Fitting of the Hearing System Affects Partial Deafness Cochlear Implant Performance

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Introduction: Previous experiments have demonstrated that optimal Electro-Acoustic Stimulation (EAS) fitting parameters differ when both electric and acoustic stimulation are used together compared to the ideal parameters when these stimulation modalities are used individually. The goal of the study was to find the optimal EAS benefit and to determine the benefit of hearing preservation in the implanted ear using the DUET audio processor. To the authors' knowledge, this study has not been performed.

Materials and Methods: Twenty-four adult EAS recipients participated in the study. All subjects except one had at least 12 months experience with their cochlear implant (range: 7 - 52 months). All participants had least 1 month experience with their hearing aid (HA). The mean duration of cochlear implant (CI) use was 23 months and the mean duration of DUET processor use was 2.8 months (range: 1 - 8 months). The mean age of the study participants was 46 years.

Subjects were implanted with either the Med-El Combi 40+ or Pulsar cochlear implant with the M electrode or standard electrode array. In all cases, the electrodes were inserted approximately 20 mm into the cochlea either utilizing either a round window or cochleostomy hearing preservation technique (Skarzynski et al., 2007; Kiefer et al., 2004). The study centres and number of participants are listed in Table 1.

Table 1 Study Centres

Study Centre	Number of Participants
Institute of Physiology and Pathology of Hearing, Warsaw, Poland	11
HNO-Univ.-Klinik, Frankfurt a. M., Germany	5
St Thomas' Hospital, London, UK	4
University Hospital of Antwerp, Antwerp, Belgium	3
HNO-Univ.-Klinik, Vienna, Austria	1

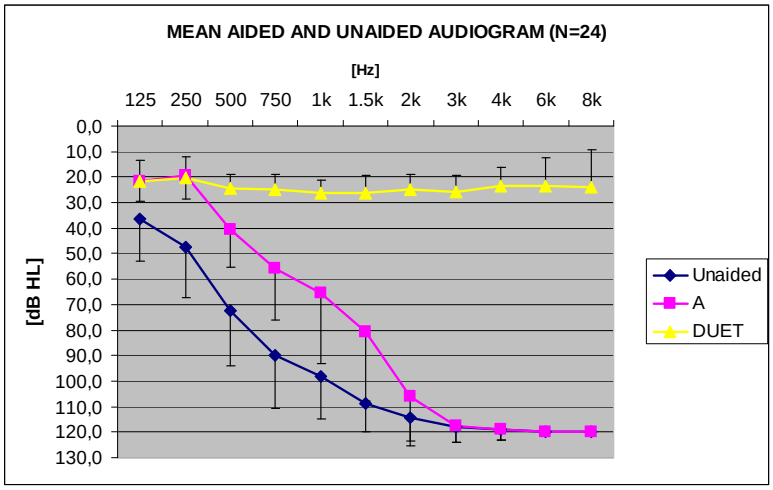
The post-implantation pure-tone average (PTA) was calculated as the mean of the hearing thresholds at 250, 500 and 750 Hz on the implanted ear (Table 2).

Table 2 Post-implantation Pure-Tone Average

Post-implantation Pure-Tone Average	Number of Participants
0 - 10 dB	12
10 - 20 dB	5
20 - 30 dB	4
30 - 40 dB	3

The mean preoperative monosyllabic word score was 31.9%. The mean increase in PTA due to EAS implantation surgery was 10.6 dB. Figure 1 depicts the post-implantation unaided and aided audiometric thresholds with the DUET processor in both the acoustic component (A) only mode and the acoustic and electric components together (DUET).

Figure 1 Post-implantation Mean Unaided and Aided Audiometric Thresholds



Blue line - mean unaided audiometric thresholds
Red line - mean aided thresholds with DUET acoustic component (A) only
Yellow line - mean aided thresholds with DUET acoustic- and electric component (DUET)

Each subject was tested for approximately 1 week. Initially, the acoustic component of the DUET was fitted based on the half gain rule plus individual adaptations. Thresholds and most comfortable levels of the electric component of the DUET were then determined. To verify thresholds, subjects were instructed to count the number of stimuli presented. To determine the most comfortable levels, either an electrically evoked stapedial reflex measurement or behavioural setting technique was used. The methodology of each technique is well documented (Polak et al., 2005).

Subjects had either 1 day or 2 hours to adjust depending on the parameter change. For each single parameter change, only a slight volume adjustment was allowed. This was necessary to always have overall equal and comfortable volume during the entire study. After each single parameter change, subjects were asked to test their map in different situations: background noise, one-to-one, multiple talkers, music. To evaluate objective speech performance in various listening conditions, monosyllabic speech tests and sentence tests at various S/N levels were used (65 dB SPL).

Subjects were initially tested in the electric (E) only mode with following parameters:

Lower CI frequency: 200 Hz from unaided audiogram – at 50, 65 and 80 dB HL

Subjects were then tested in the DUET mode (acoustic component was added) with the following parameters:

Lower CI frequency: 200 Hz from unaided audiogram – at 50, 65 and 80 dB HL
Compression Threshold: 40, 55, 70 dB
LF Slope: (Th500-Th250)/2, 0, 18dB/octave
Compression: 1:1, 1:1.33, 1:2

During the entire testing week, subjects had the contralateral (unimplanted) ear plugged. Plugging was performed by filling the ear canal and conchal bowl with impression mold using a syringe. Testing in the A mode (only DUET acoustic component on the implanted side) and best aided (DUET A + E components on the implanted side and unplugged contralateral ear or contralateral HA was used) was performed at the end of the study. A contralateral HA was used only when a subject routinely used a HA prior the study. All subjects tried a contralateral HA. However, only 25% of subjects continued to use a HA postoperatively. For 75% of subjects, a contralateral HA had either no or limited additional benefit.

