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Verification Protocol for Signal Transparency Using the Cochlear Mini-Microphone 2+ and Digital Modulation Transmitter and Receiver with Cochlear Implants

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Rhonda Sousa*
Erika Nair*
Shannon Wannagot†

Abstract

Background: Guidelines established by the American Academy of Audiology (AAA) currently recommend behavioral testing when fitting frequency-modulated (FM) systems to individuals with cochlear implants (CIs). A protocol for completing electroacoustic measures on CI sound processors has not yet been established or validated when fitting either FM or digital-modulated (DM) systems, mini microphones, or mini microphones coupled to DM systems. In response, professionals have used or altered the AAA (2008) electroacoustic verification steps for fitting FM systems to hearing aids when fitting FM/DM systems, mini microphones, or mini microphones coupled to FM/DM systems to CI sound processors.

Purpose: The purpose of this research is to determine if the electroacoustic verification guidelines established by AAA (2008) for fitting FM systems to hearing aids are feasible and verifiable when fitting mini microphones and mini microphones coupled to DM systems to CI sound processors.

Research Design: Electroacoustic measures were conducted on 51 Cochlear Nucleus 6/CP910 sound processors, one Cochlear Wireless Mini Microphone 2+ (MM2+), and one Phonak DM System (one Roger Inspiro transmitter and one Roger X receiver) using an adapted AAA (2008) protocol (Nair et al, 2017). Phonak's recommended default receiver gain setting was used with the Roger X receiver and adjusted if necessary to achieve transparency. Transparency refers to when the signal output of the device is the same when coupled and when not coupled to remote microphone technology.

Study Sample: Electroacoustic measures were conducted on 51 Cochlear Nucleus 6/CP910 sound processors. In this study, the 51 Cochlear Nucleus 6/CP910 sound processors were either streaming to the Cochlear MM2+ or streaming to the MM2+ coupled to a Phonak DM system.

Data Collection and Analysis: In a clinical setting, using the AAA (2008) protocol for electroacoustic measurements when fitting FM systems to hearing aids, electroacoustic measurements using various equipment (MM2+ and Phonak DM system) were performed on 51 Cochlear Nucleus 6/CP910 sound processors using the Audioscan Verifit to determine transparency and verify DM advantage, comparing speech inputs (65 dB SPL) in an effort to achieve equal outputs. If transparency was not achieved when the CI sound processor was streaming to the MM2+ coupled to the Phonak DM system at the default receiver gain, adjustments were made to the Roger X receiver's gain. The integrity of the signal was monitored with the manufacturer's monitor earphones.

Results: Using the AAA (2008) hearing aid protocol, when the Cochlear Nucleus 6/CP910 sound processor was streaming to the Cochlear MM2+, transparency was achieved for 50 of 51 CI sound processors. Again, using the AAA (2008) protocol when the Cochlear Nucleus 6/CP910 sound processor was streaming to the Cochlear MM2+ coupled to the Phonak DM system at Phonak's recommended default receiver gain, 28 sound processors achieved transparency. After the receiver gain was adjusted, the remaining 23 sound processors met transparency.

Conclusion: Electroacoustic measurements and transparency can be achieved for CI sound processors coupled to either a MM2+ only or to a MM2+ and a DM system by adapting the AAA (2008) guidelines.

*Soundbridge, Wethersfield, CT; †University of Connecticut, Mansfield, CT

Corresponding author: Rhonda Sousa, Soundbridge, Wethersfield, CT 06109; Email: rsousa@crec.org

Key Words: auditory rehabilitation, cochlear implants, hearing aids and assistive listening devices, pediatric audiology

Abbreviations: CI = cochlear implant; DM = digital modulation; FM = frequency modulation; MM2+ = mini-microphone 2+; RM = remote microphone

INTRODUCTION

Cochlear implant (CI) users experience difficulty in challenging listening situations. Personal frequency modulation (FM) systems have been proven to improve speech understanding in adverse environments that contain factors such as distance, noise, and reverberation which may interfere with performance (Schafer and Thibodeau, 2003; Anderson et al, 2005; Schafer and Kleineck, 2009). FM systems typically consist of a transmitter with a microphone that is worn by the talker, which then transmits the speech signal to a receiver that is coupled to each of the listener's devices (i.e., CI speech processor). The signal can be delivered via FM radio frequency or a digital modulation (DM) signal (Wolfe et al, 2013). Although FM and DM systems boast excellent efficacy, they are also costly and can add up to three to five extra pieces of equipment to manage (i.e., one transmitter and two dedicated receivers or one transmitter, two universal receivers and two euro adapters). Phonak FM and DM systems, including one transmitter and two dedicated receivers, cost >$2,300 (Phonak pricing 2016 via an estimate of in-office ordering specialist, June 24, 2016). For many CI recipients and/or their families, a FM/DM system could be considered cost prohibitive and require more equipment management despite the proven benefit.

