Research Article

Measuring Sound-Processor Threshold Levels for Pediatric Cochlear Implant Recipients Using Conditioned Play Audiometry via Telepractice

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Purpose: This study evaluated the use of telepractice for measuring cochlear implant (CI) behavioral threshold (T) levels in children using conditioned play audiometry (CPA). The goals were to determine whether (a) T levels measured via telepractice were not significantly different from those obtained in person, (b) response probability differed between remote and in-person conditions, and (c) the remote visit required more time than the in-person condition.

Method: An ABBA design (A, in-person; B, remote) was split across 2 visits. Nineteen children aged 2.6–7.1 years participated. T levels were measured using CPA for 3 electrodes per session. A “hit” rate was calculated to determine whether the likelihood of obtaining responses differed between

conditions. Test time was compared across conditions. A questionnaire was administered to assess parent/caregiver attitudes about telepractice.

Results: Results indicated no significant difference in T levels between conditions. Hit rates were not significantly different between in-person and remote conditions (98% vs. 97%, respectively). Test time was similar between conditions. Questionnaire results revealed that 100% of caregivers would use telepractice for CI appointments either some or all of the time.

Conclusion: Telepractice is a viable option for routine pediatric programming appointments for children using CPA to set behavioral thresholds.

Telepractice is the delivery of health care services via telecommunications technology, with physical distance separating the patient and provider. The American Speech-Language-Hearing Association has recognized the benefit of telepractice as a way to expand audiology service delivery (American Speech-Language-Hearing Association Technical Report, 2005). Pediatric cochlear-implant (CI) services are a highly specialized area of audiology that may benefit from telepractice because pediatric recipients require numerous follow-up appointments to program the externally worn CI sound processor. During the first year of implantation, at least eight appointments are necessary for activation and follow-up programming of the device. At our center, the first two visits occur on consecutive days that are 1–2 weeks after surgery (initial activation), with the remaining visits occurring at 2 weeks, 1 month,

3 months, 6 months, 9 months, and 12 months postactivation. After the first year, programming visits typically occur every 3–6 months for the next 3–5 years. Bilateral implantation has the potential to double the amount of appointments required, especially in the case of sequential implantation. In addition, CI centers are usually located in larger metropolitan areas, requiring rural families to travel long distances for services. Multiple visits to the center might be a burden in terms of financial resources and time away from work and/or school, which could delay or prevent appropriate follow-up. To our knowledge, pediatric CI programming has not been empirically validated for use with telepractice. If pediatric CI programming can be shown to be feasible, there exists the potential to expand and/or improve access to CI services for pediatric patients. The goal of this study was to evaluate the use of telepractice for obtaining sound-processor behavioral threshold (T) levels in pediatric recipients using conditioned play audiometry (CPA).

For adult and adolescent recipients, several studies have shown equivalent outcomes in sound-processor programming (“map”) levels between telepractice and in-person appointments (Eikelboom, Jayakody, Swanepoel, Chang, & Atlas, 2014; Hughes et al., 2012; Kuzovkov et al., 2014;

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McElveen et al., 2010; Ramos et al., 2009; Wesarg et al., 2010). In addition, audiologist and recipient feedback regarding telepractice has been positive, indicating that patients would take advantage of telepractice if it were routinely available (Hughes et al., 2012; Kuzovkov et al., 2014; Ramos et al., 2009; Wesarg et al., 2010). Device programming for adults and older children is a rather straightforward process; the recipient verbally indicates threshold and upper comfort (C or M, depending on the specific manufacturer's definition) levels for stimulation on all or a subset of intracochlear electrodes, which results in a sound-processor map. Because very young children cannot verbally express this information, programming techniques for this age group are aimed at eliciting behavioral information through conditioned reinforcement of a response to sound using a lighted toy as a visual reward (visual reinforcement audiometry, or VRA) or a play task (i.e., CPA). To do this, additional staff and specialized audiological procedures and equipment based on the age and developmental level of the child are used. At many CI centers, two pediatric audiologists provide the programming services. One audiologist (programming audiologist) manipulates the manufacturer's software to program the device (typically out of view from the child to reduce bias from visual cues) while the other audiologist (play assistant) engages the child, judges the child's response to sound, communicates responsiveness to the programming audiologist, and rewards the child for correct responses. Effective communication between the programming audiologist and the play assistant is critical to maximize the number of behavioral responses that can be obtained from the child in a short amount of time. Pediatric programming may be difficult to pursue remotely via telecommunications technology because the timing between the stimulus delivery and the child's response, and the communication between service providers are important and could be affected by compromised audio and/or video signals. In particular, it is unclear how remote service delivery will affect (a) the child's responsiveness to sound, (b) the communication between the two audiologists, and (c) the parent-audiologist relationship. These important aspects will be examined in the present study.