Results: Figure 2 shows the speech test results of all study subjects in the four different test conditions: 1) Auditory only (A) 2) Electric only (E) 3) DUET (A + E) and 4) best aided (contralateral ear unplugged). The scores for E and DUET testing were obtained with the parameter settings used for subjects to achieve the highest speech test results.

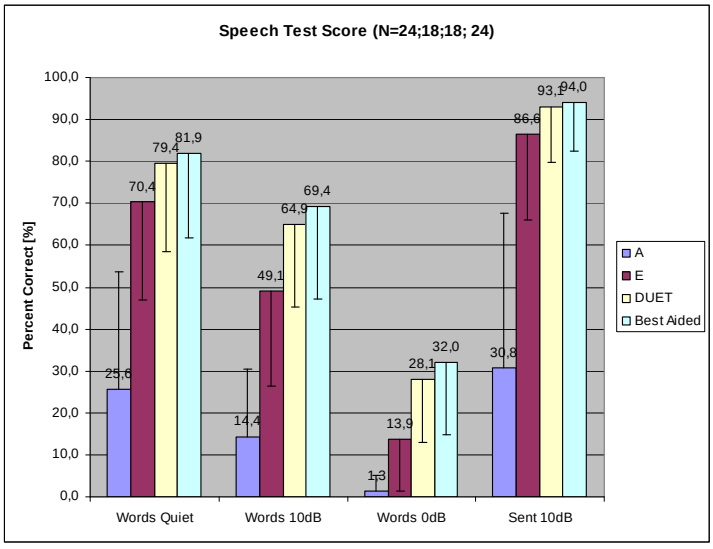


Figure 2 Speech test scores obtained at the objectively best benefit

The results of this study demonstrate a synergic benefit for EAS subjects as has been documented in previous studies. Figure 2 shows a relatively small benefit of EAS in the Auditory only condition, similar to the preoperative speech score in quiet. There was a marked benefit when switching from the Auditory only to Electric only condition both in quiet and in noise (10dB S/N, 0dB S/N). Striking improvement was noted in the DUET condition (Auditory + Electric) both in quiet and in noise (10dB S/N, 0dB S/N). Addition of

the contralateral acoustic hearing (Best Aided – contralateral ear unplugged) provided only slight additional benefit.

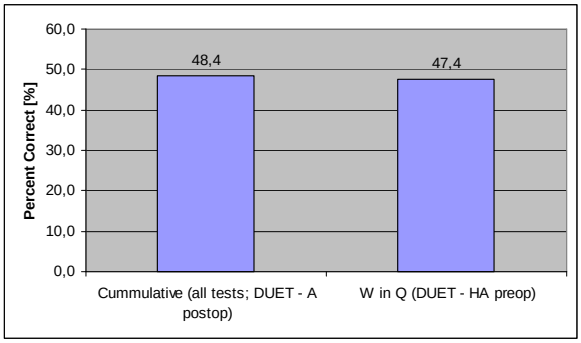


Figure 3 Measures of overall DUET benefit

Figure 3 depicts the cumulative benefit for all participants in the study. The cumulative benefit, calculated as the difference between the mean of all speech test scores (both in quiet and in noise) in the DUET (A + E) condition and the Auditory only condition was 48.4%. The overall EAS benefit on the monosyllabic word test in quiet, calculated as the difference between the mean post-implant and preoperative aided monosyllabic word scores, was 47.4%. Both measures of overall benefit demonstrate are very similar.

Programming parameters such as low frequency slope, compression, compression threshold and electric and acoustic frequency ranges play an important role in EAS fitting. A single parameter change in the Electric only or DUET condition may change individual speech test results performed in quiet or noise by up to 35% (mean change up to 17%). Figure 4 demonstrates the effect of a single parameter change from the optimized value. In the DUET mode, only a single parameter change may decrease the monosyllabic word score in quiet by up to 32.3%. The parameters having the greatest influence on overall benefit are lower CI frequency and compression.

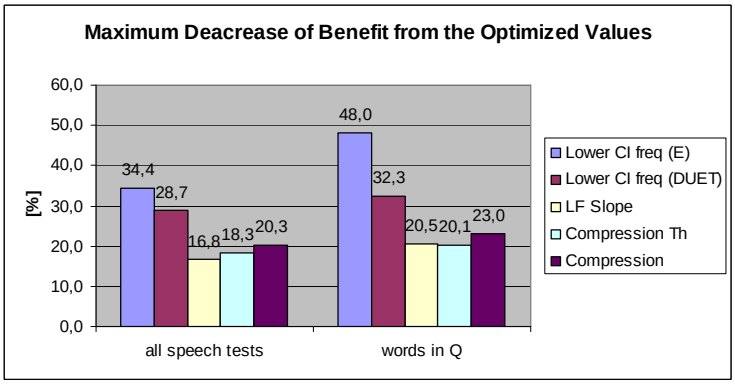


Figure 4 Effect of a single parameter change on the optimal benefit

Conclusions: This study demonstrates marked benefit of ipsilateral (implanted side) hearing preservation for EAS recipients. The addition of contralateral acoustic hearing provided only small additional benefit. When fitting parameters were optimized, subjects performed best in the best aided and DUET conditions. Optimized programming has a strong effect on speech test performance and quality of hearing in EAS. LF slope, compression, compression

threshold and electric and acoustic frequency ranges play an important role in the fitting of EAS and should be set carefully in order to achieve maximal benefit.

References:

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