Recently, CI manufacturers have begun to distribute their own remote microphone (RM) technology that are often anecdotally touted as functioning similarly to FM and DM systems, but for a far more family-friendly cost and streamlined listening experience requiring only one extra piece of equipment to manage. For example, the Cochlear Mini Microphone 2+ (MM2+) costs approximately $395 (Cochlear pricing 2016 via an estimate from phone call to Cochlear Americas, June 24, 2016). This RM technology (MM2+) couples directly to the CI speech processor via a Bluetooth signal (2.4 GHz), adding only one extra piece of equipment to manage. Although the MM2+ costs around one-fifth the price of a traditional FM/DM system and has the potential to improve listening in adverse situations for recipients, there is little independent research to support their anecdotal claims. Wolfe et al (2015) demonstrated the benefit of a previous generation of the Cochlear MM2+ coupled with a Cochlear Nucleus 6/CP910 (N6) sound processor in various listening conditions. However, many families and school districts are approaching pediatric/educational audiologists to inquire if the Cochlear MM2+ is a viable option for both personal and/or school use. Unfortunately, at this time, no research has methodically examined the unique pros and cons of recommending this type of RM technology in place of traditional FM/DM technology for home and/or educational purposes. For example, using only the MM2+ would not afford the benefits of DM technology (i.e., multiuser functions, multiple microphone modes, adaptive noise reduction, and speech enhancement in noise).

One important factor to consider is verification techniques: in this case, electroacoustic transparency measurements. Transparency refers to when the signal output of the device is the same when coupled to RM technology. Transparency measurements help to ensure that FM/DM systems, or RM technology coupled to CI speech processors, do not degrade the input beyond an industry acceptable standard such as ±2 dB (AAA, 2008) or ±3 dB (Schafer et al, 2013). At this time, verification in terms of transparency measurements has not been well established for RM technology when coupled to CI speech processors. In fact, the authors could not locate any independent recommendations when considering adopting RM technology, including the most commonly used configuration of coupling FM and DM systems to CI speech processors. Through the use of electroacoustic measurements, transparency standards have long been established by the AAA (2008) for coupling FM systems to traditional amplification (i.e., hearing aids). These protocols verify that when FM systems are coupled to hearing aids, they do not change the input signal by more than an average of ±2 dB at 750, 1000, and 2000 Hz (AAA, 2008). This ensures that the acoustic signal is transparent, helping to maintain an optimal signal for hearing-impaired listeners.

Whereas some CI recipients can make subjective decisions regarding whether RM technology are meeting their personal listening needs based on their experience, young children and those with limited reporting abilities cannot. As Schafer et al (2013) summarized in a recent article, "the inability to perform electroacoustic test measures on CI speech processors coupled to personal FM (or DM) systems are concerning for many reasons." These same concerns apply to other RM technology, which are readily available to parents, caregivers, and school-based professionals; however, the impact of the coupling is poorly understood. Concerns cited by Schafer et al (2013) that apply to RM technology verification in general, include the following:

- There is currently no objective way to verify an appropriate fitting.
- Younger children may not be able to complete speech understanding in noise testing to verify FM (DM and/or RM technology) benefit.
- Young children might not be able to report issues with an FM (or DM) system (and/or RM technology).
- It is important that children receive access to the primary speech signal for speech and language development.

As an anecdotal observation, an increased number of families of young CI recipients are being directed to choose the Cochlear MM2+ for their personal accessory option at initial implantation or at the time of an upgrade. However, as stated earlier, very little is known regarding whether these devices couple in an electroacoustically transparent way. Although FM and DM systems have been shown to be functionally beneficial for CI users in background noise, the transparency of the signal may be affected by streaming through MM2+ and/or FM systems. The development of a protocol to verify transparency for CI sound processors when coupled to the Cochlear MM2+ and FM/DM systems is warranted to optimize gain settings for these technologies. There are other concerns as well. Although there are numerous studies showing the benefit of RM technology for individuals with CIs, there is a lack of information specifically with the use of the Cochlear MM2+ (Fitzpatrick et al, 2009; Wolfe et al, 2013; 2015; De Ceulaer et al, 2016). It is beyond the scope of this article to dissect all of these questions, but further research in these areas is necessary. As a first step, we want to address the question of whether the Cochlear MM2+ could meet current transparency standards (AAA, 2008; Schafer et al, 2013) in two conditions (with and without coupled to a DM system); the hypothesis is based on clinical observations which indicate that transparency can be met in all conditions with little or no gain adjustment.