Early intervention and regular follow-up are critical for the success of young children with new implants because of the sensitive period of auditory development that occurs within the first 3 years of life (e.g., Sharma, Dorman, & Kral, 2005; Sharma, Dorman, Spahr, & Todd, 2002). The sooner an appropriate sound-processor map can be fit, the more likely an optimized outcome will be achieved for the child (e.g., Manrique, Cervera-Paz, Huarte, & Molina, 2004). However, generating an appropriate map is a process that occurs over numerous visits, primarily because young children cannot engage in these kinds of tasks long enough to obtain reliable behavioral responses on all electrodes. To compound this problem, missed appointments can delay the fitting of an appropriate map and contribute to sub-optimal outcomes. Only a few studies have described the use of telepractice for pediatric CI services (Franck, Pengelly, & Zerfoss, 2006; Kuzovkov et al., 2014; Wesarg et al., 2010).

Franck et al. (2006) provided a descriptive account of the authors' experience with remote CI programming for 10 patients. Whereas the authors felt their experience was successful, the study did not provide empirical data to show whether telepractice methods yielded equivalent outcomes compared with in-person programming methods. Further, only "experienced" CI users were included in their study; therefore, the age of the children tested was unclear, and it was not stated whether VRA, CPA, or standard behavioral techniques were used for the remote programming. In Wesarg et al. (2010), 69 CI recipients were programmed remotely, which included 13 pediatric recipients as young as 1 year of age. The authors found no significant difference between remote and in-person T and C levels. The programming audiologist used either behavioral or objective measures to set levels; however, the techniques that were used with the children were not explicitly stated (e.g., VRA or CPA). To conclude, Kuzovkov et al. (2014) reported that children as young as 5 years of age took part in remote CI programming in their study. The results only stated outcomes of a questionnaire that was administered; no information regarding behavioral techniques was included. Although several studies have tested children via remote CI programming, none of the published studies has explicitly stated the techniques that were used, or specifically assessed map outcomes for this group. Therefore, there remains a clear need to empirically validate behavioral measures using remote programming with young children.

The aim of this study was to compare CI sound-processor behavioral T levels for remote and in-person conditions in pediatric recipients. CPA techniques were used to obtain the behavioral responses in children aged 2–7 years. Setting of upper comfort levels in very young children is often affected by clinician preferences or clinic protocols because young children (particularly those who are prelingually deafened) cannot adequately scale loudness. In general, T levels are measured first, and then the stimulus is increased by some amount to set upper comfort levels. Therefore, only T levels were measured in this study. Because young children can become fatigued with behavioral tasks quickly, a "hit" rate was calculated for the remote and in-person conditions to determine whether either condition resulted in fewer measurable responses for the number of attempts made to obtain a response. The hit rate was calculated by dividing the number of electrodes for which T levels were successfully measured by the number attempted. Last, a parent/caregiver questionnaire was administered at the conclusion of the study to assess the caregivers' impressions of remote CI service delivery. It was hypothesized that (a) T levels would not differ significantly across the remote and in-person conditions, (b) the hit rate would not differ significantly across the two conditions, and (c) the remote test time would be longer than the in-person test time, on the basis of results from previous studies (Eikelboom et al., 2014; Hughes et al., 2012; Wesarg et al., 2010) and the possibility that variables associated with the remote procedure (e.g., distractions from equipment, unfamiliar environment, etc.) might prolong testing time.

