The ClearVoice™ Speech Enhancement Algorithm

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Background

Cochlear implant users often achieve high levels of speech understanding when listening to well articulated speech in quiet, for presentation at a comfortable listening level, without substantial reverberation or other distortions which are commonly encountered in real life listening environments. This paper presents results from a technique designed to improve speech understanding in challenging listening environments: ClearVoice, a new proprietary algorithm from Advanced Bionics.

A review of the Medical University of Hannover cochlear implant database produced results from 480 adult implant recipients with test results for speech perception in both quiet and noise. The only additional restriction made for this query was that recipients must have experienced less than ten years of profound deafness prior to receiving their implant. A strong ceiling effect was seen for the HSM sentence test (Hochmair-Desoyer et al. 1997) conducted in quiet; the group mean score being just over 80% correct. However, increasing the listening difficulty by simply adding speech-shaped noise with a signal-to-noise ratio (SNR) of +10 dB reduced the group mean score to only 30% correct. While such a simple manipulation does not even begin to approach the difficult listening environments which normal hearing individuals manage in everyday life, it already highlights the limitations of today's cochlear implant technology. Other than implant recipients restricting themselves to highly favourable listening situations, thus limiting participation in most everyday activities, the need for algorithms to enhance listening in challenging situations is all to obviously demonstrated.

Method

A group of twelve Advanced Bionics Harmony® processor users was tested acutely with the ClearVoice speech enhancement algorithm. Eleven used the HiRes 90K® implant, one the CII implant. Both devices are electrically equivalent. The group had a mean age of 58.4 years (range 33.2 to 80.7). No restriction was placed on duration of deafness aside from all participants being postlingually deafened. The mean duration of deafness was 3.3 years (range 0 to 11.2). The group had a mean listening experience with their implant of 1.7 years (range 0.7 to 6.7). All participants were unilaterally implanted and listened with their implant only.

Testing was carried out in a sound treated room having a noise floor of less than 30 dBA. A baseline test was performed when each participant used their standard clinical programme. The HSM sentence test was administered with speech presented at 65 dB SPL. Two lists, each of 20 sentences, were scored per condition. The SNR administered was selected for each participant. A group mean SNR of +3 dB (range 0 to +6) was used. Selection of the SNR was made such that a baseline score of around 50% correct was obtained. The same SNR was used to evaluate the clinical programme and two different settings of ClearVoice: -12 and -18 dB. Following the baseline test, each participant had the ClearVoice algorithm applied to their clinical programme. No other programming changes were made, although a change in volume was permitted and typically small increases in the participants' volume control were observed following ClearVoice being applied. Only a few minutes was allowed to acclimatize to the sound quality of the ClearVoice algorithm. Both the -12 and -18 dB ClearVoice programmes were downloaded to each participant's processor. Testing of the two ClearVoice conditions employed a counterbalanced test order, although

ClearVoice testing always followed testing of the clinical programme since this was necessary to determine the test SNR in the first place.

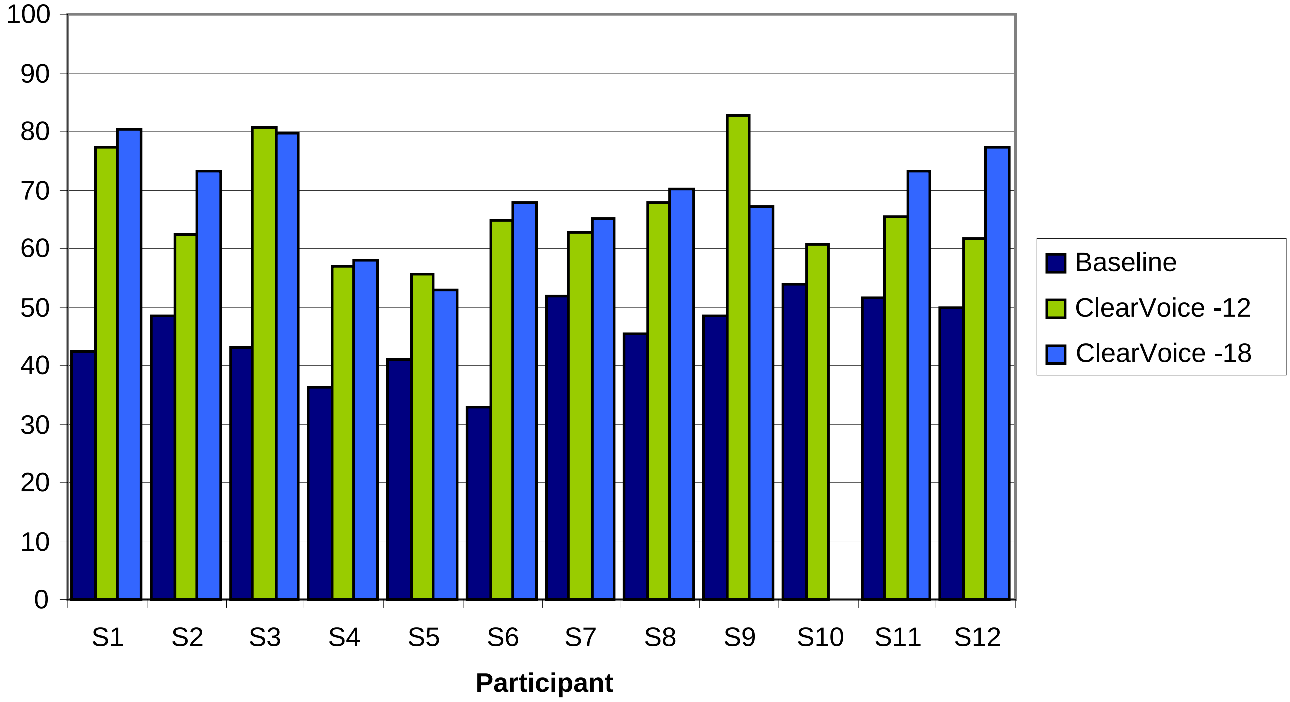

Figure 1: Individual participant scores for the HSM sentence test presented in speech-shaped noise. SNR varies by participant, the same SNR being used for each participant's three test conditions.

Results

The individual test scores for all twelve participants are shown in Figure 1 above. A group mean baseline score of 45.4% was recorded. All twelve participants showed improved scores for both ClearVoice conditions, apart from S10 who was only tested with the moderate -12 dB condition due to a lack of time. The improvements in group mean scores for the -12 and -18 dB conditions were 21.2% and 24.1% respectively. Both of the ClearVoice conditions were highly significantly higher ($p<0.01$) than the baseline condition but were not statistically different from each other. Of the eleven participants where both ClearVoice conditions were tested, only three showed a difference between the ClearVoice conditions of more than 10%.

Conclusions

The extent of improvement produced by ClearVoice was unexpectedly large. Also surprising was the fact that all participants improved and with only a minimal amount of experience. Subjective preference for the *moderate* versus *strong* ClearVoice was evenly distributed across the group. There were no reports of sound quality degradation for more straightforward listening conditions, for example, in quiet at a comfortable presentation level. ClearVoice was sometimes said to make the background a little too quiet. This was resolved through a small increase in the volume control. Given how positive this evaluation has been, a chronic evaluation should be undertaken as soon as possible to evaluate challenging listening situations familiar to each participant.

Reference

Hochmair-Desoyer, I., Schulz, E., Moser, L., & Schmidt, M. 1997, "The HSM sentence test as a tool for evaluating the speech understanding in noise of cochlear implant users", *Am J Otol*, vol. 18, no. 6 Suppl, p. S83.