As our center regularly evaluates CI speech processors for transparency with the use of FM and/or DM systems based on a protocol developed from careful examination and adaptation of the AAA (2008) transparency guidelines and the Schafer et al (2013) proposed protocol (Nair et al, 2017), our team was uniquely poised to develop a protocol and verify transparency for CI speech processors when coupled to the Cochlear MM2+.

METHODS

Using an altered version of the AAA (2008) electroacoustic verification steps for fitting FM systems to hearing aids, electroacoustic measurements were conducted in a clinical setting with Cochlear N6 (CP910) sound processors, a Cochlear MM2+, and a Roger DM system to compare transparency using equivalent inputs in the following conditions:

1. CI sound processor paired to the MM2+ and
2. CI sound processor paired to the MM2+ and coupled to a Phonak Roger DM system.

Electroacoustic measurements were performed on 51 Cochlear N6/CP910 sound processors using one Cochlear MM2+, and one Phonak Roger DM system (one Phonak Roger Inspiro transmitter and one Phonak Roger X receiver). The electroacoustic assessments comparing the two transparency configurations were conducted with the Audioscan Verifit system using the following steps and calculations.

Cochlear N6/CP910 Sound Processor and Cochlear MM2+

Step 1

One earbud of the CI sound processor monitor earphones (Nucleus CP900 Monitor Earphones) was attached to the hearing aid - 1 (HA-1, in-the-ear [ITE]) coupler with putty. The other earbud of the CI sound processor monitor earphones was used by the examiner to monitor if the speech signal was consistent and if noise or interference was present. The CI sound processor microphones were positioned next to the reference microphone (as shown in Figure 1). The Verifit chamber was closed, and a curve was run at 65 dB SPL using speech-std (1). The following SPL values for 750, 1000, and 2000 Hz were recorded and an average was calculated.

(Note: Cochlear N6 sound processors that are programmed at our center are routinely set to a 1:1 mixing ratio with SCAN turned off; this was the case for all processors included in this study.)

Step 2

Pair the Cochlear CR230 Remote Assistant to the processor (turn on the remote assistant by pressing and holding the OK button until the two startup screens display. Hold the coil on the coil guides on the back of the CR230 Remote Assistant. The Pair Processor screen will appear. Press the OK button to pair. When pairing is complete, the Processor Paired screen will appear, followed by the Home screen).

Turn on the MM2+ (on/off button on the top of the MM2+) and initiate streaming (press and hold the upper button on the sound processor for two seconds, then release. The sound processor will flash a blue light to indicate audio is streaming. Long-press the Telecoil button on the CR230 Remote Assistant—top left button on remote. Audio will start streaming through the MM2+).

Figure 1. Configuration for Step 1 for a Cochlear N6 sound processor coupled to a MM2+ with and without a Phonak Roger DM system. The Cochlear N6 sound processor is in the Verifit chamber.

The CI sound processor was placed in a sound-attenuating box outside the Verifit chamber, and the MM2+ was positioned in the test box near the reference microphone (as shown in Figure 2). The Verifit chamber was closed and a second 65 dB SPL speech-std (1) curve was run. This measure was conducted to ensure that the addition of the MM2+ did not change the output of the CI sound processor inputs delivered to the CI sound processor microphones. The SPL values for 750, 1000, and 2000 Hz were recorded and an average was calculated.

(Note: The sound-attenuating box that was used was fashioned from a typical pencil box lined with foam packing material. A small hole was bored out of one end to accommodate wires.)

