Aural rehabilitation and speech-language therapy is described for severe-to-profoundly deaf, college-age students. Students in therapy are often cochlear implant users and are quite variable in spoken communication skills. Individual therapy rationale, techniques, materials, and computer resources are illustrated by 2 audiologists and a speech-language pathologist whose work is collaborative. An illustrative case history is provided.

KEY WORDS: severe/profound deafness, cochlear implant, speech-language therapy, audiologic rehabilitation, computer program, individual therapy

This article describes audiologic rehabilitation (AR) and speech-language therapy (S-LT) services that are available to young adult students who attend the National Technical Institute for the Deaf (NTID). NTID, a college of the Rochester Institute of Technology (RIT), provides support to approximately 770 students enrolled in other colleges of RIT and to 440 students in NTID academic programs. In order to attend NTID classes, students must have at least a severe hearing loss and a demonstrated need for sustained, academic support services as a result of hearing loss, but there is great variability in their expressive and receptive spoken communication skills.

The work of both the speech-language pathologist (SLP) and the audiologist are described because they often can work collaboratively. The American Speech-Language Hearing Association (ASHA, 2001, p. 1) states, “Both audiologists and speech-language pathologists traditionally have provided rehabilitative services for children and adults with hearing disorders. Because hearing disorders can profoundly affect the acquisition, development, and use of speech and language, audiologists’ and speech-language pathologists’ roles may be complementary, interrelated, and, at times, overlapping.” In our clinic, audiologists provide individual AR that is focused primarily on building speech reception skills but also assists with the students’ articulatory skill building as needed. Conversely, SLPs facilitate the acquisition of speech skills by integrating audition into the student’s articulatory feedback loop and including a listening component into as many aspects of therapy as possible. The audiologic assessment of distinctive feature reception may guide the SLP’s choice of articulatory targets, or the SLP’s work may guide training activities in AR sessions with the audiologist. For this article, the authors from each profession separately describe the relevant literature that supports the choices of therapeutic approaches and resource materials. The article ends with a case history that brings this discussion to life. It is our hope that this article will encourage and facilitate work with young adults who are deaf.

AR & S-LT STUDENT CHARACTERISTICS

Currently, 90% of NTID/RIT students receiving AR services and 40% of those receiving spoken language
therapy have cochlear implants (CIs). Students with CIs have an average age of implantation of 13 years (Clark, Snell, & Wallber, 2006). Students enrolled in S-LT have been using their CIs for an average of 6 years, with 25% of this group having been implanted for 10 years or more (Conklin & Hrnčírek, 2008).

The skills, abilities, and high levels of self-motivation required to gain admission to NTID/RIT generally position these students well to take full advantage of the AR and S-LT services available. Plant (1998, p. 6) stated, “[His young adult deaf students] have seen a need for speech communication, they have decided to improve their individual skills, …and they are prepared to devote the time and effort needed to achieve that aim.”

Students at NTID/RIT are considered partners with their AR/SLP professionals in the establishment of therapy goals and activities. This sets the tone for the students’ adult-level participation in defining their rehabilitative programs. One aspect of this adult-oriented process is the students’ involvement in their pretherapy/posttherapy evaluations and anonymous surveys to evaluate the performance of their therapists and overall programming.

It should be noted that what a professional may consider a minor therapeutic gain could be a giant step in the mind of the student. However, realistic, adult-to-adult conversations are conducted when a student is seeking to achieve spoken language goals beyond his or her capabilities. This may include counseling a student to seek developmental opportunities in other communicative skill areas. This is another example of students’ adult-level, open and honest participation in the therapy process.

Young adult students at NTID/RIT “must often overcome (spoken language) error patterns that have been habituated for 10–15 years or more” (S. Barefoot, personal communication, Spring 2008). This situation necessitates students committing to at least several 10-week academic quarters of services to achieve their goals. In addition, students may be receiving their last formal S-LT services as they near graduation. These factors require modifications in therapy techniques such as working on multiple articulation targets simultaneously; using a “close enough is good enough” approach to articulatory accuracy for those students with low-medium speech intelligibility (Whitehead & Barefoot, 1992); and working on several need areas simultaneously, such as an integrated emphasis on articulation, pronunciation, voice, and conversational management.

Students at NTID/RIT have a wide variety of communicative preferences that are respected by the staff. Staff are all capable signers and can comfortably switch back and forth from oral-only to oral-sign communication modes depending on the therapeutic and general communication needs of the student. Additionally, NTID/RIT provides varied communication opportunities for students using both spoken and signed language. This offers a rich practice venue for those students who are trying to hone their spoken language skills. A number of students receiving services are international students who add a refreshing diversity to the program yet offer therapy challenges in terms of English as a Second Language (ESL) issues and dialectical differences.

Overall, adjustments to living away from home, dormitory life, decisions on picking and choosing social opportunities, the necessity of taking part-time jobs to help pay college expenses and, most of all, rigorous academic requirements can sometimes act as distractions to the therapy process. These issues are part in parcel in working with young adults in a university setting. However, the majority of students do a great job prioritizing their commitments and are a great joy to work with as a result of their youthful but professionally focused enthusiasm.

S-LT CONSIDERATIONS

Calvert and Silverman (1975) explained that deaf speakers may be considered successful at various levels of functionality. Some may be intelligible only to their immediate family, close friends, and teachers; others may be understood by a larger group of friends, fellow workers, relatives, classmates, neighbors, and familiar merchants; others may be intelligible to the general public. It is important for the SLP to keep in mind that how intelligible or understandable a deaf speaker is judged to be depends on several factors including the speaking proficiency of the talker, the listener’s prior experience in listening to persons with hearing impairment talk, the visibility of the talker to the listener, the complexity of the material spoken, the context in which the utterance occurs, and the possibility of repetition of the utterance to the listener (Monsen, 1983).