Method

Subjects

Twenty pediatric CI recipients were enrolled. One subject did not complete the study, so results are reported for 19 subjects (9 boys, 10 girls). Subject demographics are detailed in Table 1. All three device manufacturers approved by the Food and Drug Administration were represented in the study group, which consisted of five Cochlear Ltd. devices (one CI24RE[CA] and four CI512 devices; Macquarie, New South Wales, Australia), 13 Advanced Bionics HiRes 90k devices (Valencia, CA, USA), and one MED-EL Concert device (Innsbruck, Austria). Fifteen subjects were congenitally deafened; one subject was deafened by a sudden illness at 17 months of age (C77); and the onset of deafness was unknown for the remaining three subjects. The average age of subjects at the time of participation was 5 years, 3 months (range: 2 years, 5 months to 7 years, 1 month), and the average length of CI use was 3 years, 3 months (range: 6 months to 6 years, 2 months). All subjects' parents or guardians signed an informed consent and were compensated for hourly participation and travel. For subjects with bilateral implants, only one ear was tested. The ear that was implanted the longest was typically chosen as the test ear. This study was approved by the Boys Town National Research Hospital (BTNRH) Institutional Review Board under Protocol 13-09-XP.

Study Design

An ABBA design was used over two visits, in which A represented the in-person condition and B represented the remote condition. For the first visit, the in-person session was first, followed by the remote session (AB). For the second visit, the remote session was first, followed by the in-person session (BA). At each visit, a small break

Table 1. Subject ID, processor type, and number of days between visits for study subjects.

Subject ID	Processor type	No. of days between visits
C48	Neptune	2
C51	Naida CI Q70	7
C52	Neptune	2
C54	Harmony	31
C55	Neptune	27
C56	Neptune	21
C58	Neptune	13
C62	Neptune	23
C63	Naida CI Q70	6
C65	Harmony	3
C68	Neptune	5
C77	Neptune	6
C83	Naida CI Q70	30
F29	CP810	26
N13	CP810	0
N14	CP810	0
N15	CP810	3
N17	CP910	0
M3	Opus 2	6

was provided between the in-person and remote sessions. This repeated-measures design was intended to control for potential order effects and/or fatigue in the children. The two visits were no more than 1 month apart (mean, 10 days; see Table 1) because it has been shown that programming levels in children can change over time, especially during the first year of implant use (e.g., Hughes et al., 2001). For one subject (C77), a third visit was added to repeat the BA portion of the study because reliable behavioral information could not be obtained at the second visit. Despite the addition of a third visit for this child, a complete data set could not be obtained for all electrodes, conditions, and visits.

The in-person condition always occurred in the laboratory. For the remote condition, the programming audiologist remained in the laboratory while the subject, parent/caregiver, and play assistant were in a conference room on a different floor in the same building. In every case, the programming audiologist had a minimum of 5 years of experience programming pediatric CI recipients. The play assistants were two audiologists and one speech-language pathologist who worked in the laboratory. In all but one case (C83), the same programming audiologist and play partner were used for both visits for each subject in order to eliminate any potential effects that a different staff member would have on eliciting the child's responses.

Equipment Setup

The equipment at the in-person and remote visits was identical to that used at a regular clinical programming appointment. Schematics of the equipment and room setup for the in-person and remote conditions are shown in the top and bottom panels of Figure 1, respectively. The following CI software was loaded onto a Dell Optiplex 780 desktop personal computer running Windows 7 in the laboratory: Custom Sound (Version 4.3; Cochlear Americas, Centennial, CO); SoundWave (Version 2.3.23; Advanced Bionics, Valencia, CA); and Maestro (Version 6.0.1; MED-EL, Durham, NC). The same software was loaded onto a Hewlett Packard ProBook laptop computer running Windows 7 for use at the remote site. The respective CI interfaces and programming cables were used to connect to each subject's processor at both the in-person and remote sites (programming pod for Cochlear, CPI-3 for Advanced Bionics, and DIB for MED-EL). Age-appropriate toys were used to elicit behavioral responses for the in-person and remote conditions. For the remote procedure, the programming audiologist's desktop computer (also used for programming in the in-person condition) commanded the remote-site laptop via Windows Remote Assistance, a secure network that creates an encrypted pathway between the two computers. For two-way audio and video streaming between the two sites, a Polycom HDX 7000 System (Polycom Inc., San Jose, CA) with a 28 × 16-inch (71 × 40-cm) video monitor was used in the laboratory, and a CISCO system (CISCO Systems, San Jose, CA) with a 52 × 29-inch (132 × 74-cm) video monitor was used at the remote site. As shown