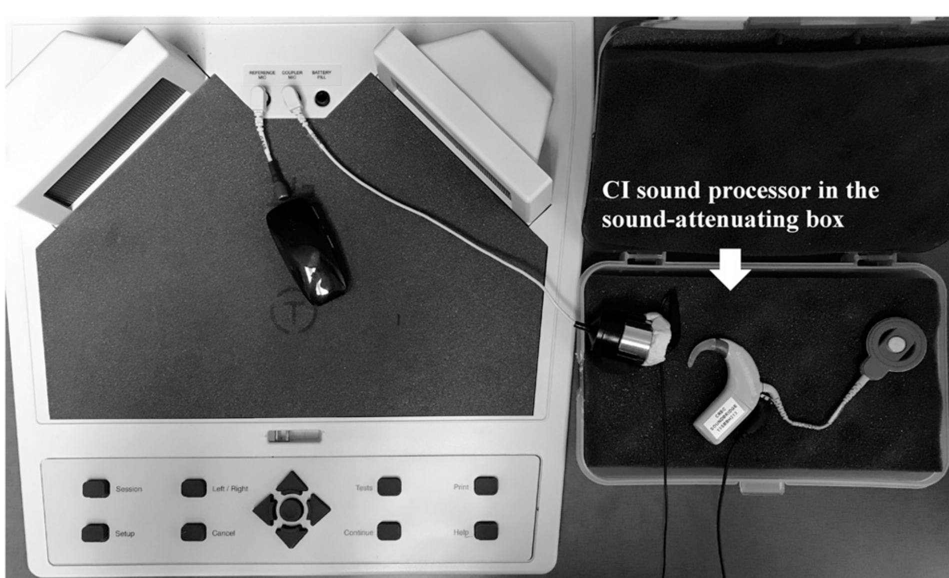

Figure 2. Configuration for Step 2 for a Cochlear N6 sound processor coupled to a MM2+. The MM2+ is in the Verifit chamber and the Cochlear N6 sound processor is in the sound-attenuating box.

Step 3

The CI sound processor, still in streaming mode, was placed back into the Verifit chamber, and the MM2+ was muted and put into the sound-attenuating box (as shown in Figure 3). The SPL values for 750, 1000, and 2000 Hz were recorded and an average was calculated.

The AAA (2008) protocol requires that the average for step 3 be subtracted from the average of step 2. If the offset value was ≤2 dB, transparency was considered to have been achieved.

Cochlear N6/CP910 Sound Processor and Cochlear MM2+ Coupled to a Phonak Roger DM System

Step 1

One earbud of the CI sound processor monitor earphones (Nucleus CP900 Monitor Earphones) was attached to the HA-1 coupler with putty. The other earbud of the CI sound processor monitor earphones was used by the examiner to monitor if the speech signal was consistent and if noise or interference was present. The CI sound processor microphones were positioned next to the reference microphone (as shown in Figure 1). The Verifit chamber was closed, and a curve was run at 65 dB SPL using speech-std (1). The following SPL values for 750, 1000, and 2000 Hz were recorded and an average was calculated.

Step 2

Pair the Cochlear CR230 Remote Assistant to the processor (turn on the remote assistant by pressing and holding the OK button until the two startup screens display. Hold the coil on the coil guides on the back of the CR230 Remote Assistant. The Pair Processor screen will appear. Press the OK button to pair. When pairing is complete, the Processor Paired screen will appear, followed by the Home screen).

Turn on the MM2+ (on/off button on the top of the MM2+) and initiate streaming (press and hold the upper button on the sound processor for two seconds, then release. The sound processor will flash a blue light to indicate audio is streaming. Long-press the Telecoil button on the Remote Assistant—top left button on remote. Audio will start streaming through the MM2+).

Attach the Phonak Roger X receiver to the FM Connector Port on the bottom of the MM2+. Connect the Phonak Roger X receiver to the Phonak Roger Inspiro transmitter (turn transmitter on and press the right Connect softkey). The Phonak Roger X receiver was set to the manufacturer default gain (i.e., 0/+10 DM advantage). Check the icon on the CR230 Remote Assistant and perform a listening check to ensure that you are still in streaming mode and that the Phonak Roger Inspiro is transmitting the DM signal.

The CI sound processor was placed in a sound-attenuating box outside the Verifit chamber, and the Phonak Inspiro transmitter microphone was positioned in the test box near the reference microphone. The MM2+ was also

