Making AGC work: variable presentation level speech testing

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BACKGROUND

While cochlear implant users may score well on traditionally applied speech perception measures they often struggle to understand speech in everyday listening situations. The main problems reported are competing noise and a lack of audibility of some speech signals [Spar and Dorman, 2004]. The Automatic Gain Control (AGC) and Input Dynamic Range (IDR) provided by the processor are critical features for enabling access to sufficient acoustic range for real life speech understanding [Spar and Dorman, 2007]. This work examined the ability of cochlear implant recipients using different types of sound processor to attempt a new speech test. The test set out to evaluate AGC by roving the presentation level of the test material as well as adding competing noise. This mimics practical listening situations in which the sound processor's AGC and IDR are typically forced to work, unlike the case for fixed presentation level test conditions. The study was carried out under an ethics approval granted by the Freiburg ethics committee and in compliance with the Declaration of Helsinki.

System	Age	Years Deaf	Device use	HSM +10 dB
Cochlear	63	1.5	2.4	61
Advanced Bionics	63	2.5	4.2	63

Table 1: Mean age and duration of deafness and device use for the Cochlear and Advanced Bionics study groups, all in years and percentage score on HSM sentence test at +10 dB Signal to Noise Ratio

METHOD

Two groups of experienced adult cochlear implant users were studied. One group used the Cochlear Pty system [Patrick, 2006] with either the Freedom™ (n=4) or 3G® (n=2) BTE processors. All Cochlear subjects were programmed with the ACE® processing strategy. The second group (n=6) used the Advanced Bionics Corporation system. All Advanced Bionics subjects used the Auria® BTE processor programmed with the HiRes® processing strategy [Frijns, 2003; Koch, 2004]. All study subjects were programmed in the clinical routine. Demographics were similar between groups as may be seen in table 1. The 3G® group used a syllabic AGC system while the Auria® used the Cambridge dual-action AGC system [Moore, 1991].

Subjects were tested in a sound treated room. Test material was presented from a loudspeaker placed 1 m from the subject's microphone at zero degrees azimuth. Before each test session the presentation level was calibrated using a sound level meter. Each test consisted of a set of 30 sentences delivered by a male speaker. Sentences were of the HSM material [Hochmair-Desoyer, 1997] containing typically six words, all of which were scored. The presentation level of each sentence was randomly roved by either 0, +10, or -10 dB from the nominal 65 dB SPL presentation level. There were therefore, ten sentences delivered at each of the three presentation levels. Speech shaped noise was presented in competition with the sentence, the noise starting 0.5 seconds before the sentence and finishing 0.5 seconds after the sentence. The initial SNR was always calculated with respect to the presentation level of the individual sentence and was initially set to +20 dB. When a subject made two or less errors when repeating back the words in a sentence, the SNR was decreased for the next sentence, alternatively the SNR was increased. A three stage adaptive rule was used to adjust SNR where, 10, 5 and 2.5 dB changes in SNR were made following reversals in the direction of SNR change. In this way a Speech Reception Threshold (SRT) was estimated for the SNR at which 50% of sentences were understood. Before data were collected each subject was allowed to adjust their processor controls. Adjustment was permitted during a practice list of 30 sentences. Subjects were allowed to take as long as necessary before attempting to repeat back words of the sentence they had just listened to. The test was scored automatically in response to mouse driven inputs from the clinician running the test.

Additionally, the response time, from the end of the sentence being presented until the clinician mouse clicked to start entering the subjects' response, was recorded for analysis. Clinician responses could be "all correct", "all incorrect" via single mouse clicks or involve clicking on the individual words which were repeated correctly. Across sentence scoring clinician scoring added a relatively unbiased time penalty, the large majority of time being subject thinking time.

RESULTS

The individual SRT scores for each group may be seen in figure 1. A lower score indicates better performance since this is the SNR estimated for 50% sentence

understanding. SRT ranged from approximately +1 dB to +24 dB. Mean SRT score was significantly better for the Advanced Bionics group than the Cochlear group, Student t-test, ($p<0.05$), the group mean scores being, +4.4 dB (range 0.8 to 9.3) and +11.4 dB (range 3.3 to 24.3) respectively. Subjects C3 and C4 used the 3G processor and returned the poorest SRT scores in the study. In figure 2 the mean difference in response times between the highest and lowest presentation levels are shown for each subject. The Cochlear group shows a pattern of increasing response time for the lower presentation level compared to that of the higher presentation level for five of the six subjects. These differences are not significant, Student t-test ($p>0.05$). For the Advanced Bionics group this pattern is much less evident, half of the subjects showing a smaller response time for the lower presentation level sentences.