Figure 1. Illustration depicting the test setup for in-person (top) and remote (bottom) conditions. Top: The in-person condition was conducted in the laboratory. The audiologist (A) manipulated the manufacturer's software to obtain threshold levels while the play assistant (PA) engaged the child (C) in the behavioral task. Bottom: In the remote condition, the audiologist was located in the laboratory and manipulated the software through a secure internet connection to the remote site. At the remote site, the child sat with his/her back to the programming audiologist. The same play assistant engaged the child in the behavioral tasks to obtain the map threshold data. The audiologist and play assistant communicated via the videoconferencing system. An audible alarm that played through the laptop speakers from the manufacturers' software alerted the play partner to the presence or absence of stimulation. Figure is adapted from Hughes, Goehring, Miller, & Robinson (2016).

in Figure 1, the video screen in the remote condition was positioned behind the child to avoid distractions; however, the camera was positioned behind and to the right of the child (approximately 135 degrees azimuth) for better viewing of behavioral responses by the programming audiologist.

Measurements

Electrode impedances were measured at the beginning of each in-person and remote session to ensure all electrodes were functioning within normal limits. None of the impedance values for the test electrodes was abnormal for any of the measurements.

Behavioral Thresholds (T Levels)

Traditional CPA techniques were used to elicit the T level for three electrodes representing the basal, middle,

and apical portions of the electrode array (3, 11, and 19 for Cochlear; 13, 8, and 3 for Advanced Bionics; and 10, 6, and 3 for MED-EL). No changes were made to the subject's everyday program. The children used a laboratory processor for the study measures. To ensure that the programming audiologist was blinded to the child's current sound-processor map levels, a blank map was created during each session. One of the staff clinical CI audiologists (who was not the test clinician in the study) provided limited map information from the child's existing clinical program, including processor type, processing strategy, rate of stimulation, and pulse width, to the programming audiologist responsible for the measures. The programming audiologist was also provided with a starting level to use for conditioning in the behavioral tasks. This starting level was arbitrarily assigned by the clinical CI audiologist between 40% and 60% of the dynamic range from the child's already-established program. This allowed the programming audiologist to present a stimulus that was audible enough for conditioning to the task without overstimulation. The rationale for this design is that, in practice, remote programming would only be used for follow-up visits, not initial activation. Therefore, clinicians should have access to a prior map from which to adjust program levels during remote follow-up visits.

The goal was to obtain at least one reliable behavioral threshold on each test electrode at each session using CPA techniques. With one exception, behavioral thresholds were measured twice at each session, and the final threshold for each subject's session was the average of the two behavioral responses. The exception was subject C77, for whom repeated measures could not be obtained for all electrodes/conditions.

For the Cochlear recipients, T levels were measured using a traditional bracketing procedure with a step size of 6 clinical units down and 2 clinical units up. For the Advanced Bionics recipients, bracketing was performed with a step size of 10 charge units down and 5 charge units up. For the MED-EL subject, a 3% change in charge was used as the step size (one arrow key up or down on the keyboard). For the remote session, the same procedures were followed as those used for the in-person condition. For both the in-person and remote procedures, the child sat with their back to the programming audiologist or video monitor, respectively. This eliminated any visual cues to stimulation for both conditions, and it minimized any distraction from the video monitor in the remote condition. Response reliability in young children can vary substantially within a session. For example, children can fatigue quickly of behavioral tasks, resulting in elevated threshold estimates, or children can respond with false positives (i.e., a behavioral response is given in the absence of sound). In these cases, the programming audiologist only recorded thresholds for electrodes that were rated subjectively as "good" or "good-to-fair" reliability. Responses to the stimulus for conditioning and while seeking threshold were judged by both the play assistant and by the programming audiologist, who conferred verbally about response reliability.

Measurement Hit Rate

To ensure the telecommunications technology did not interfere with obtaining reliable threshold measures, a hit rate was calculated for both the in-person and remote sessions. This calculation was made using the number of electrodes that were tested. As noted above, the goal was to obtain at least one behavioral threshold on each of three electrodes (basal, middle, and apical) during each of the two in-person or remote conditions (total of six attempts per condition). If, for example, thresholds could only be obtained for two out of the three electrodes at both of the in-person visits, the hit rate for the in-person condition was 67% (4/6).