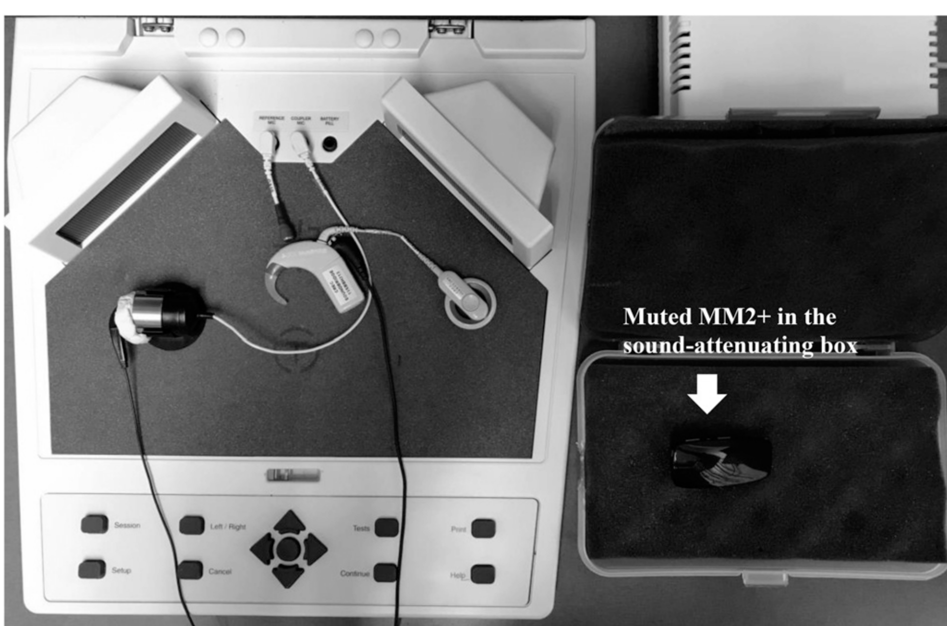

Figure 3. Configuration for Step 3 for a Cochlear N6 sound processor coupled to a MM2+. The MM2+ is muted in the sound-attenuating box and the Cochlear N6 sound processor is in the Verifit chamber.

placed in the Verifit chamber 2–3″ from the reference microphone (as shown in Figure 4). At this time, the microphones on the MM2+ are automatically muted. The Verifit chamber was closed and a second 65 dB SPL speech-std (1) curve was run. This measure was conducted to ensure that the addition of the Phonak Roger X receiver coupled to the MM2+ did not change the output of the CI sound processor inputs delivered to the CI sound processor microphones. The SPL values for 750, 1000, and 2000 Hz were recorded and an average was calculated.

Step 3

The CI sound processor, still in streaming mode, was placed back into the Verifit chamber, and the Phonak Roger Inspiro was muted and put into the sound attenuating chamber along with the MM2+ (as shown in Figure 5). The SPL values for 750, 1000, and 2000 Hz were recorded and an average was calculated.

The AAA (2008) protocol requires that the average for step 3 be subtracted from the average of step 2. If the offset value was ≤2 dB, transparency was considered to have been achieved. If the measured DM advantage did not meet transparency at the default receiver gain setting, then the gain on the Phonak DM receiver was adjusted.

RESULTS

Cochlear N6/CP910 Sound Processor and MM2+

As shown in Figure 6, in the default gain setting (0 dB), 50 of 51 CI sound processors (98%) met transparency using the adapted AAA (2008) guidelines. The processor that did not meet transparency had an offset value of 3 dB versus 2 dB. Gain cannot be adjusted to meet transparency for the MM2+ only condition as the MM2+ does not have a gain setting control.

Cochlear N6/CP910 Sound Processor and MM2+ Coupled to a Phonak Roger DM System

As shown in Figure 6, in the default gain setting (0 dB), 28 of 51 CI sound processors (55%) met transparency using the adapted AAA (2008) guidelines. The processors that did not meet transparency had a range of offset values from 3 to 4 dB versus 2 dB. For the receivers that did not meet transparency in the default gain setting (0 dB; n = 23), the gain was adjusted to meet transparency. Following gain adjustment, transparency was met at ±2 dB for the remaining 23 CI sound processors (45%) using the AAA (2008) guidelines. Overall, 51 of 51 CI sound processors (100%) met transparency after the receiver gain was adjusted.

