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ORIGINAL RESEARCH

Use of a Parabolic Microphone to Detect Hidden Subjects in Search and Rescue

Nathaniel L. Bowditch, MS; Stanley K. Searing, BS; Jeffrey A. Thomas, BS; Peggy K. Thompson, BS; Jacqueline N. Tubis, MS (Hons.) CANTAB; Sylvia P. Bowditch, BA

From the Santa Clara County (California) Sheriff's Search & Rescue Team, San Jose, CA (Mr. Bowditch, Mr. Searing, Mr. Thomas, Ms. Thompson, and Ms. Tubis); and the California Northstate University, Elk Grove, CA (Ms. Bowditch).

Introduction—This study compares a parabolic microphone to unaided hearing in detecting and comprehending hidden callers at ranges of 322 to 2510 m.

Methods—Eight subjects were placed 322 to 2510 m away from a central listening point. The subjects were concealed, and their calling volume was calibrated. In random order, subjects were asked to call the name of a state for 5 minutes. Listeners with parabolic microphones and others with unaided hearing recorded the direction of the call (detection) and name of the state (comprehension).

Results—The parabolic microphone was superior to unaided hearing in both detecting subjects and comprehending their calls, with an effect size (Cohen's d) of 1.58 for detection and 1.55 for comprehension. For each of the 8 hidden subjects, there were 24 detection attempts with the parabolic microphone and 54 to 60 attempts by unaided listeners. At the longer distances (1529–2510 m), the parabolic microphone was better at detecting callers (83% vs 51%; $P<0.00001$ by χ^2) and comprehension (57% vs 12%; $P<0.00001$). At the shorter distances (322–1190 m), the parabolic microphone offered advantages in detection (100% vs 83%; P=0.000023) and comprehension (86% vs 51%; $P<0.00001$), although not as pronounced as at the longer distances.

Conclusions—Use of a 66-cm (26-inch) parabolic microphone significantly improved detection and comprehension of hidden calling subjects at distances between 322 and 2510 m when compared with unaided hearing. This study supports the use of a parabolic microphone in search and rescue to locate responsive subjects in favorable weather and terrain.

Keywords: lost person, sound localization, listening aid, audible, hearing

Background

During a missing person search in a rural or wilderness environment, the incident commander will typically divide the search territory into distinct areas with boundaries defined by physical objects (eg, a creek or trail) or global positioning system coordinates.[1] Ground search teams will be assigned a specific area and asked to conduct a search that results in a specified success rate (eg, 80% probability of detection) for a defined subject status (ie, responsive or unresponsive).[2,3] As areas are searched and searchers debriefed, the search may expand to new areas. Conversely, if signs from the search (such as tracks or a dog alert) or other sources (such as eyewitness accounts) point to a specific area, more and/or different resources may be assigned to that area.

If there is any hope that the subject is responsive, ground search teams are trained to call the subject's name and listen for a response.[4] Subjects are often heard before they are detected by other means. However, there are no published studies documenting the distances over which calling subjects can be heard. Additionally, devices that improve sound detection have not been studied in search and rescue and are not used in practice.

A parabolic microphone uses a parabolic reflector to collect and focus sound waves into a microphone, much in the same way a parabolic antenna (eg, satellite dish) focuses radio waves. The sound input into the microphone is processed and sent to headphones worn by the user. The extent of sound enhancement is proportional to

Corresponding author: Nathaniel L. Bowditch, MS, Santa Clara County (California) Sheriff's Search & Rescue Team, 55 West Younger Ave., San Jose, CA 95110; e-mail: nat1058@yahoo.com.

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Table 1. Distances, compass bearings, and elevations of the 8 subject locations

Location	*Distance from listening point (m)*	*Compass direction from listening point*	*Elevation (m)*
1	322	208	263
2	627	245	274
3	1045	109	445
4	1190	97	533
5	1529	09	448
6	1851	50	622
7	2155	352	497
8	2510	358	558

The listening post elevation was 195 m.

the square of the diameter of the parabolic microphone. Thus, a 66-cm (26-in) parabolic microphone (the largest standard size) will be approximately 2.6 times as sensitive as a 41-cm (16-in) parabolic microphone. Parabolic microphones are routinely used on the sidelines of televised football games. Sound technicians aim the microphones toward the players, and the collected sound becomes part of the televised broadcast. Additionally, ornithologists use parabolic microphones to record bird calls.[5] We are not aware of any published study that has evaluated parabolic microphone use in search and rescue.

This study compares a 66-cm parabolic microphone (Klover Products, Janesville, WI) to unaided hearing in detecting and comprehending the calls of hidden subjects in favorable conditions and terrain.

Methods

This study was conducted on April 9, 2017 from 1015 to 1602 hours at a private ranch in California by members of the Santa Clara County Sheriff's Search & Rescue Team. A centralized listening point was set up in a grassy field. Eight subject locations were identified, all at different distances and compass bearings from the listening point. All subject locations were at higher elevations than the listening point, and each had a direct line of sight to the listening point. Each location also allowed the subject to be concealed (eg, hidden behind bushes) so that listeners could only rely on sound to locate the subjects. These subject locations were located around a 253 degree arc from the listening point. Distances, elevations, and compass bearings were determined by global positioning system (Garmin GPSMAP 60CSx; Garmin Inc, Olathe, KS). The distances from the listening point, and the elevations for each, are shown in Table 1. The locations and distances are shown graphically in Figure 1.

Immediately before deployment, each of the 8 subjects was asked to call 5 m away from a sound meter and was provided feedback ("louder, quieter") until they were calling at 75±2 dB. They were then asked to call at the same level once deployed. There was no additional calibration during or after the test. A Quest 211A sound meter (serial number 703010V; 3M Corp. Minneapolis, MN) was used for the calibration. Each subject was given a radio and a sheet of paper with 3 call signs (ie, letters the subject would answer to over the radio such as A, L, and W) and state names (eg, Michigan, North Dakota, and Arizona) associated with each call sign. A radio operator located at the listening point would call a given call sign and instruct the subject to start calling the name of the state associated with that call sign. The subject would do so approximately every 3 s for 5 min. At the end of 5 min (tracked by a timekeeper at the listening point), the radio operator would tell the subject to stop calling. If all listeners signaled the timekeeper that they had heard the call and recorded their results, the timekeeper would tell the subject to stop calling before 5 min. This was common with the subjects who were closer to the listener.

The order in which the subjects called was predetermined and random. In a given sequence, the first calling subject might call "Arizona" from 2155 m; the second might call "New Hampshire" from 1190 m. The order of the callers was independent of where each was located (by compass direction). Importantly, no one at the listening point knew the spot from which a given subject was calling, so no one could bias the listeners toward a particular direction. Furthermore, when a second set of subjects replaced the first set halfway through the day, all of the call signs, names of states being called, and the order of calling were changed so that new listeners (who were previously subjects) could not use the information they had gained in calling to bias the results as listeners.

A hill near the listening post was too close to conceal a subject from the listeners. The listeners were informed that there were no subjects located on this hill (between 260 and 340 degrees). Thus, the arc of potential subjects