Test Time

Test time was recorded (in minutes) by the programming audiologist using the start and end time for the behavioral tasks. In particular, the start time commenced when the programming software was opened and the end time was recorded when the last behavioral response was obtained. Because the primary purpose for recording the test time was to determine whether the remote procedure caused testing to take longer (e.g., due to distractions, unfamiliar environment, or the need for additional communications between testers), the recorded test time did not include the time it took to administer and obtain informed consent, equipment setup time, or time needed to complete the questionnaire at the end of the study.

Parent/Caregiver Questionnaire

At the end of the study, the parent/caregiver that accompanied the child to the appointments completed a short questionnaire that consisted of seven questions and space to add open-ended comments. The questions were aimed at evaluating how positively or negatively the remote testing procedure was perceived, as well as determining how often the parent/caregiver would utilize remote services if they were available. The specific questions are detailed in the Results section.

Results

Behavioral Thresholds (*T* Levels)

Figure 2 shows group *T*-level data plotted as box-and-whisker plots for 18 subjects. For subject C77, *T* levels could not be obtained for the basal and middle electrodes in the remote condition at the second visit. As noted above, a third visit was added to attempt measures in the BA condition (replication of visit two), but reliable responses could not be obtained. As a result, subject C77 was not included in the group analyses for *T* level.

In Figure 2, boxes and whiskers represent confidence intervals of 25%–75% and 10%–90%, respectively. Filled circles represent outliers. Means and medians are indicated by dashed and solid lines, respectively. For the Cochlear and Advanced Bionics subjects, *T* levels were converted from clinical units (clinical units and charge units, respectively) to electrical charge (nC) in order to compare results

across all of the subjects (MED-EL uses charge units by default). A three-way repeated measures analysis of variance (RM ANOVA) was performed to evaluate the factors of *visit* (1 vs. 2), *condition* (in-person vs. remote), and *electrode* (basal, middle, and apical) on *T* level. Results indicated no significant effect of visit, $F(1, 17) = 1.08, p = .31$; condition, $F(1, 17) = 3.69, p = .07$; or electrode, $F(1.42, 24.16) = 2.19, p = .15$. On average, the remote condition yielded *T* levels that were 0.13 nC lower than those obtained in the traditional in-person condition (2.95 vs. 3.08 nC, respectively). In summary, *T* levels were not significantly different between in-person and remote sessions, consistent with the hypothesis.

Measurement Hit Rate

In total, 57 electrodes were tested (three electrodes for each of 19 subjects). Because there were two visits per condition (in-person, remote) for 18 subjects (108 attempts per condition) and three visits per condition for one subject (C77; nine attempts per condition), 117 total attempts were made to measure *T* level in each condition. The hit rate was calculated for each individual subject (number of electrodes measured divided by the number attempted). All subjects except C77 had a hit rate of 100%. For C77, the average hit rate was 67% for the in-person sessions and 44% for the remote sessions. This yielded an overall hit rate of 98% for the in-person condition and 97% for the remote condition. A Wilcoxon signed rank test indicated no significant difference in hit rate between conditions ($Z = -1.00, p = 1.0$), which suggests that the remote technology did not influence the subjects' ability to engage in the behavioral tasks.

Test Time

The amount of time spent obtaining the behavioral measures was compared to determine whether the remote procedure yielded significantly longer test time than the in-person sessions. Results are displayed in Figure 3. Data are plotted as in Figure 2. A two-way RM ANOVA with factors *visit* (one vs. two) and *condition* (remote vs. in-person) indicated no significant effect of visit, $F(1) = 2.39, p = .14$, or condition, $F(1) = 0.63, p = .44$. Across conditions, the mean duration for visit one and two was 16.9 and 14.9 min, respectively. Across visits, the mean duration for the in-person and remote session was 16.4 and 15.4 min, respectively. The hypothesis that the remote procedure would yield longer testing time was not supported.