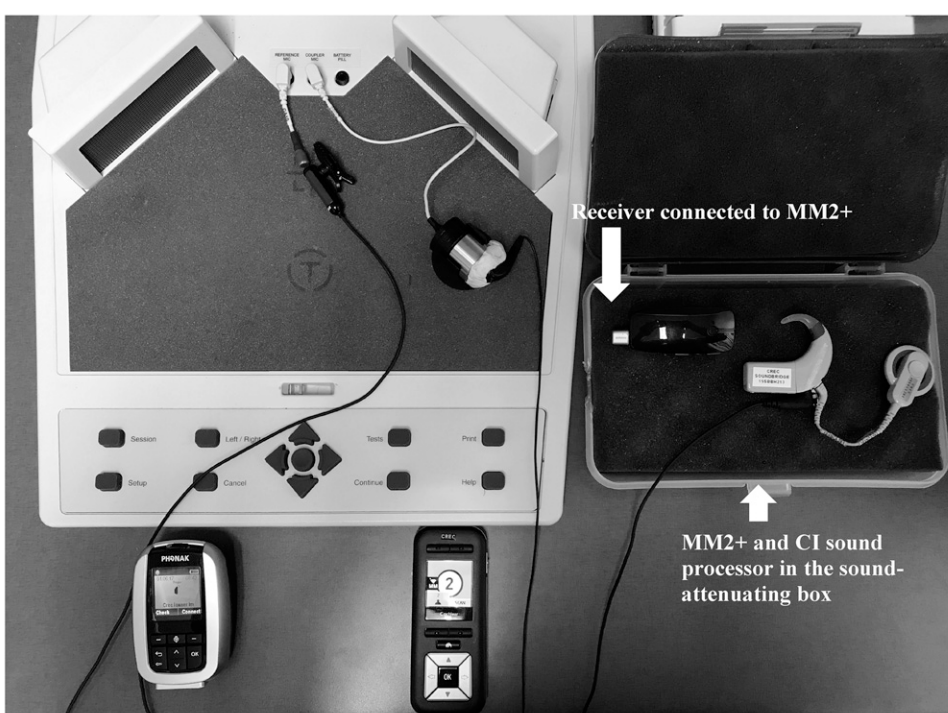

Figure 4. Configuration for Step 2 for a Cochlear N6 sound processor coupled to a MM2+ and a Phonak Roger DM system. The Phonak Roger transmitter microphone is in the Verifit chamber. The MM2+ and the Cochlear N6 sound processor are in the sound-attenuating box.

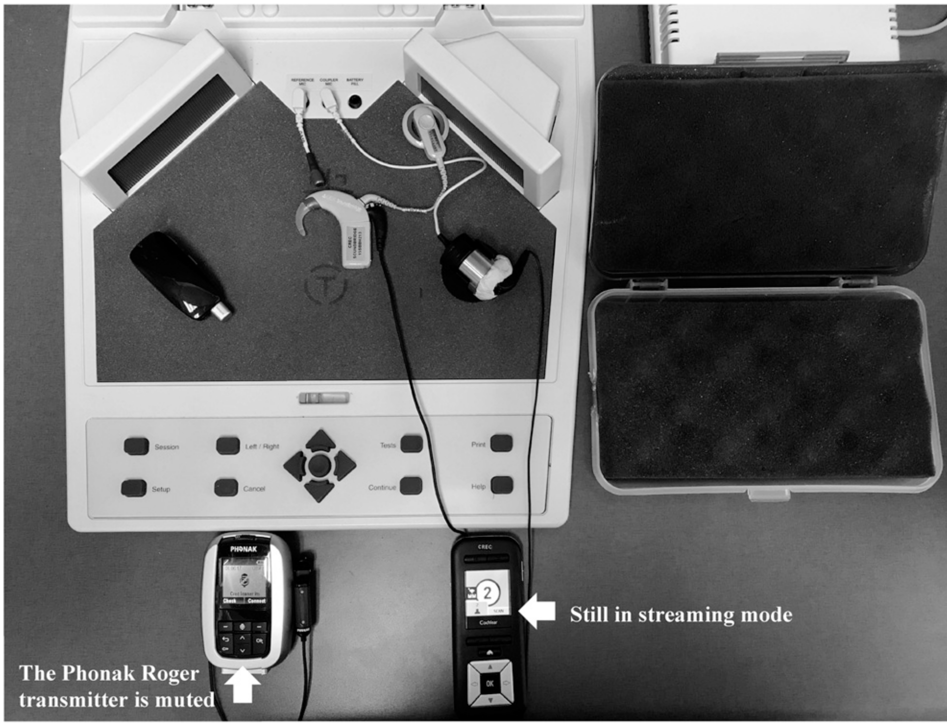

Figure 5. Configuration for Step 3 for a Cochlear N6 sound processor coupled to a MM2+ and a Phonak Roger DM System. The Phonak Roger transmitter is muted and the Cochlear N6 sound processor and MM2+ are in the Verifit chamber.

DISCUSSION AND LIMITATIONS

Electroacoustic transparency can be tested and obtained reliably for both conditions, CI sound processor and the MM2+ alone, and CI sound processor and the MM2+ coupled to DM equipment. In terms of meeting transparency standards, both configurations can confidently be fit to individuals using assistive technology to better meet a user's listening needs.

Although it may seem like a straightforward cost versus benefit decision to begin to purchase and use the MM2+ with all CI recipients, the authors would be remiss in not describing the limitations that were encountered during this project, specifically the functional feasibility of these devices when in use in the field. It should be emphasized that each CI sound processor evaluated was first subjected to a biologic listening check to ensure that the CI sound processor was

