for humans performing in extreme environments. He is currently conducting research in the realm of Bone Conduction Communication and Human Performance in Extreme Environments. Mr. Patrick has published and presented at a number of professional conferences throughout his educational career at Embry-Riddle. In 2008, he presented at the 6th Annual Meeting of the Society for Human Performance in Extreme Environments in New York City, the Florida Student Conference of Human Factors and Applied Psychology, and the McNair Scholars Research Conference at the University of Maryland – College Park.

Bone Conduction Microphone: A Head Mapping Pilot Study

Major: Human Factors and Systems

Mentor: Maranda McBride

Abstract

This study looked at the intelligibility of vocal signals previously recorded via bone conduction (BC) microphones. This research sought to explore the clarity of BC microphone signals transmitted through predetermined locations on the skull. The positioning of the BC microphone was distributed throughout eight different locations, where each location was deemed significant through prior studies. A total number of twelve ERAU college students were randomly selected to participate in the study. Since the study utilized a within-subject design, each participant was exposed to recording from each of the BC microphone locations. The recording consisted of ten scripted words with each word presented to the participant using both male and female voices. The signals were transmitted to the participant through a BC vibrator headset. This study’s results will provide evidence on whether or not BC communication devices can be used as an effective means of communication.

Introduction

In an extreme environment soldiers are expected to have the capability to interact with team members via two-way radio communication in an attempt to navigate through
dangerous situations, without compromising awareness of the acoustic environment. At this point in time, the main mode of communication between soldiers in a combat situation is through air conduction (AC) communication. “In the case of AC communication, sounds are transmitted from a talker to a microphone and from a loudspeaker or an earphone to the listener’s ear,” (McBride, 2005). In the case of AC communication, sounds are required to navigate a three-step process in order for an individual to recognize the stimuli. Sounds are initially collected from the environment by way of the pinna, commonly known as the ear. Following the collection of sound waves, they are then funneled by the pinna into the ear canal. Once sound waves reach the tympanic membrane (eardrum), which is said to be an imaginary division between the outer and middle ear, sound waves are then distributed between three tiny bones called ossicles. The malleus, incus, and stapes are responsible for amplifying sound waves and transmitting these vibrations to the oval window. The oval window is the dividing point for the middle and inner ear. Within the inner ear, complex components of the cochlea are responsible for transferring sound waves into neural signals that can be further interpreted by the brain, (Wolfe, 2006).

AC communication is the basic means of hearing and is widely understood in the realm of communication. An alternative to two-way AC communication is what is known as bone conduction (BC) communication. BC communication is when sounds are transmitted through vibrations from the skull of the talker to a contact microphone and from a vibrator to the skull of the listener, (McBride, 2005). BC communication reduces the three step AC process and primarily utilizes portions of the middle ear and directly stimulates components of the inner ear, such as the ossicles and cochlea. BC communication is an attractive alternative to communications in extreme environments because the transducers are lightweight, inconspicuous, and allows for a free range of motion for users. In combat situations, BC communication devices have been proven to successfully transmit the necessary radio communications in both quiet and high noise environments, especially when combined with an appropriate hearing protection system, (Letowski et al., 2004, 2005).

The main objective of the present study was to explore the clarity of BC microphone signals transmitted through predetermined locations on the skull and to
identify which BC microphone locations produce the greatest intelligibility for listeners. The reported study is in conjunction with a broader research program intended to determine the optimum number and locations of BC devices, both vibrators and contact microphones, for use in radio communication interfaces.

**Methods**

**Participants**

Twelve Embry-Riddle Aeronautical University students volunteered to participate in the study. Participants ranged in ages between 19 and 23 years old. In an attempt to increase participant motivation, each received compensation upon completion of the study. Prior to the start of the study all participants were screened for normal hearing ($\leq 20$ db) of pure-tone octave frequencies from 250 Hz through 8000 Hz and hearing symmetry within 10 dB for all signals. The audiometric tests were conducted with an Interacoustics clinical audiometer AC40, Telephonic TDH-39 earphones, and a response button. Each participant was tested in a sound-treated booth, which reduced the amount of external interferences. In addition, demographic information (name, age, known hearing complications, etc) was collected from each participant as well as a signed and dated consent forms.

**Procedure**

Upon completion of all the necessary paperwork and preliminary hearing tests, participants were instructed to remain seated in the sound treated booth to begin the experiment. Since the study utilized a within subject design, each participant was exposed to recordings from each of the BC microphone locations. The signals used were previously recorded from the Chin, Forehead, Temple, Fz, Mastoid, Inion, Vertex, and Collar Bone. The BC headset was positioned on the participant’s Condyle. The stimulus was presented to the participant in the form of a single word verbal recording. The order of stimuli was selected at random to allow for variability and to eliminate bias. The experiment required each participant to partake in a subjective ratings test to determine the intelligibility of signals transmitted through the BC headset. The test consisted of 20 prerecorded words, both male and females voices, presented to the participant 4 times.
from each of the 8 locations, resulting in 32 exposures per word. The intelligibility test was designed in such a way that signals were first presented to the participant through the perspective headset, then immediately prompts the user to subjectively identify on a rating scale, the intelligibility of the signal. Figure 1 is a visual representation of the intelligibility user interface. The scale ranged from 0 – 100: 0 signifying very difficult to understand while 100 signifying very easy to understand, with increasing increments of 10.

![Intelligibility Test Interface](image)

**Figure 1: Intelligibility Test Interface**

### Data Analysis and Results

Upon completion of the experiment, all data was complied and run through statistics software, (SPSS 14 ®). A two way ANOVA was used to determine whether or not selected BC microphone locations created significant levels of intelligibility, where male and female genders were the two factors and the 8 locations as levels. Results showed that the location with the greatest intelligibility was the forehead, with an 80% subjective rating, while the collar bone produced the lowest intelligibility with a mean score of 26% of subjective ratings. Results also found that there were distinct locations, which showed little to no difference from one another. This means that such locations may be interchangeable with a minimal difference in intelligibility. Such locations included the Mastoid and the Fz, Mastoid and Inion, and the Fz and Inion.
Implications

During a hostile situation, military personal are required to clearly understand detailed directions from commanding officers’. Often background noise is an issue that may compromise intelligibility. This study looks into alternative means of communication, through the use of bone conduction headset technology. Based on the results of the study, BC headset has shown promising results of high quality intelligibility amongst users. In addition, the results of this study also showed the differences in intelligibility between specific locations on the skull, through the use of a bone conduction communication device. In addition to increased intelligibility, soldiers using BC communication have the capability of communicating with perspective teams without compromising acoustic awareness of the external environment. The ability to do so in a combat situation can allow soldiers to continue constant two-way radio communication without compromising their locations.
References