Wilson and Scott (1996) remind us that speech therapy for the young adult deaf individual must be designed using an “integrated therapy model,” simultaneously focusing on speech/voice skills, language skills, pronunciation skills, auditory skills, and speechreading skills. This comprehensive, integrated approach to therapy has been found to be effective with our NTID AR/S-LT clients and allows the student/therapist to “cover a lot of territory” quickly given the overall time constraints of the older learner.

A related concept is the importance of simultaneously working on speech production and auditory perception, and integrating listening activities into speech production target activities. Lieberth and Subtelny (1978, p. 410) stated that “training to improve perception and production of speech cannot be considered as independent functions.” Kosky and Boothroyd (2001) provided additional insight into this perception/production relationship.

It is a common mistake to therapeutically program for students who are hard of hearing in the same way as “deaf” students because of the higher level of access to sound that is possessed by the individuals who are hard of hearing. Ross, Brackett, and Maxon (1982, 1991) pointed out that children who are hard of hearing learn spoken language more like hearing children than deaf children.

Gustafson and Dobkowski (1995) provided an excellent summary of techniques that can be used with deaf and adults and those who are hard of hearing to improve their overall conversational skills. A comprehensive model of conversational targets, strategies for teaching turn-taking
and conversational clarification, and establishment of an overall conversational mind-set are presented.

**S-LT Services and Resources at NTID**

S-LT services, which are offered through NTID’s Spoken Language Learning and Practice Lab (SLLPL), are available on request to all NTID/RIT students. S-LT services can be accessed on a stand-alone basis or provided in tandem with an array of audiologic and AR services. Students’ services are designed to accommodate their individual communication skills and preferences. In one convenient location on the RIT campus, students with hearing loss can take advantage of audiology, speech-language, and CI services (Gustafson, 2006). S-LT/AR staff maintain daily interaction, allowing for quick and efficient information exchange, opportunities for consultation, and coordination of therapy.

To learn more about the services provided in NTID’s SLLPL, the reader is encouraged to visit the SLLPL Web site (www.ntid.rit.edu/speechlangpros). This site includes discussions and demonstrations of S-LT and assessment strategies. There are audio samples of deaf speakers, longitudinal case studies, and tutorials on the use of visual, biofeedback speech training devices. A detailed listing of equipment that is essential to the delivery of S-LT services in the SLLPL is provided in the Appendix.

The following spoken language therapy services are available to students through the SLLPL:

- intensive receptive and expressive spoken language therapy
- on-call S-LT services
- communication evaluations
- job-related communication practice
- job interview practice
- practice making a presentation for an academic class
- pronunciation and vocabulary instruction
- conversational practice
- homework help for communication studies courses
- informal spoken language social interchange in a friendly atmosphere
- practice of communication skills required for (RIT) graduation expectations

**Assessment.** Once a student begins therapy, the therapist completes a detailed case history. The case history focuses on the student’s (a) degree, onset, and etiology of hearing loss; (b) hearing aid/CI history; (c) educational history; (d) S-LT history; and (e) home and school communicative mode preferences. After gathering the case history data, the test protocol shown in Table 1 is administered, as appropriate.

In conjunction with the assessment battery, the therapist asks a most important question of the student: “What do you hope to achieve by coming to the SLLPL for therapy?” After all of the test results have been interpreted, long-term goals and short-term objectives are developed, are agreed on by the SLP and student, and are then put into action. A prognosis statement is also developed. The interviewing, testing, and target establishment process is completed as promptly and as efficiently as possible so that therapy can begin almost immediately. Possible S-LT goal areas include articulation, pronunciation/word attack skills, voice, prosody, oral vocabulary expansion, syntax/morphology, discourse organization, conversational management, pragmatics, auditory perception and auditory–vocal feedback, and speechreading. Auditory and speechreading skills can be stand-alone goals but are routinely integrated within therapy activities for all goal areas.

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<td>Live-voice auditory perception</td>
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<td>AR Student Characteristics</td>
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Currently, approximately 245 young adults enrolled at RIT have a CI(s). These young adults’ communication skills vary according to etiology of hearing loss, duration of deafness, condition of surviving auditory neural fibers, age aided, age at implantation, CI model, communication methodologies, educational placement, and CI use. Ninety percent of the group has a significant hearing loss that occurred before spoken language development. Young adult students who are newly implanted are among the growing number of prelingually deaf CI recipients. Additionally, 90% of the students who request AR have CIs.

The AR process with students who have CIs is different from AR for adult deaf persons with hearing aids in two respects. First, compared to users of conventional hearing aids, CI users exhibit surprising differences in the detection and discrimination of speech sounds. In the past, the audibility of speech was the primary problem, but with modern CIs, there are few audibility problems as usually all speech sounds are detected. However, speech sounds may not be immediately recognizable, which may be due, in part, to the modified peripheral frequency map provided by the implant’s electrode placement in the cochlea. For example, according to Svirsky, Silveira, Neuburger, and Suarez. (2004), the place in the cochlea for detection of 1000 Hz pre-implant now is stimulated by the implant with sounds in the 250 Hz range. Consequently, discrimination errors among vowels are not similar to errors made by hearing aid users. Fortunately, targeted auditory training has been shown to be helpful (Fu, Galvin, Wang, & Nogaki, 2004).