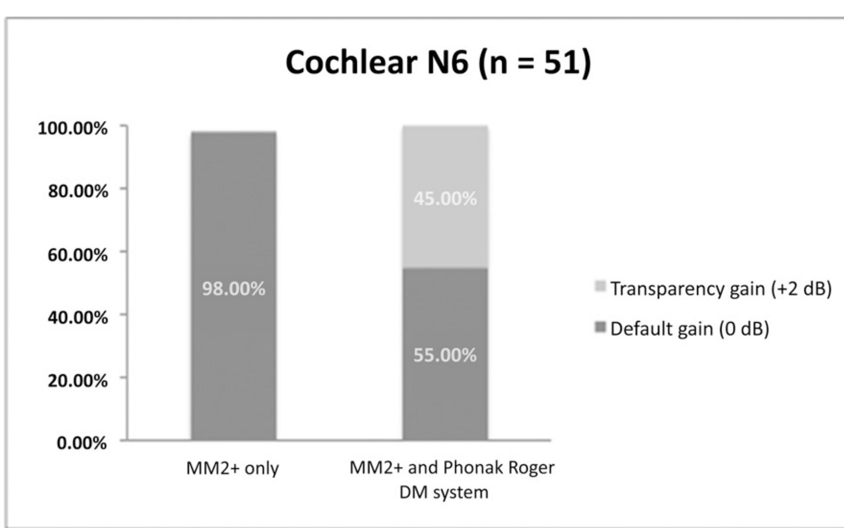

Figure 6. Percentage of Cochlear N6 CI sound processors that met transparency for the two equipment conditions depending on the gain setting.

working alone (i.e., no additional equipment coupled). A biologic listening check continued throughout the process of pairing the CI sound processor to the CR230 remote assistant, the MM2+ in both conditions, and the DM equipment in the latter condition. After ensuring the integrity of the pairing, the equipment was evaluated for transparency. During transparency runs, the equipment was monitored via listening and by viewing the CR230 Remote Assistant display. These steps ensured proper coupling of the equipment. Although it would not be feasible for someone to monitor equipment with this level of diligence while in the field, it would be imperative that a caregiver/teacher be clearly trained on a daily listening check procedure that included listening to the CI sound processor alone, and again after coupled to the RM system. It would also be our recommendation that the responsible party have both hands-on experience with the equipment to learn this procedure and be provided with clearly written instructions from the educational audiologist fitting the device.

In addition, a responsible party may require some basic troubleshooting skills. Despite the experience of the professionals completing this study, there were multiple instances that required basic troubleshooting skills to identify minor problems. For example, starting and stopping streaming via the MM2+, occasionally identifying bad auxiliary ports on the CI sound processor, resolution of static by creating new networks on the DM system, etc. Whereas none of the earlier identified problems should or would preclude the feasibility of using this equipment, it was determined that a knowledgeable, responsible party on-site (i.e., at the school) should be available for basic help.

The responsible party may also need to support the use and care of the equipment, as well as understand the limitations of the streaming range and battery life. The streaming range of the MM2+ when used alone in a clear line of sight is quoted as approximately up to 82′ (Cochlear Americas MM2+ Data Sheet, March 2016); it is assumed that this would decrease when outside the line of site (i.e., hallways, etc.). The Phonak Roger DM system can transmit from 50′ indoors to 170′ outdoors (Phonak, 2014). In most cases, these ranges should be sufficient, but in certain circumstances for school-aged children such as field day, field trips, or large group assemblies, these restrictions would need to be considered. The responsible party would also need to understand how the equipment behaves when a streaming signal is stopped. For example, when the MM2+ is out of range for approximately five minutes, the streaming of the MM2+ will stop to conserve battery life. For the signal to be started again, a CI sound processor level keypress or a keypress on the CR230 Remote Assistant is required. When the DM system goes out of range, the signal will degrade (i.e., can sometimes cause static) or stop; however, the equipment will always search for a signal, eliminating the need for additional keypresses.

The battery life for the MM2+ is estimated to be 11 hours when used alone and 10 hours when coupled to a FM system, similar to a DM system (Cochlear Americas MM2+ Data Sheet, March 2016). The battery life for the MM2+ when coupled to a DM system was not available, but the battery life of the DM system alone is approximately 12 hours, as stated in the Phonak Roger User's Guide (2014). Each system will require daily overnight charging. A responsible party may need to supervise this or take charge of it depending on the abilities of the person using the equipment.

In addition, the authors recognize that there are many other variables, including proper use (i.e., wearing the MM2+ appropriately) and coupling to additional equipment (i.e., iPads, Chrome Books, etc.) that still need to be evaluated because, if not used appropriately, can adversely impact the integrity of the signal.

