

## Verification of FM Systems Directly Interfaced with Cochlear Implants

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### Abstract

Previous findings support using FM systems for improving speech recognition in noise for persons with cochlear implants (CIs)<sup>2,3,4,5,6</sup>. Testing and verification of this interface is an important issue to explore. Procedures and findings related to electroacoustic and behavioral testing of CIs interfaced with FM systems are discussed. Results of both testing procedures verify FM system and CI functioning and provide an estimate of the audio mixing ratio between the CI and the FM system.

### Electroacoustic Testing of CIs and FM Systems

- ❖ Acoustic output from a CI monitor earphone is used to verify functioning and to measure the FM advantage
- ❖ Currently available on Nucleus ESPrIt 3G and SPrInt
- ❖ A modified ASHA procedure<sup>1</sup> is used for testing the FM systems electroacoustically



Figure 1. Nucleus 3G speech processor, ESPrIt MicroLink Adaptor with Phonak MLxS (left) and Nucleus SprInt speech processor with Phonak MicroLink-CIS (right)

### Testing Equipment

- ❖ **Hearing aid analyzer:** Fonix FP40
- ❖ **Coupler:** ½ inch to 1 inch adaptor
- ❖ **Speech processor:** ESPrIt 3G mapped with ACE strategies, set for M, knob at user settings
- ❖ **FM system:** Phonak Campus S Transmitter, MLxS Receiver, ESPrIt 3G MicroLink Adaptor - set to FM+M
- ❖ **Monitor earphones:** Nucleus ESPrIt 3G Monitor Earphones

### Testing Procedure for 3G Processor

- I. Connections:
- ❖ Connect the ESPrIt 3G processor to the MLxS receiver using the ESPrIt 3G MicroLink Adaptor
  - ❖ Plug in the monitor earphones and fit one into the coupler
  - ❖ Place the coupler and earphone in a stable location outside the analyzer
  - ❖ Turn on the 3G, MLxS, and Campus S



Figure 2. Nucleus 3G speech processor with Phonak MLxS and Nucleus ESPrIt 3G Monitor Earphones

- II. Measuring RMS for Input to CI:
- ❖ Position 3G in test box and close lid
  - ❖ Present 65 dB SPL complex signal: ECI/FM65
  - ❖ Place transmitter in quiet location
  - ❖ Record RMS



Figure 3. Equipment set-up for measuring RMS for input to CI

- III. Measuring RMS for Input to FM Transmitter:
- ❖ Place transmitter microphone in test box and close lid
  - ❖ Present 80 dB SPL complex signal: EFM/CI80
  - ❖ Place 3G in quiet location
  - ❖ Record RMS



Figure 4. Equipment set-up for measuring RMS for input to FM transmitter

- IV. Calculate FM Advantage:
- ❖ FM Adv=EFM/CI80-ECI/FM65
  - ❖ If speech processor is set for sensitivity, adjust sensitivity knob to improve FM advantage (Figure 5)
  - ❖ Ideal FM advantage is at least 10 dB

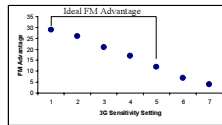


Figure 5. FM advantage (RMS difference) as a function of sensitivity setting on the 3G

### Behavioral Testing of CIs and FM Systems

- ❖ A modified AHSA procedure<sup>1</sup> is used for behavioral testing with FM systems
- ❖ Speech recognition (SR) is the most effective way to measure behavioral benefit with an FM system

### Testing Equipment for Speech Recognition

- ❖ Soundbooth with a speaker and seating at a zero degrees azimuth (Figure 6)
- ❖ Audiometer that allows for presentation of SR materials using live voice
- ❖ Appropriate SR measure with multiple lists

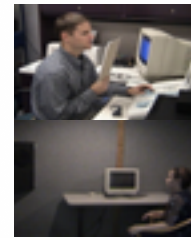


Figure 6. Examiner (top) and patient (bottom) setup for speech recognition in the soundbooth

### Testing Procedure

- I. General Setup for Testing a Child with a CI
- ❖ Seat the child at a 0 degrees azimuth
  - ❖ Check CI functioning with monitor earphones or informal listening check
  - ❖ Select presentation level for stimuli that is appropriate for the child's hearing thresholds - Ideally 35 dB SL
- II. Measure SR with CI alone:
- ❖ Measure SR in quiet with the CI alone: BCI55
  - ❖ Measure SR in noise with the CI alone at a +5 signal-to-noise ratio (SNR): BC155/50
- III. Measure SR with CI Interfaced with FM System
- ❖ Attach the FM system and verify that it is functioning
  - ❖ Measure SR in noise with the CI+FM at +5 SNR: BFM/CI55/50
  - ❖ Measure SR in quiet with the CI+FM: BFM/CI55

### Testing Procedure

- IV. Compare Results with and without the FM System
- ❖ SR scores in Table 1 show benefit with FM use

Table 1. Speech Recognition Scores of Two Children Using Nucleus 3G Processors and Phonak MLxS Receivers

Subject	CI/FM	CI: Quiet	CI: Noise	CI+FM: Noise
Case#1	3G/MLxS	92%	72%	88%
Case#2	3G/MLxS	92%	68%	84%

### Conclusions

- ❖ Electroacoustic testing can be done for CIs that allow for connection of monitor earphones and an FM system
- ❖ Electroacoustic measures with a 3G and MLxS show greater FM advantage as the 3G sensitivity setting is decreased
- ❖ SR testing is an effective tool for measuring benefit with FM systems
- ❖ Results from two child case studies using Nucleus 3G processors and Phonak MLxS receivers show gains in SR in noise of 16% from the CI alone to the CI+FM condition

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