The second difference between AR with CI users and AR with hearing aid users is that there may be more need to
interact with the audiologist responsible for mapping the CI. Even though many students at NTID have had their CIs for years, AR intake histories often reveal comfort, audibility, and equipment upgrade issues that need further exploration, with multiple sessions required for mapping (Picioli, Wallber, Sims, & Clark, 2008). Fortunately, students at NTID are in residence and can more easily participate in mapping sessions that enable exploration of map parameters for improved satisfaction and performance. The same is often true regarding hearing aid technology. With this population, students are scheduled 1 hr per week for 6 weeks for hearing aid evaluations in order to give them a chance to acclimate to “real-world” listening using the advanced signal processing alternatives available on today’s high-tech hearing aids.

When establishing AR goals for recently implanted prelingually deaf adults, clinicians must consider the plasticity of the central auditory system, hearing aid use on the nonimplanted ear, and the speech processor’s maps/settings. Long-term users may be adjusting to a second implant as they become bilateral users. Regardless of the individual differences, research findings indicate that auditory-only instruction is an integral part of the AR process (Bodmer et al., 2007; Chee et al., 2004; Schramm, Fitzpatrick, & Seguin, 2002).

### POPULATIONS OF CI USERS

#### Population 1: Students Implanted as Adolescents or Young Adults

The level of speech recognition performance of prelinguistically deaf adults has generally remained below that of postlingually deaf adults (Busby, Tong, & Clark, 1992; Dawson et al., 1992; Peasgood, Brookes, & Graham, 2003; Waltzman & Cohen, 1999). Consequently, young adults would like to know the potential outcomes for their personal investment in CI technology. How does research and experience guide pre- and postimplant counseling and AR?

Early studies with prelingually deaf adult CI recipients showed little or no open-set, auditory-only, speech recognition abilities (Busby et al., 1992; Eisenberg, 1982; Skinner et al., 1992). Duration of deafness has been consistently reported as having the greatest influence on CI performance. This conclusion is based on the premise that longer durations of deafness may produce accelerated degeneration in the cochlea, and the resulting auditory deprivation may affect memory for speech and specific auditory aspects of language and cognitive function (Blamey et al., 1996).

Some researchers suggest that any person with a long-standing hearing loss in childhood may have de facto cognitive processing differences (Baran, 2007). Reviews by Conway, Karpicke, and Pisoni (2007), and Pisoni et al. (2008), suggest more specifically that “sequence memory in [some] deaf individuals is affected by a combination of both [generalized] and phonological-specific impairments in encoding, storing, and retrieving sequential information, and both kinds of sequencing impairments may directly influence subsequent language and speech development” (Conway et al., 2007, p. 320).

In cases of late onset deafness, the central auditory system relies on neural plasticity to adapt to new auditory input provided by CIs. As a result, postlingually deafened young adults have the neural foundation for learning how to interpret electrical stimulation. In contrast, before cochlear implantation, the auditory system in the congenitally deaf person is underdeveloped and/or reassigned to other functions.

Electrical stimulation by the CI provides a mechanism for initiating developmental plasticity (Kral, Hartmann, & Tillein, 2001; Kral & Tillein, 2006; Manrique et al., 1999; Sharma, 2002, 2005). Normative data on the plasticity of the central auditory system has been established with cortical auditory evoked responses (P1) and compared to pediatric congenitally deaf CI recipients. Although children who are implanted later in life (age 7) had P1 latencies that changed immediately after implantation, they never reached normal values even after several years of CI use (Sharma, Dorman, & Kral, 2005; Sharma, Dorman, & Spahr, 2002; Sharma, Gilley, Dorman, & Baldwin, 2007).

Electrical stimulation may also lead to a new competition for resources (cortical reorganization), resulting in abnormal sensory perception skills, atypical responses to multisensory input, and a general sluggishness of systems (Teoh, Pisoni, & Miyamoto, 2004a, 2004b). Studies by Snik, Makhdoum, Vermeulen, Brokx, and van den Broek (1997) and Teoh et al. (2004b) found that congenitally deaf (onset < 3 years of age) participants who were implanted as adults showed progress only during the first few months of CI use. In the retrospective study with 103 adults, postimplantation scores improved 0–30% on City University of New York (CUNY; Boothroyd, Hanin, & Hnath, 1985) sentences in quiet, 0–20% on the Hearing in Noise Test (HINT; Nilsson, Soli, & Sullivan, 1994) sentences in quiet, and 0–15% on the Consonant-Nucleus-Consonant Test (CNC; Peterson & Lehiste, 1962) word lists after 3 months of CI use. A plateau in performance was reached within the first year (Teoh et al., 2004a, 2004b). Cross colonization and reorganization of the secondary auditory cortex regions with other senses (visual stimuli) was suggested as the reason for the lack of continuous improvement. Again, age of implantation, duration of deafness, and auditory experience through hearing aids before cochlear implantation contributed to the variability among study participants.

Cross-modal plasticity research with bilingual (speech and sign language) congenitally deaf adult CI recipients supports the findings of Teoh et al. (2004b). In a study by Lee et al. (2001), the 20-year-old adult had a score of 0% on the CID Everyday Sentences Test (Davis & Silverman, 1970; Sims, 1975) after 1.9 (years/months) of CI use and training. PET scans of increased blood flow and glucose metabolism in the auditory cortex and related areas before implantation revealed that secondary auditory cortical regions (not the primary auditory cortex) were activated by visual stimulation (i.e., sign language, lipreading). This was evidence of cross-modality plasticity. After implantation, the primary auditory cortex was activated by the sound of...
spoken words and still functioned as an auditory area, whereas the adjacent language areas were not stimulated by the sound input (Lee et al., 2001). These findings imply that occupation of the secondary auditory associated regions of the cortex by visual stimuli could block the potential improvement of the CI performance for congenitally and prelingually deaf adults (Nishimura et al., 1999; Teoh et al., 2004b). Teoh et al. concluded that early amplification and/or implantation and aurally based education could reduce the reliance on visual stimuli and subsequent cross-modality effects. Caveats to Teoh’s retrospective study include the fact that measurement occurred after only 1 year of CI experience, older coding strategies (i.e., Speak and CIS) were used, and there was no mention of postimplantation AR. Given that the brain may continue to acclimate to electrical stimulation, 1 year of CI experience may not be sufficient to determine that a plateau has been reached. CI use for the better performing oral, prelingually deaf adults ranged from 6 months to 3 years in the Waltzman, Roland, and Cohen (2002) study. These adults also used newer coding strategies. Additionally, CI candidacy has expanded to include adults with more residual hearing and hearing aid benefit before implantation. Recent adult studies have shown improvements in speech recognition for clients who have been educated with an auditory–verbal approach (Kaplan, Shipp, Chen, Ng, & Nedzelski, 2003; Moody-Antonio et al., 2005; Schramm et al., 2002). The research findings validate why we find that recently implanted students with long-term deprivation frequently request AR and S-LT.

