Speech Based Optimization of Cochlear Implants

Alice E. Holmes* Lee Krause*** Rahul Shrivastav*** Hannah W. Siburt*
*Department of Communicative Disorders, College of Public Health & Health Professions, Gainesville, Florida; **Communication Sciences and Disorders, College of Liberal Arts & Sciences, Gainesville, FL; ***Audience, Inc.

INTRODUCTION

Modern CI devices allow multiple programmable parameters. In a number of studies that have manipulated parameters such as rate (PR), number of electrodes used, and pulse width (PW), no single parameter setting has been shown to be universally optimal for all patients (Steele, 2000; Hildred, et al., 2002). This makes it difficult for audiologists to know which parameters to focus on during device mapping. Most audiologists fit CI speech processors to manufacturer recommended settings. These can be modified based on patient feedback regarding perceived sound quality and not actual performance on speech intelligibility tests.

We have developed a novel fitting approach utilizing optimization theory to rapidly “scan” a patient’s performance at multiple device settings, thereby creating a “multidimensional” “performance space” for each individual patient.

METHODS

Participants: 20 experienced CI users were recruited from the University of Florida Speech & Hearing Clinic. All participants used a Freedom implant processor (Cochlear, Inc.). This was essential because the optimization routine needs access to the device programming interface. This was made available to us by Cochlear, Inc. Participants received monetary compensation for their time.

Procedures:

The experiment was conducted as a repeated measures design where each subject was compared to their own baseline. Each subject was tested in 3 sessions, approximately two weeks apart. All test conditions were conducted following U.S. governmental Food and Drug Administration (FDA) approval.

RESULTS

SESSION 1 (Cont)

4. The optimization routine (Figure 1) was run for a period of 30 minutes with the following:
   a. A series of VCV syllables were presented and the subject’s verbal responses were recorded by the researcher.
   b. A unique optimization matrix, summarized as the “net weighted feature error” (NWF) for the processor settings, was calculated by the optimization algorithm.
   c. The next combination of FAT, PW & LG was automatically recommended and tested.
   d. This procedure was repeated until the end of the 30 minute optimization session.

5. The combination of LG, PR, and FAT was then selected as Optimization 1 (Opt 1) and programmed into the speech processor.

6. Subjects were asked to use the optimized map until Session 2.

SESSION 2 (~2 weeks after Session 1)

1. Outcome performance using Opt 1 was evaluated using CNC lists in quiet and BKB-SIN measurements as reported in Session 1.

2. The Optimization procedure described above was then repeated to obtain Optimization 2 (Opt 2) and programmed into the speech processor.

3. Subjects were asked to use the optimized map until Session 3.

SESSION 3 (~2 weeks after Session 2)

1. Outcome performance using Opt 2 was evaluated using CNC lists in quiet and BKB-SIN measurements as reported above.

2. Subjects then chose the maps that they wanted to use in their speech processors for regular/everyday use.

CONCLUSIONS

The optimization method used in this study resulted in improved subject performance in all outcome measures. Speech perception was significantly better in word and phoneme identification with optimized maps. In addition, subjects reported feeling better in noise using the optimized maps. All subjects entered the study wearing CIs programmed in the traditional clinical approach. However, as seen in Table 2, significant individual variability was found between baseline and optimized maps. The current clinical method for cochlear implant programming is both subjective and time consuming. For example, in the current study, 40 maps were tested in a 30 minute optimization session. In contrast, testing the same number of maps using the traditional method would have taken multiple programming sessions with the clinician relying on patient report rather than objective data. The optimization process described here was successful in greatly reducing the time necessary to optimally program a CI with improved patient performance. In addition to obtaining CNC and BKB-SIN test outcome measures, subjective measures were also gathered from our subjects. Subjective feedback regarding the optimization procedure and its results were both extremely positive. Feedback included the report of increased clarity, increased ability to talk on the telephone and watch television, as well as better understanding in the presence of background noise. Subjective questionnaires with specific data points are currently being analyzed statistically.

Future applications using the optimization method include expanding the number of parameters adjusted during the procedure, and increasing the CI population eligible for optimization. In addition, this method is being investigated for use with other hearing devices such as hearing aids.