Parent/Caregiver Questionnaire

Table 2 displays the results of the parent/caregiver questionnaire. Each question is listed in the table along with a numerical value that indicates how often (percent of total in parentheses) that answer was chosen by the respondent. In general, parents/caregivers felt the efficiency of the remote appointment was the same as the in-person appointment (Q1), and that the test environments were

Figure 2. Box-and-whisker plots illustrating map threshold (T level) data in electrical charge (nC) for the basal (left), middle (middle), and apical (right) electrodes tested for 18 subjects (a full data set could not be obtained for C77; see text). Boxes and whiskers represent confidence intervals of 25%–75% and 10%–90%, respectively. Filled circles represent outliers. Means and medians are indicated by the dashed and solid lines, respectively. Each visit is labeled along the x-axis. The in-person results are shaded in gray; remote results are in white. The gray and white boxes within a panel are arranged in the order of testing across the two visits (the first session was in-person, the second and third sessions were remote, and the fourth session was in-person).

similar (Q2). Everyone responded that they would take advantage of remote programming either some or all of the time (Q3). In general, respondents felt comfortable communicating with the programming audiologist via the videoconferencing equipment (Q4). Most parents and caregivers indicated that it can be a hardship to attend clinical appointments (Q5). In general, the distance technology did not overwhelm the parents/caregivers or the children (Q4, Q6, and Q7). In addition to the numbered questions and answers, there were open-ended questions for respondents to leave anecdotal comments. One of the general trends among responses was that parents or caregivers liked the option of remote programming for routine appointments; however, several reported that there would be instances in which an in-person appointment would be necessary. These instances were noted for device activation, when parents or caregivers are oriented to the equipment, and during times of troubleshooting or device integrity checks. Several respondents noted that there are considerable costs associated with making appointments in terms of time off of work and school, arranging for care for additional children, and

the financial burdens of fuel and possible hotel stays. Last, there were several respondents that stated they preferred in-person appointments over remote options. Some families in this study were local, which could have affected their responses. Another parent noted that with several children in their family, an appointment at the center required the siblings to stay home; therefore, this parent preferred to travel to the center for appointments. This was also beneficial to her daughter, who had bilateral CIs, because it allowed her to better focus on the behavioral tasks.

Discussion

The objective of this study was to determine whether telepractice could be used to set behavioral T levels in young children using CPA. To our knowledge, this study was the first empirical examination of this nature. We hypothesized that T levels would not be significantly different between remote and in-person sessions, and this hypothesis was supported with the present data. It was expected that the hit rate would be similar between the two appointment types, and this hypothesis was also supported. Last, it was hypothesized that the remote testing time would take longer than the in-person testing time. Test times did not differ significantly between conditions; therefore, this hypothesis was not supported. The questionnaire revealed that 100% of parents and caregivers would take advantage of telepractice options some or all of the time, and in general, they did not feel overwhelmed by the distance technology. However, caregivers did note instances in which in-person appointments would be necessary, such as the initial stimulation, equipment checks, or visits related to device function.

Feasibility of Remote CI Programming for Young Children

Previous studies that have evaluated the feasibility of remote CI programming have focused on using this technology only with adults and/or adolescents (Eikelboom

Figure 3. Box-and-whisker plots showing session duration in minutes across the two visits and two conditions (in-person and remote). Data are plotted as in Figure 2.

Table 2. Results of the parent/caregiver questionnaire. Each question is indicated in the far-left column. The numerical values in the table indicate the number of responses for that category (percent of total in parentheses).

Question	Much worse	Slightly worse	The same	Slightly better	Much better
Q1. How smooth or efficient were the remote procedures compared to the in-person procedures?	0 (0%)	1 (5%)	16 (84%)	1 (5%)	1 (5%)
Q2. How did the remote test room compare to the in-person room?	0 (0%)	1 (5%)	15 (79%)	2 (11%)	1 (5%)
Question	Never	Some of the time	All of the time		
Q3. How often would you take advantage of remote options if they were regularly available for clinical appointments close to your home?	0 (0%)	13 (68%)	6 (32%)		
Q4. Would you feel comfortable speaking with your child's clinician through videoconferencing technology?	0 (0%)	5 (26%)	14 (74%)		
Q5. Do you feel it can be a hardship to attend clinical CI programming appointments for your child (e.g., travel, cost, time off work/school)?	1 (5%)	13 (68%)	5 (26%)		
Question	Not at all	Somewhat	Yes		
Q6. Did you feel overwhelmed by the distance technology?	18 (95%)	1 (5%)	0 (0%)		
Q7. Do you feel your child was distracted or not engaged due to the distance technology?	17 (89%)	2 (11%)	0 (0%)		