The audiologic definition of benefit (e.g., open-set speech recognition) is not the only measure that is used by clients to define benefit. Consistent CI use, lipreading enhancement, and reports of improved overall quality of life are how clients describe CI benefit (Chee et al., 2004; Moody-Antonio et al., 2005; Peasgood et al., 2003; Skinner et al., 1992; Zwolan, Kilieny, & Telian, 1996). Peasgood et al. (2003) reported on a longitudinal retrospective study comparing “traditional” CI recipients (adults with acquired hearing loss) with “nontraditional” users (3 congenitally deaf and 7 early-deafened adults). The mean length of CI experience was 40.9 months. Although 3 participants were fluent with sign language, all used oral communication. Records reviewed from 1996 to 1999 revealed that the nontraditional participants’ mean score on the environmental test (40.5%) and lipreading enhancement score (7.6%) were lower than those of the traditional CI user. Speech pattern perception (73%) results were comparable for the groups. Yet, the gain from speech pattern perception scores did not transfer to word recognition. All nontraditional participants scored 0% on open-set sentence speech recognition tests after implantation. Despite the low performance on the speech perception tests, the overall satisfaction ratings (82.7%) were comparable for both groups. Nontraditional CI recipients reported improved environmental awareness, better control of their voice, increased confidence and relaxation while communicating, and less stress while lipreading. In comparison, the 8 participants (3 congenital and 5 early-deafened adults) in the study by Moody-Antonio et al. (2005) were good lipreaders before implantation, and most showed significant improvement in the auditory–visual mode after a year of CI experience. Sentence recognition scores on the HINT ranged from 0% to 83% (median = 12.5%). Despite the low scores for auditory-only performance, all participants were satisfied with the CI.

Based on the research and clients’ experiences, we recommend that self-perceived benefit and speech recognition performance be viewed as separate outcomes when counseling prelingually deaf adult CI candidates and users enrolled in AR. In AR, CI benefit should not be based solely on improvements in speech recognition performance. The true perception of benefit may be a combination of test results and self-examination.

### Population 2: Long-Term CI Users

Some students seeking AR have been using a CI for 10 years or more. These students are considered “late” by today’s candidacy criteria (implanted after 3 years of age) and may be using older CI technology. When designing an AR program, research on long-term effects of age of implantation for prelingually deaf young adults provides some insights.

After 10 years of CI experience, 70% to 95% of the children continue to use their CI on a regular basis with improvements in open-set speech perception over time (Beadle, McKinley, Nikolopoulos, O’Donoghue, & Archbold, 2005; Haensel, Engelke, Ottenjann, & Westhofen, 2005; Spencer, Gantz, & Knutson, 2004; Uziel et al., 2007). Uziel et al. studied 82 children with a mean age of implantation of 4:8 and a mean length of CI use of 11:7. At the 10-year follow-up, 79% (65/82) of these children could use the telephone. Mean scores were 72% for a pediatric monosyllabic word recognition test, 44% for word recognition in noise, and 55.3 words per minute for continuous discourse tracking. Sixty-seven percent had intelligible speech to an average listener with little experience with deaf speech. The greatest improvement in auditory skills was seen in the first 5 years. However, the highest scores were obtained after 10 years of CI use. In all of the studies reviewed, duration of deafness and age of implantation appeared to influence postimplant outcomes. Uziel et al.’s best performers were implanted before the age of 4. However, there were instances of high-achieving individuals who received implants at age 7 years and older.

What about the study participants’ academic future? Spencer et al. (2004) found that more than 50% of the college-eligible students who were implanted as children are enrolled in college.

### AR with Deaf Young Adults at NTID

#### Assessment

The typical CI audiogram for sound-field thresholds is at 20 dB HL–40 dB HL for 250 Hz–6000 Hz despite little or no hearing using earphones. If these CI thresholds levels are not seen, the referring CI audiologist is contacted.
Most often, when dealing with profound hearing loss, the standard open-set phonetically balanced (PB) word test will yield a score of 0% correct. However, there are a number of speech recognition tests that are less difficult and demonstrate functional speech recognition abilities (See Dillon & Ching, 1995; Tye-Murray, 1998). The CID Everyday Sentences Test or the HINT are used often with CI candidates and users. Sentence tests are relevant to communication function with the college-age student because English-language competency may improve scores and be more relevant to functional oral communication benefit.

If sentence tests yield poor results, the audiologist may choose a test with multiple-choice answer formats and a test with assessments directed at more basic speech discrimination abilities, such as detection of the number of syllables in a word or discrimination among limited sets of spondee or monosyllabic words. An example is the adult version of the Early Speech Perception Test (Moog & Geers, 1990).