Perhaps most importantly, it is critical to remind the reader that this study only evaluates transparency. Although transparency is the foundation of providing appropriate access, it does not address the functional needs of the individual. Each hearing impaired listener's unique needs must be addressed in both objective and subjective/functional measures. Although this study aims to verify transparency, the functional aspect of using the MM2+ and the DM system must also be considered carefully with each hearing impaired listener. The only piece of information that could be identified at the time of writing this article was a recent talk at the 2016 International Pediatric Audiology Conference in Atlanta, GA, where Dr. Jace Wolfe presented data that examined a patient's AZ Bio (i.e., word recognition) scores across varying background noise levels in four conditions: (a) no assistive technology, (b) the use of the MM2+, (c) the use of a previous generation of the MM2+ [MM2], and (d) the use of a DM system alone (Wolfe, 2016). The study had a relatively small sample size (N = 15) and has not yet been published, so further details of the study are not currently available.

CONCLUSIONS

Research has shown that FM/DM systems are beneficial for all children with hearing loss in a classroom setting and help to overcome factors that adversely impact speech understanding, such as distance, reverberation, and noise. The AAA (2008) fitting guidelines recommend the use of objective electroacoustic measures and behavioral testing when fitting FM systems to hearing aids. Currently, AAA only recommends behavioral testing when fitting FM systems to individuals with CIs, and RM technology have not yet been addressed or discussed.

In this study, we have demonstrated that by adapting the AAA (2008) electroacoustic measurements for hearing aids connected to an FM system, electroacoustic measurements can be obtained and transparency can be achieved for CI sound processors coupled to either a MM2+ alone or to a MM2+ coupled to a DM system.

Although some limitations have been observed for both conditions, future research from other clinicians and researchers is critical to reach a consensus in establishing an industry protocol for CI sound processors coupled to RM technology or to RM technology coupled to DM system. This is not only the best practice, but is necessary for individuals that cannot participate in objective verification measures. It is also important that future research includes behavioral testing, such as listening in noise, as well standards for mini microphone placement.

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APPENDIX

Summarized Transparency Protocols for a Cochlear N6 Sound Processor Coupled to a MM2+ with and without a Phonak Roger DM System

Cochlear N6 sound processor coupled to a MM2+	Cochlear N6 sound processor coupled to a MM2+ and a Phonak Roger DM System
Step I: • Connect the monitor earphones to the processor • Attach one earbud to the HA-1 coupler with putty; place in the sound-attenuating box • Place the processor in the test box with the processor microphone near the reference microphone • On the Verifit, choose TEST, TEST BOX MEASURES, and SPEECHMAP • Close the Verifit and run at 65 dB SPL using speech-std (1) Step II: • Pair the Cochlear CR230 Remote Assistant to the processor • Turn on the MM2+ and initiate streaming • Place the processor in the sound-attenuating box • Place the MM2+ in the test box near the reference microphone • On the Verifit, choose TEST, TEST BOX MEASURES, and SPEECHMAP • Close the Verifit and run at 65 dB SPL using speech-std (1) Step III: • Remove the MM2+ from the test box and put in the MUTE position • Place the muted MM2+ in the sound-attenuating box • Place the processor back in the test box with the processor microphone near the reference microphone • On the Verifit, choose TEST, TEST BOX MEASURES, and SPEECHMAP • Close the Verifit and run at 65 dB SPL using speech-std (1) • While in the TABLE view (under FORMAT OPTIONS on screen), subtract Test 3 from Test 2 at 750, 1000, and 2000 Hz, then calculate a three-frequency average • The offset value should be between ±2 dB	Step I: • Connect the monitor earphones to the processor • Attach one earbud to the HA-1 coupler with putty; place in the sound-attenuating box • Place the processor in the test box with the processor microphone near the reference microphone • On the Verifit, choose TEST, TEST BOX MEASURES, and SPEECHMAP • Close the Verifit and run at 65 dB SPL using speech-std (1) Step II: • Pair the Cochlear CR230 Remote Assistant to the processor • Turn on the MM2+ and initiate streaming • Note the FM gain setting; plug the receiver into the bottom of the MM2+ • Perform a listening check to ensure streaming • Place the processor in the sound-attenuating box • Place the transmitter microphone in the test box near the reference microphone • Place the MM2+ in the test box 2–3 inches from the reference microphone • On the Verifit, choose TEST, TEST BOX MEASURES, and SPEECHMAP • Close the Verifit and run at 65 dB SPL using speech-std (1) Step III: • Remove the transmitter and the MM2+ from the test box • Mute the transmitter • Place the muted transmitter and MM2+ in the sound-attenuating box • Place the processor (still in streaming mode) back in the test box with the processor microphone near the reference microphone • Close the Verifit and run at 65 dB SPL using speech-std (1) • While in the TABLE view (under FORMAT OPTIONS on screen), subtract Test 3 from Test 2 at 750, 1000, and 2000 Hz, then calculate a three-frequency average • The offset value should be between ±2 dB, if not, adjust the gain settings and repeat the process until transparency offset value is met