Title: Integrating Auditory and Visual Information to Improve Hearing Aids
Principal Investigator: Peter G. Jacobs
Funding Agency: VA RR&D
Timeline: Two years from funding date (Submitted June 2010)
Objectives: Nearly everyone benefits from visual cues (seeing a speaker's face) when trying to communicate with another person in a noisy environment such as a busy restaurant or party. The improvement in understanding speech in a noisy environment when given visual cues can be as high as an 18 dB increase in equivalent SNR. And a 60% improvement in word recognition can be achieved in a noisy environment when adding visual cues as compared with presentation of the audio information alone. However, this benefit from visual cues is variable across the population, and is reduced or eliminated altogether in people with aging eyes and ears, or those who have significant dual sensory losses. The objective of the research described in this proposal is to develop and evaluate a new signal processing approach where audio and visual information are fused together to ultimately improve speech intelligibility in noise for Veterans who suffer from dual-sensory hearing and vision loss as well as those subjects who suffer from hearing loss alone. The dual-sensory assist technology described here uses the relevant visual information observed on a speaker's face such as lip movement to more accurately identify and amplify target speech while suppressing noise. Even poor lip-readers, including those with vision loss may then benefit from this technology because improved signal-to-noise ratio has been shown to improve speech intelligibility scores.
Plan: The algorithm that is being developed in this project is called the "visually enhanced auditory filtering" (VEAF) algorithm. The algorithm fuses visual cues including lip and facial movement with auditory information to dynamically generate an auditory filter. This dynamic filter only allows audio data that correlates with the visual cues to enter the patient's ear. In this way, speech is allowed to pass through while noise is suppressed. The first year of the project involves further development and refinement of the VEAF algorithm as well as the generation of the audio-visual speech corpus. Refinement of the algorithm will include performance optimization to enable the algorithm to function in a real-time hearing aid environment. The second year of the project will involve clinical evaluation of the VEAF technology.
Methods: The project will include two areas of research: development and clinical evaluation. Phase 1 will include development of both the audio-visual speech corpus and also further development of the VEAF technology. The Phase II part of this study will involve evaluating the efficacy of the VEAF algorithm in improving patients' ability to comprehend speech in noise. A total of 36 subjects will be recruited from the Portland VA Medical Center hospital. Half of the subjects will have hearing impairment and half will have normal hearing. The subjects will be given a simple speech-in-noise test to evaluate at what noise level they are identifying approximately 67% of the key words in an IEEE sentence correctly. The level of the noise will be adjusted adaptively based on their score during the test using a two-up-one-down adjustment paradigm as described by Levitt. The end threshold at which they are guessing 67% of the words correctly will be the noise level at which the remainder of the test will be presented. The subjects will then be given the same speech-in-noise test at the threshold level found earlier using unprocessed speech, visually processed speech using the VEAF algorithm, a competing audio-only hearing aid algorithm, and a combination of VEAF with the audio-only hearing aid algorithm.
Findings to date: A preliminary VEAF prototype has been built and tested using a simple audio-visual corpus of only a few words. We have found that the VEAF algorithm is capable of improving the signal-to-noise ratio of the noisy audio data by up to 11 dB.
Clinical Relevance: Hearing and vision loss are major health care problem among Veterans, and the diagnosis and rehabilitation of sensory loss represents a major expense to the Veterans Administration Health Care system. Even though Veterans in need receive state-of-the-art hearing aids, the satisfaction with amplification among Veterans parallels the somewhat dismal reports among the general population. The audio-visual assist technology proposed here will directly benefit Veterans with hearing and vision loss.