Because of computer assistance via the C-Katz software (Sims et al., 2006), we often complete an in-depth assessment of phonetic feature reception using a forced-choice response to the test’s 23 consonants and/or 13 vowel and vowel-blend stimuli. The test may be administered in the auditory, visual, and/or auditory + visual modalities. Confusion matrix scoring informs the selection of which speech features should be included when selecting phonemes for drill and practice (See also Iowa Consonant Test, Dorman & Loizou, 2008).

Pedagogical Possibilities

A combination of analytic and synthetic training is typically used. Analytic training focuses on bottom-up processing by training the perception and identification of individual phonemes and syllables; synthetic training involves a top-down approach with longer length materials like sentences, paragraphs, and stories (Pedley, Lind, & Hunt, 2006). Erber’s (1982) speech perception training hierarchy (e.g., discrimination, identification, recognition and comprehension) is a model for tailoring the training exercises.

Stacey (2006) found that training with words or sentences using multiple talkers (20), administered during several short sessions each week, was more effective than single talker and phoneme recognition training. Also, the amount of time-on-task was important for obtaining AR benefit. Ideally, training at home and/or in session would be daily for weeks, if not months (see also Stacey & Summerfield, 2007). With the number and variety of computer-assisted programs available now, it is possible to attain this amount of practice, and it has been proven to be effective (Fu et al., 2004). At NTID, one-to-three, 50-min sessions per week are scheduled over a 10-week academic quarter. Session time is divided among fitting/mapping, information exchange, live voice drill, and guided use of computer-assisted training materials. Students often return for a series of academic quarters over a year or more.

An AR program may incorporate a combination of spoken and printed stimuli, recorded material (e.g., CDs, audiocassettes), and computer-based learning. A menu of topics and recommended materials to support the activity include phoneme identification, connected speech, telephone training, speechreading, word recognition, sentence recognition, auditory memory, auditory sequencing, environmental sounds, music, and noisy backgrounds.

During the first few AR sessions, students sample the activities at computer stations that are set up in the Cochlear Implant Center. Ultimately, activities are selected based on a combination of assessment outcomes and student interest.

AR MATERIALS

Phoneme Identification

Analytic training activities serve as the building block for students who have access to new sounds via digital hearing aids or CIs. Many activities focus on the identification of high-frequency phonemic features. These are new cues for most students with CIs enrolled in AR. After familiarization, the student is asked to identify the phoneme or the word containing the phoneme. The level of difficulty can be increased by enlarging the set size and/or selecting phonemes with similar acoustic cues (Pedley & Giles, 2005; Rhodes, 2001). Some examples of typical activities are voice/voiceless contrasts (t/d), F2 vowel formants (she/shoe), consonant manner (chip/ship), position in words (eage/eagy), phonemically dissimilar words (table/sofa), consonant place (lock/rock), plurality (boy/boys), and nonsense syllables (asA/aSHa).

Computerized materials. Consonant and vowel modules contained within Cochlear Americas’ (http://cochlearamericas.com) Sound and Beyond computer-assisted listening training program provide excellent training materials for the identification of phonemes in words (Fu & Galvin, 2007a, 2007b). Initial assessment scores for a large set of vowels [V] and consonants [C] in an [hVd] or [aCa] format typically results in low scores for new CI users. Assessment results are reported in vowel and consonant confusion matrices to determine error patterns. Although assessment scores may place students in Level 1 (lowest level), students have preferred to start with Level 2, where they are presented with the target words in print. Lesson steps automatically increase in difficulty from easy contrasts (i.e., initial consonants) to harder contrasts (i.e., final consonants). The goal is to meet the criterion for the 16 steps within a level in order to move to the next level. Immediate feedback and time-on-task data show progress, which is tracked with printed charts. On completion of a lesson, there is a review of the confused word pairs. These pairs can be used for additional practice.

Phonemes in confused words pairs (e.g., teen vs. tin; cot vs. pot) can be further trained in an auditory-only mode or

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[1] Sound and Beyond is temporarily unavailable from Cochlear Americas. See Sound Express (http://www.tigerspeech.com/tst_soundex.html) for currently available versions of this application.
with speechreading by enrolling the student in the computerized C-Katz auditory training program (Sims et al., 2006). This program trains vowel and consonant recognition, auditory phonetic memory, and sequencing for word recognition. The reader is referred to Katz (2002) and Katz and King (2000) for rationale and details of live-voice training techniques. In addition, vocabulary building, pronunciation cues, and spelling are reinforced. After phoneme recognition assessment, confused vowels and consonants (up to six phonemes) are entered into the limited set phoneme identification lesson. First, students listen to and then identify the phonemes presented in random order (e.g., [i], [I], [k], [p]). If passing criterion for identification is not met, same/different lessons are generated by the program. The difficulty of the lesson can be changed by reducing the stimulus set size. Following confirmation of discernible phonemes, the phonetic synthesis lesson asks the student to practice combining the sounds (synthesizes) into English words (e.g., [k][i][p] = keep; [p][l][k] = pick). In the final decode lesson, students listen to words generated from the phonemes in the limited set phoneme identification lesson (including words from the phonemic synthesis lesson) and identify the phonemes composing the word (e.g., key = [ki]; peak = [pik]). The decode lesson reinforces word and phoneme recognition skills. Video recordings of four speakers are used in the lessons for auditory, visual, or auditory + visual stimuli.

ESL online activities such as minimal pair practice and quizzes (www.manythings.org/pp/) are designed for drill and practice of commonly confused phonemes. For example, lesson #23 contrasts eat/it, he’s/his, leave/live, and reach/rich. Students first practice by listening repeatedly to the stimuli until they feel that they are ready for the quiz. The quiz provides immediate feedback and tracks the score. The lessons are assigned as homework.