et al., 2014; Hughes et al., 2012; McElveen et al., 2010; Ramos et al., 2009; Wesarg et al., 2010). Young children, however, present additional challenges to behavioral testing. These challenges include difficulty maintaining attention, lack of cooperation, and failure to condition to the auditory stimulus. Each of these challenges can result in additional visits to the clinic if sufficient behavioral information cannot be obtained to construct an appropriate sound-processor program. Given that the number of regular clinic visits within the first year can already be burdensome for families, additional visits that stem from a child's inability or unwillingness to cooperate can be too overwhelming for families to manage, especially if they live far from the CI center. Further, delays in optimal processor fittings can result in delays in speech and language development. The children in this study ranged in age from 2 to 7 years and were familiar with the behavioral CPA task. The results of this study were similar to that of the studies with adults, in that behavioral thresholds obtained for in-person and remote conditions were not significantly different. Therefore, we consider telepractice a good option for routine follow-up appointments in which the relationship between a clinician and patient/family has already been established. Telepractice for device activation and equipment/integrity checks has not been validated; therefore, we recommend those appointment types be conducted in person.

Measurement Hit Rate

This study showed that the type of session did not affect a child's ability to engage in a conditioned play task. The in-person hit rate was 98%, compared with 97% for the remote condition. The average age of the children in this study was 5 years, 3 months. There was only one child

(C77, who was the youngest) who did not respond to every electrode attempted. Two factors likely contributed to difficulty measuring responses for this child. First, he was almost 2.5 years old at the time of testing. He had matured enough that VRA was no longer engaging or effective, but he was not quite ready to respond reliably to CPA. Second, this child lost his hearing secondary to a sudden illness at 17 months of age. Because he had normal hearing for the first 17 months of life, he would not tolerate removing his CI processor to connect to the programming software because it made the microphone inactive. These issues resulted in an average hit rate of 67% for the in-person sessions and 44% for the remote sessions for C77. It is possible that having two clinicians present at the in-person session helped with increasing this child's response to the behavioral tasks compared with the remote session, in which only one clinician was present to reassure the child and engage him in the task. This particular case highlights the difficulty that can result when testing very young children and may further support the use of telepractice as a means to obtain behavioral information without excessive travel by the family.

Test Time

The time it took to complete behavioral testing did not differ significantly between the in-person (16.4 min) and remote (15.4 min) conditions. It is important to note that these times only reflected the actual test time for the behavioral tasks, and not the time it took to connect the videoconference call or remote into the laptop at the recipient site. The rationale for recording only the time for the behavioral testing was to determine whether the remote procedure itself prolonged testing time due to factors such as procedural distractions, environment, signal delays, or

the need for additional communications between the audiologist and play assistant. If we factor in the time it took to power on the videoconferencing equipment and place the video call (approximately 20 s) and to connect to the remote computer (also approximately 20 s), the test times would still be similar. As with the CI programming procedure, setting up the remote connection will take longer for those who are new to the technology and procedure, but that time decreases substantially with experience.

Parent/Caregiver Questionnaire

The motivation for conducting this study was based on the rural state in which our center is located, and the long travel times that many families face when traveling to the center, which sometimes prevents access to services. Ninety-five percent (18/19) of parents/caregivers reported that it can be a hardship to attend clinical programming appointments (see Table 2). These hardships may include coordinating travel, time off work or school, and/or child care for other children in the family. Most respondents reported that they never felt overwhelmed by the distance technology (95%), and 89% said they did not think their child was distracted by the technology. This is likely due to the widespread use of personal technology such as cellular phones, tablets, and personal computers, which utilize webcams for video chatting (e.g., Skype, FaceTime, Google Chat). Responses to the questionnaire in the present study are similar to responses obtained in other reports (Hughes et al., 2012; Kuzovkov et al., 2014; Ramos et al., 2009; Wesarg et al., 2010), which generally show a positive attitude toward remote CI service delivery.

Study Limitations

In this study, the same play assistant was used for the remote and in-person conditions to control for potential differences between play assistants at different sites. For example, play assistants might differ in the ability to establish rapport with the child, communicate with the programming audiologist, and general skill level in working with children. In reality, a telepractice visit would likely occur at a local education agency, private-practice audiologist or hearing-aid dispenser office, or hospital, which would mean a staff member from that institution would likely serve as a play assistant. Therefore, the play assistant would be different for visits at the center versus visits at a local facility. However, if remote options were used regularly, a child and his or her family would become familiar with staff at both locations. In the ideal situation, the child's early interventionist, local speech-language pathologist, or local audiologist could serve as the remote assistant.