DISCUSSION

The subjects were selected on the basis of both similar demographics and quite similar clinical routine speech scores, ranging around 50% correct on the HSM sentence test in noise at an SNR of +10 dB. Despite these similarities the roving presentation level test showed a much larger distribution of SRT score. This indicates that testing with an adaptive SNR and a roving presentation level is quite different to the traditional fixed level tests used in the clinical routine. Subjects reported that the roving test was much more difficult than their usual tests. The mean SRT scores by processor type for 3G, Freedom and Auria, were: 23.7, 5.3 and 4.4 dB respectively. These are ordered by increasing IDR: 30, 45 and 60 respectively. It appears likely that in roving the presentation level of the test material that the sound processor is forced to use its AGC in order to compress the sentences so that they may be perceived by the implant user. Hence, the ability of the processor to handle real-life situations is evaluated. When simply testing blocks of sentences at different presentation levels use of the processor's pre-compression gain control (sensitivity) effectively deals with the variation in level. Thus traditional tests are not representative of what an implant user needs to be able to do to follow conversation in everyday life.

CONCLUSIONS

The roving level test brings out differences between subjects who scored quite similarly on traditional fixed presentation level tests. There was a statistically significant advantage for the larger IDR in the Advanced Bionics Auria group. This supports the theory that a larger IDR may be helpful in handling more difficult listening situations [Spar and Dorman, 2004 and 2007] where a range of presentation levels are encountered. The use of competing noise during testing demonstrated that a larger IDR was still able to deal with this type of listening difficulty.

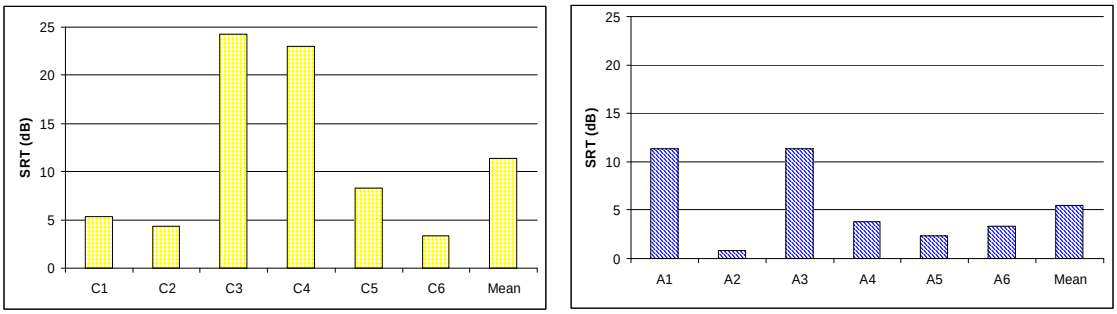

Figure 1: SRT scores for Cochlear subjects C1 to C6 (C8 mean score) in the left panel and Advanced Bionics subjects A1 to A6 (A8 mean score) in the right panel. A lower score indicated better performance since this is the SNR for 50% sentence understanding.

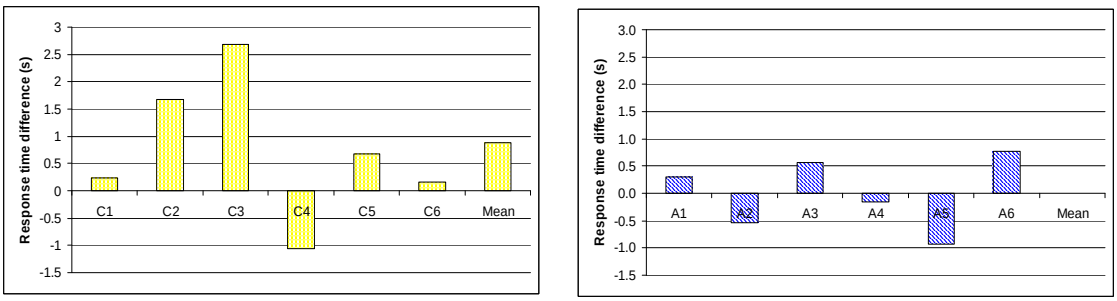

Figure 2: Response time differences between the lowest and highest presentation levels. In the left panel the Cochlear subjects C1 to C6 are shown with C8 being the mean time difference. In the right panel the Advanced Bionics A1 to A6 subjects are shown with the (zero) mean at A8

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