**Live-voice practice.** If computer programs are not available, a set of vowel and consonant flash cards with diacritical markings or phonetic symbols are good for drill and practice. A pair of cards is placed on the table (i.e., voiced vs. voiceless contrasts). The student listens and then repeats or points to the correct phoneme. This type of live practice allows for acoustic highlighting (i.e., slower speech, amplitude, duration, and pitch emphasis) and controlling of set size. The level of activity can be easily increased or decreased in difficulty.

Analytika analytic testing and training lists (Plant, 1994) save time generating target contrasts. There are 379 minimal pair training lists. For example, based on the results of the C-Katz lesson, supplemental practice for (p/d) confusions are performed with an Analytika minimal pair word list.

**Word Recognition**

Most students desire to improve their word recognition abilities. To facilitate this goal, materials can be generated from students’ social, academic, and/or employment environments. The importance of reliance on contextual cues is stressed (Pedley & Giles, 2005). Activities may include words varying in syllable length or stress pattern (e.g., room vs. roommate, RE-cord/RECORD), closed-set recognition of common topics (family members, class names, job skills), and fill-in-the-missing-words (High predictability: *When will you ___ the box?* Low predictability: *She gasped when she saw the _____*)

**Computerized and CD word materials.** Sound and Beyond word discrimination assessment and training modules are a good introduction to word recognition training. The student builds a listening vocabulary based on a particular category (e.g., time, number, colors, family, animal, food). There are 100 words within each category. In some cases, the program introduces unfamiliar vocabulary and idioms (i.e., Dutch uncle). Although the student may have understood the word, there is a tendency to not select unfamiliar words. This is a teaching opportunity for new vocabulary and the pronunciation of unfamiliar words.

For practice with larger set sizes, the *Making the Connection* workbook and CDs are recommended (Koch, 2006). Words are presented in a large (10–30 items) closed-set format or with topic cues for common categories (i.e., money, dates, alphabet, weather, etc.) In exercise 1 of 10, for example, the student is required to identify 10 words from the category. The exercises build auditory skills by starting with easy activities, gradually increasing rate of speech, word similarity, and set size. Exercise 10 includes identification of two or more words from the list of 30. The audiologist records the responses on the answer forms while the student controls the CD. The CD assists with auditory tracking skills. These activities are also ideal for live practice with a significant other or a therapist.

**Auditory Memory and Sequencing**

Short- and long-term auditory memory strongly influences a student’s ability to listen to and process linguistic information that is stored in the brain. Therefore, strengthening the auditory memory is critical to developing and maintaining spoken language skills. The Earobics for adolescents and adults connectivity lesson (Cognitive Concepts, 1999) blends words into compound words and blends syllables and sounds into words. The lesson activities provide extensive practice with listening to sounds, storing the sounds in the student’s auditory memory for gradually increasing amounts of time before blending them into words. For example, the first item requires the student to blend base + ball and select the picture of the baseball from among three other pictures ending in the word ball. In a more challenging lesson, the student hears [p], [I], [n] and has to identify the correct picture. Students often struggle when they are required to hold the sound in auditory memory for longer periods of time before responding.

The C-Katz auditory training program uses auditory memory to blend phonemes into words and or identify the phonemes in words. For a review, see the examples of the phoneme synthesis decode lessons described above.

**Sentence Recognition and Connected Speech**

Auditory fluency for connected speech is practiced to improve the student’s ability to recognize and comprehend
auditory information with and without contextual cues (Pedley & Giles, 2005). For these activities, students must listen to an entire sentence or paragraph.

**Live practice.** Adult Aural Rehabilitation (Pedley et al., 2006) includes lessons for teaching the importance of contextual clues. In one activity, a key word is presented and the student identifies a sentence related to the key word. For example, the key word is bird. The sentence is “There is a nest in the tree.” In topic-related activities, students are asked to listen to and repeat the related sentence to a specific topic (e.g., sports). The activity encourages students to use semantic context, topic clues and associated words to guess any part of the sentence that was missed or only partially heard. The activities also provide good practice for communication strategies (i.e., requests for repetition, rephrasing, spelling, confirmation).

**Speech tracking.** Auditory only or auditory–visual speech tracking builds conversational fluency. Different tracking techniques can be employed (DeFilippo, 1988). The traditional approach requires the clinician to read aloud, segment by segment, from a book or magazine that is of interest to the student. The student is required to repeat each sentence verbatim before moving on. A word per minute score is generated. The score will vary with the student’s skill level, familiarity with the content, and use of communication strategies (e.g. “Please repeat,” “Did you say___?”) during the activity as well as the speaker’s intelligibility.

**Audio books/CDs.** Unabridged versions are recommended to ensure access to the complete text, word for word. Although children’s books are initially recommended due to their use of simple vocabulary and sentence structure, students typically prefer books that are interesting to them or that match their reading level.

**Web activities.** Tracking stories and scripts from ESL Web sites is a popular activity for students. For example, the Daily ESL Web site (http://www.dailyesl.com/) provides audio samples on common topics (i.e., renting an apartment), and the Voices of America Web site (http://www.voanews.com/english/portal.cfm) contains audio recordings of current events. Topic selection is based on student interest. The student also determines a comfortable tracking speed. Meaningful auditory associations with words in contexts are created. After the tracking activity, a discussion of the topic is conducted with the therapist. For example, a marathon runner listened to and read along with a story about the New York City marathon. After the story, the student was questioned about his own experiences. Familiarity with the topic increased the student’s ease of communication as well as his level of interest. Reading stories aloud also assists with pronunciation practice. Internet radio stations and podcasts are also popular sources of practice material. The Advanced Bionics Web site (www.HearingJourney.com) offers a constantly changing array of online practice materials including word recognition activities.