Timing of reinforcement for establishing a conditioned bond is critical when programming a CI. For the first few sessions, a slight time delay was noticed during the remote sessions between the stimulus onset in the manufacturers' software and the verbal indication by the programming audiologist (to the play assistant) over the

Polycom/CISCO system. As a result, there were times when the child was reinforced inaccurately by the play assistant. To correct for this time delay, the audible stimulus from the manufacturers' software was activated to immediately indicate to the play assistant that the stimulus was presented. This act eliminated any issue with establishing a conditioned bond. For children with residual hearing in the non-implanted ear, the contralateral hearing aid was removed, and the volume of the audible alarm was decreased. It is important to note that signal delays were not empirically measured in this study, and that delays will be influenced by the specific technology, internet connection, and bandwidth used for videoconferencing.

Last, it is important to recognize that the lack of a significant difference in T levels between the two methods does not necessarily mean the two conditions are equivalent. This study was not designed as a noninferiority study or as an equivalence study (e.g., Greene, Morland, Durkalski, & Frueh, 2008; Hahn, 2012; Lesaffre, 2008). The goal of a noninferiority study is to demonstrate that an experimental treatment is not worse than the control treatment by a clinically important difference (a one-sided test). The goal of an equivalence study (a two-sided test) is to show that a difference between an experimental and control treatment (regardless of the direction of the differences) is not of clinical importance. As reflected by our hypotheses, the goal was to examine the evidence for a difference existing between the two conditions, as provided by the data.

Future Directions

The next logical step for evaluating the effectiveness of telepractice with pediatric recipients is to evaluate processor programming for children younger than those tested in the present study. In particular, there are currently no published reports that evaluate the use of VRA techniques to program CI processors for very young children (approximately 1–3 years of age). These very young children are possibly the most difficult-to-test population because they have little to no experience with sound or listening tasks, and they can fatigue very quickly during behavioral testing. A study in our laboratory is currently investigating the use of telepractice to program CI processors for young children who are tested using VRA. There is also a need to investigate setting M or C levels using telepractice with children. As stated, setting comfort levels is not as straightforward as it is with adults. For children, comfort levels are often set relative to measured T levels, and this can be affected by clinician preferences or center protocols and/or objective measures. Finally, the programming audiologist in the present study was provided with starting levels from the child's already-established map; therefore, this process is similar to what would occur for follow-up programming appointments rather than initial activation appointments. The use of telepractice for initial activation should be empirically validated before it is used on a routine basis.

One of the primary limiting factors in implementing widespread clinical use of telepractice is reimbursement for

services. The Centers for Medicare and Medicaid have a substantial amount of influence on other payers (Brannon, 2012). Medicare has specified only a small group of professionals as being eligible to provide telepractice services; these include physicians, nurses, psychologists, and social workers, but not audiologists. Medicaid, on the other hand, supports telepractice services; however, it is up to each state Medicaid office to choose whether or not to cover telepractice services. The Telehealth Promotion Act of 2012 (H.R. 6719) was designed to remove restrictions that deny coverage for services delivered via telepractice that would otherwise be covered in person for government-based programs (Medicare, Medicaid, military, and other federal health care programs). In addition, it only required health care providers to be licensed in the state in which they were located, rather than the state in which the patient was located. The bill was never passed (<http://www.govtrack.us/congress/bills/112/hr6719>). The National Telehealth Policy Resource Center's website (see the Center for Connected Health Policy at <http://cchpca.org>) offers up-to-date information on a state-by-state basis about current and pending legislation that pertains to private insurance coverage of telehealth services.

We hope the results of this study can be used to expand and/or improve access to CI services for pediatric recipients. Our findings indicate that telepractice can be used to obtain T levels in children for whom conditioned play techniques are used to elicit behavioral information, without adding additional time to the appointment. In addition, respondents to the questionnaire were overwhelmingly receptive of telepractice services. The next step is to validate CI programming techniques for younger children using VRA.

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