Optimizing the Use of FM Systems with Cochlear Implants

by Jace Wolfe and Erin Schafer

Personal FM systems can provide significant improvement in speech recognition in adverse listening situations for persons using cochlear implants.

Current research suggests that patients with cochlear implants (CIs) experience significant difficulties understanding speech in noise. The most straightforward way to enhance the signal-to-noise ratio for people with cochlear implants is the use of a frequency modulated (FM) system.

FM systems for cochlear implant users consist of a transmitter worn by the talker and a receiver for the listener. The FM receiver may be coupled to wall-mounted or desktop sound field speakers, or it may be directly connected (direct connect) to the user's CI speech processor. The advantages and disadvantages of each type of receiver are outlined in Figure 1 (online). A recent meta-analysis suggests that FM receivers directly connected to the CI allow for significantly better speech recognition in noise than desktop or wall-mounted sound-field FM systems (Schafer & Kleineck, in press); therefore, this article will focus on evidence related to programming considerations for the FM-CI interface.

Receiver-Gain Setting and Input Processing

FM gain, available on some FM receivers, adjusts the strength of the signal from the receiver to the implant sound processor. Presumably, larger gain values will enhance the salience of the FM signal. In several recent studies, we examined the effect of FM-receiver gain on performance for persons with CIs (case studies in Table 1 online). In the first study, we found an average 20% improvement in speech recognition in noise when increasing the FM receiver gain from the +10 to the +16 dB setting for children using the Phonak MicroMLxS receiver, Advanced Bionics iConnect adaptor, and Auria sound processor (Schafer & Wolfe, 2008).

In a second study with adults using Advanced Bionics implants, we found a 5 dB improvement in the signal-to-noise ratio required for 50% intelligibility in noise when the FM-receiver gain was increased from the +10 to +14 dB setting (Schafer et al., in press). At the +20 dB setting, participants complained of poor sound quality. Increases in FM-receiver gain from +10 to +20 dB did not improve speech understanding in noise for persons using the Cochlear Corporation Esprit 3G sound processors (Schafer et al., in press). Therefore, future research was focused on programming adjustments that optimize FM benefit for Cochlear Corporation users.

In another study related to FM gain, we examined performance using traditional versus Dynamic FM systems (Wolfe et al., in press). The Phonak Dynamic FM system automatically adjusts the FM gain according to the intensity of the noise in the environment. Speech recognition in noise of participants using Advanced

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Bionics implants improved by up to 50% when using Dynamic FM compared to traditional, fixed-gain FM systems. Initial testing with Cochlear Corporation recipients showed poor performance with both FM systems and no differences between the two types. We hypothesized that performance differences between manufacturers may be related to the default input dynamic range (IDR) of the sound processor, which determines the range of inputs mapped into the recipient's electrical dynamic range. All inputs exceeding the IDR receive substantial compression. Because the FM signal input (72 dB SPL) may exceed the IDR for Cochlear Corporation processors (65 dB SPL), the FM signal may be compressed and embedded in noise.

To address this issue, we examined the effects of the input preprocessing feature Autosensitivity for users of Cochlear Corporation processors (Wolfe et al., in press). Autosensitivity adjusts the sensitivity of the speech processor microphone according to the signal-to-noise ratio in the environment and may reduce the likelihood that the FM signal will be embedded in noise. With this adjustment, Cochlear Corporation users achieved excellent speech understanding in noise and showed significant benefit with Dynamic FM relative to traditional FM. In addition, use of Autosensitivity resulted in better speech recognition of stimuli presented to the speech processor (FM muted).

Audio-Mixing Ratio

The audio-mixing ratio is a clinician-controlled parameter in CI programming software that adjusts the relative strength of inputs from the FM system and CI sound processor. The 3:1 and 30/70 mixing ratios provide 10 dB of attenuation to the signal from the microphone of the CI sound processor to provide emphasis for the FM signal. The 1:1 and 50/50 mixing ratios provide equal emphasis to the signals provided from the FM systems and the sound processor microphone. Two recent studies examined the effect of mixing ratios for adult CI users (see case studies in Table 2 online).

In the first study, we evaluated the effects of a 30/70 and 50/50 mixing ratio on speech recognition in quiet and noise for adults using Advanced Bionics cochlear implants (Wolfe & Schafer, 2008). No significant differences were found between mixing ratios in noise; however, when listening to speech in quiet through the sound processor (i.e., environmental microphone), users experienced speech recognition that was significantly poorer for the 30/70 mixing ratio relative to the 50/50 mixing ratio. Similar results were found for users of Cochlear Corporation Nucleus Freedom implants, for whom speech recognition in quiet through the sound processor was significantly poorer with a 3:1 compared to a 1:1 mixing ratio (Wolfe et al., in progress).

Personal FM systems can provide significant improvement in speech recognition in adverse listening situations for persons using cochlear implants. To optimize a recipient's performance, it is important to set adjustable parameters appropriately for the CI sound processor and the FM system. In particular, the fixed-gain FM receivers should be set to a gain of +14 to +16 dB; Dynamic FM should be used when available; Autosensitivity should be enabled for users of Cochlear Corporation CIs; and the audio mixing ratio should be set so that the sensitivity of the sound processor microphone is not reduced.

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Recommendations for Optimizing the FM System-Cochlear Implant Interface

Based on recent research, the following are are suggestions for fitting personal FM systems for CI users:

- Use Dynamic FM to optimize sound quality in quiet situations and improve speech recognition in noise.
- Set the FM gain for +14 to +16 when using fixed-gain receivers. Higher gain settings result in better speech recognition in noise.
- Enable Autosensitivity for users of Cochlear Corporation implants to improve speech recognition in noise with and without the use of personal FM.
- Set the mixing ratio on the sound processor for 50/50 or 1:1 to provide equal emphasis from the FM system and sound processor microphone to ensure optimal audibility of environmental speech.
- Consider use of multiple programs on the sound processor for older children and adults to allow for use of FM only as well as the mixing ratios.
- Evaluate FM benefit, as well as the appropriateness of FM settings, through speech-recognition assessment in the clinic and standardized questionnaires completed by the recipient, family members, and teachers.

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Selected References

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