### Speechreading

With our current, one-on-one AR sessions, speechreading is almost always practiced using voice. Generally, when students are unable to master an auditory distinction, visible articulation is added by the clinician. This is done for two reasons. First, augmentation of the auditory signal with visual cues reduces frustration by making the task easier, and second, in the “real world,” listeners often use speechreading cues to assist perception. Adding speechreading cues is done for both analytic and synthetic training. The reader is referred to Sumby and Pollack (1954) for psychoacoustic evidence, and to Beauchamp, Argall, Bodurka, Duyn, and Martin (2004) for physiological evidence.

At NTID, speechreading is assessed at both the viseme and sentence levels, with and without sound, in order to describe the needs of the client according to his or her goals for AR. For example, a client with poor auditory speech recognition may be best served by AR that focuses on training that combines auditory and visual modalities for speech reception. If English skills are good, then tracking (DeFilippo, 1988) sentences from textbooks may be a good place to start. If English is poor, then AR may focus on “survival” word or phrase recognition in the combined auditory + visual modality. On the contrary, when speech recognition skills are highly developed, the student may wish to focus on auditory-only phoneme recognition in order to sharpen perception before attempting phone calls or other forms of conversation where visual cues are absent.

**Computerized and recorded materials.** DAVID—The Dynamic Audio Visual Instructional Device (Sims, 1988)—is a multimedia computer program that is used to provide sentence-based training using topics from everyday environments (i.e., general conversation, job interview, on-the-job communication). The clinician has the option of selecting auditory–visual, auditory-only, or visual-only presentations. The student can select from a menu of topics. Multiple student response strategies are available, including four-alternative multiple choice, fill-in-the-blanks, and open-set with topic cues. Initial placement in lessons is based on the results of a speechreading and auditory assessment. For example, a student who scores 80% in the auditory–visual condition and 20% in the auditory-only condition would start speechreading practice at Level 4 (fill-in-all-the-blanks) and auditory training at Level 2, where only one key word is missing. This activity reinforces the use of contextual cues and speechreading/listening strategies. Sims (1988) and Sims and Zhwei (1993) discussed how student response time can be used in a single-subject design to document improved skills.

**Speech tracking.** CasperSent (n.d.) is a computer program developed by Boothroyd that is designed to provide speech perception training based on conversational context. The stimuli consists of 60 sets of sentences representing 12 common topics and 3 sentence types (statements, questions, and commands) that are presented through lipreading only, hearing only, or a combination of the two. The student has to repeat back verbatim phrases or sentences of stories. If an incorrect answer is made, prompts are included to facilitate a correct response.

**Sensimetrics.** Seeing and Hearing Speech (n.d.) is an interactive CD-ROM that has 11 speakers ranging from easy to difficult to lipread. Each lesson can be presented in the auditory-only, visual-only, or combined (auditory +
visual) modality. Background noise of varying types and levels can be added to make lessons more challenging. All closed-set activities have practice and test options, and feedback is provided immediately. There are several lesson groups, including vowels, consonants, word stress, intonation and length, and common phrases.

Communication Strategies
The use of communication strategies is essential for good communication flow or conversational fluency. Specific strategies to facilitate listening and repair communication breakdowns may need to be demonstrated. “Conversation Made Easy: Speechreading and Conversation Strategies Training for Adults and Teenagers With Hearing Loss” (Tye-Murray, 2002) is an example of an interactive, multimedia computer program that provides examples of different repair strategies such as asking clarifying questions (“Did you say _____? Do you mean _____?”) or asking for repetition of key words or modifications to the listening environment. The student is required to navigate a communication situation by using different repair strategies.

Music
Interest in music varies greatly among students, ranging from little to no interest to enjoyment of classical and modern forms of music. Experienced music listeners bring in their own music to sessions. Lyrics are downloaded before the session to determine if the printed lyrics match the recording. If not, the audiologist edits the lyrics before the tracking activity begins. Listening to a cappella music or music with relatively few instruments is a good starting point. While listening to familiar music (i.e. children’s song), different speech processor programs are assessed to determine the best quality of sound. Cochlear Americas’ “Sound and Beyond” contains a music module with exercises that focus on the identification of various instruments and familiar melodies.

Environmental Sound Detection and Recognition
One of the first things that new CI users usually notice is the ability to hear new sounds as they strive for better contact with their environment. There are numerous anecdotal comments from new users about hearing environmental sounds that many normal-hearing individuals take for granted, such as birds chirping, the ticking of a clock, or footsteps across a snow-covered walkway. The overall training goal is to associate meaning with these new sounds and reduce confusion. Both Making the Connection and “Sound and Beyond” contain environmental sound training materials and recommended Web sites.

Telephone Training
For some students, AR will be the first opportunity to make a voice phone call. Before practice, determining the best CI/hearing aid settings for telecoils, Bluetooth-enabled devices, and other equipment is important for facilitating telephone conversations. AR is also an opportunity for students to evaluate commercially available telecommunication technologies including Blackberries, captioned telephones, and Internet video calling systems. Sample practice activities include identification of telephone signals (dial tone/busy/voice); using telephone scripts/role plays; listening to recorded messages (time/temperature, movie times); and telephone strategies such as codes (“No/Yes”), digits (0–9), letters (A, B, etc.) and code words (Is that “E” as in “elephant?”) (Castle, 1988; Giles, 2005).

CASE HISTORY: RECENT CI RECIPIENT WHO RECEIVED S-LT & AR SERVICES SIMULTANEOUSLY
This congenitally deaf, female student received bilateral hearing aids by age 1 and was schooled through high school in India in English, in the oral tradition, not learning sign language until coming to NTID. At age 23, just before she left her homeland, she was implanted with a Nucleus Freedom CI. On entry to NTID, this student’s audiogram indicated no unaided residual hearing in the right ear and a 108 dB HL loss in the left. With her CI 3 months following implant, she had 30-dB HL sound-field thresholds with speech recognition at 1% for CID Everyday Sentences. She claimed that before implantation, she understood approximately 50% of spoken communication when using the combination of her hearing aids and speechreading skills.

