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Title: Improving Communication for Miners Wearing Hearing Protection: Algorithms for Mine Machinery Noises

Organization: University of Connecticut Health Center

Principal Investigator: Anthony Brammer

Topic: Health and Safety Interventions, Personal Protective Equipment

According to the National Institute for Occupational Safety and Health, one in four miners has a hearing problem and, by retirement age, four out of five mine workers have impaired hearing. Studies have documented that many miners exposed to noise are unwilling to wear hearing protection for fear of failing to understand speech or hear warning sounds. During the last twenty years, specialized electronic hearing protectors (HPDs) have been developed to automatically adjust the amount of hearing protection in situations in which noise levels change with time, such as when walking towards or around a machine or when a nearby machine stops operating. Unfortunately, at the present state of development, these devices fail to improve the intelligibility of speech in the noises commonly leading to overexposure in a mine (i.e., continuous mining machines, roof bolting machines, longwall miners) compared to when conventional hearing protectors are worn.

We have recently completed an Alpha Foundation Proof-of-Concept Technology Development project entitled "Improving Communication in Noise for Miners Wearing Hearing Protection" (AFC518-10). The primary challenge for the research was to develop an algorithm for use in an electronic HPD that could distinguish desired sounds buried in environmental noise from the noise. We summarized the performance of our best algorithm as: i) a demonstrable improvement in speech intelligibility when tested in speech-spectrum shaped noise at one signal-to-noise ratio (SNR): ii) no statistically significant effect on the intelligibility of speech in the absence of noise, and: iii) an increase in warning sound SNR, which implies improved audibility of a tonal back-up alarm. We also noted that the performance of the algorithms remains to be established for different talkers, different environmental noises, different sound levels, and different SNRs.

This proposal has been prepared at the request of the Alpha Foundation to address "further proof-of-concept development such that it can reach a level whereby sufficient confidence can be ascertained to justify continued advancement to a functional prototype that could be demonstrated in an actual mine or high-fidelity simulated mine environment". We therefore propose to continue algorithm development specifically for mine machinery noises, which will be simulated from their published frequency spectra as they would be heard by a miner wearing a hearing protector. Promising algorithms will be evaluated at different SNRs, and different noise levels. The effect of varying sound levels (e.g., continuous miner) and intermittent operation of a machine (e.g., roofbolter) will also be simulated. The performance of the algorithms will be determined by subjects in listening tests. The Modified Rhyme Test (MRT), a word test of consonant confusion used extensively for its relevance to critical communications in which a single word error could have serious consequences (e.g., air traffic control, military and first responder operations, etc.), will be employed for this purpose. The MRT will consist of 25-, 50-, or 75-word trials with a pause between each trial. The number of trials and subjects will be determined by the desired resolution of the test. The duration of the pauses and/or number of trials will be adjusted to enable the effect on speech communication of a mine machine starting, stopping or changing operation to be evaluated. The change in speech intelligibility when an algorithm is employed will be established by comparison with an MRT undertaken without signal processing. Hence it will be necessary for the varying and intermittent noises to be identical and time synchronized for the two test conditions. The statistical significance of the difference between mean word scores for the two test conditions will be assessed by a two-sided t-test. The subjects for the study will be males and females with normal hearing. Listening tests will be conducted in our audiometric booth with subjects wearing insert earphones.

Based on the work conducted to date, we continue to believe that, with additional funding, a working prototype can be developed. Assuming the work proposed in this proposal is successfully completed, a way forward will need to involve a number of activities, including: obtaining recordings of typical noises occurring in mines; recording a corpus of MRT phrases when the talker is talking loudly or shouting (as will occur close to noisy machines); evaluating and fine-tuning

algorithms at elevated voice levels; developing a hardware implementation of selected algorithms; constructing a packaged, portable unit with integrated electronics to enable the algorithms to be connected to a hearing protector when "worn" initially by a dummy head (to avoid injury from algorithm malfunction), and finally; constructing a wearable unit suitable for evaluation by a miner or trainee in a simulated mining environment.