Her spoken language skills were as follows: (a) a 92% speech intelligibility score on the Clarke Sentences (modified scoring procedure; Magner, 1972); (b) very natural prosodic features in conversational speech; (c) poor pronunciation or word attack skills, omission of the final interoral consonants [s, z, “sh”, “ch”, k, g, t, d], [t / s, d / z, g / “ng”], substitutions, [ s ]-blend errors; (d) a weak voice level; and (e) an 85% (modified scoring procedure) speechreading score (unaided) on the Utley Test of Lipreading (Utley, 1946). All of this indicated that she had an efficient visual speech learning system. Auditorily, she could detect all elements of the Ling Six Sounds Test (John Tracy Clinic, 2001, pp. 11–12) and could discriminate between paired words when there was a strong acoustic/prosodic contrast.

S-LT Activities
Therapy consisted of building pronunciation skills for more than 200 mispronounced words by using the American Heritage Dictionary (Anderson, 2004) and its online dictionary correlate at www.education.yahoo. Target words were phonetically transcribed using American Heritage Dictionary pronunciation symbols and were analyzed for word division, accent placement, and sound–symbol association rules such as “ce, ci, cy, sc, s, ss” = [ s ].

Target words were used for varying closed-set listening
drills as well. Use of online dictionary audio clips for independent learning of vocabulary pronunciation was stressed. All target words were recorded on audiotape and were given to the student for self-study outside of therapy.

Along with the standard Ling Approach (Ling, 2002) for phonetic and phonologic target sound development for the omissions and substitutions listed above, place of articulation and manner of articulation principles were reviewed using computer-generated animations from www.uiowa.edu/~acadtech/phonetics and spectrographic display visual feedback (Visi-Pitch, IV). The tactile-kinesthetic feedback available from articulatory contacts and manner of articulation features were also discussed. Vocabulary from lists of the most common English words, and campus life and career vocabulary mispronounced during therapy, were used for targets. Self-monitoring of the presence or absence of final consonant sounds and voice loudness was stressed.

Some auditory training activities were intertwined with speech production activities in the student’s S-LT sessions; that is, “Speech Tracking” as discussed by DeFilippo (1988) and “telephone training” as discussed by Castle (1977). For telephone training, two phone lines in the SLLPL were used to practice simple dialogues, first through listening and speechreading, and then using auditory cues alone. Telephone communication strategies used included practicing codes such as “Was that ‘A’ as in ‘apple’?”, counting such as “Did you say five as in 12345?”, and questioning for clarification as in “Did you say____?”

**S-LT progress report.** This student improved articulation accuracy, voice projection, and difficult word pronunciation. She also learned to monitor her own spoken language and voice level. Therapeutic recommendations were that she should maintain a careful speaking “mind-set,” enlisting the help of friends and family members in the process of identifying hard to pronounce words, using online dictionaries for word pronunciation help, listening to music on CDs with accompanying written lyrics, and listening to Web sites of famous speeches with the accompanying written form.

**AR Activities**

During the student’s 2 years of S-LT and AR therapy, her CI was remapped several times as she acclimatized to CI stimulation. She was enrolled in individual auditory training, 2 periods each week for 8 weeks. She requested auditory training to improve her phoneme discrimination. She trained by identifying phonemes in small groups of 4–5 consonants and 1–2 vowels, followed by identification of single words made up from the phoneme group using C-Katz.

**AR progress report.** Her C-Katz pretest, auditory-only, consonant results were 22%, and her posttest, 45% for correct phoneme identification. Examining pretest confusion matrix results (Figure 1) indicated little or no ability to discriminate manner cues with the exception of “voicing.” The posttest confusion matrix (Figure 2) showed much more ability to differentiate the duration feature (stops vs. other sounds of longer duration). Fricatives versus glides were also discriminated. Scores for the various manner distinctive features advanced to the performance range of 63% to 100% correct. Place feature scores ranged from 25% to 100%. It should be noted that a combination of good CI technology; consistent CI use; excellent audiologic CI support; and AR and S-LT services, and strong student motivation “came together” and resulted in excellent AR and S-LT gains.

**REFERENCES**


presented at the annual meeting of the Alexander Graham Bell Association, Pittsburgh, PA.


APPENDIX. ESSENTIAL SPOKEN LANGUAGE LEARNING AND PRACTICE LAB EQUIPMENT

Visi-Pitch IV, Model 3950. www.kaypentax.com. A versatile visual speech feedback device that provides real-time pitch/intensity and spectrographic displays.

Sound Studio. www.felttip.com. A Mac OS X application for recording/editing audio into a digital format. Used to record, store and share high quality speech samples/test results.

Split-screen video recording system. Useful for visual/audio comparisons of the SLP’s and students’ speech productions. Videos produced can be converted to a CD format so students can speechread and listen to the recorded material in their dorms or at home.

Digital-display sound level meter, Radio Shack Model 33-2055. This device provides students working on voice projection/habitual vocal loudness level targets with quantitative speech intensity feedback measured in decibels.

Listening hoop. This device is simply audio speaker cloth mounted on a 12-in. embroidery hoop. Its purpose is to cover the mouth to prevent the student from speechreading the SLP while still allowing the audio signal to pass through unattenuated.

Large hand-held mirror. The mirror allows the students to speechread their own productions and compare them with the SLP’s model.

See-Scape. www.proedinc.com. This simple, inexpensive device provides visual feedback on oral versus nasal air flow.