The Acquisition of the Prosodic Word by Children with Hearing Loss Using a Cochlear Implant
Limor Adi-Bensaid, Ph.D., and Tova Most, Ph.D.

Hearing Aid Innovations: 100+ Years Later
Ruth Bentler, Ph.D.

Literacy and Deafness: Listening and Spoken Language (Review)
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Editors’ Preface

This year marks the 110th anniversary of *The Volta Review*. In recognition of its centurion status among publications in our field, we decided to include alongside the empirical research two articles from the formative years. The first article comes from Volume 1, Issue 1, of *The Association Review* (*The Volta Review* was first published in 1899 as *The Association Review*). In this article from that very first issue, Frank W. Booth, the journal’s first Editor, describes the essence of *The Volta Review* as the preeminent journal for hearing loss and listening and spoken language.

From its inception, the journal focused on publishing articles that would be of assistance to practitioners working on hearing health issues related to spoken language and moving the knowledge base of the profession forward. From the beginning, association members were made to feel that the journal was theirs and that they held a proprietary interest in making it successful. As Booth noted, “the magazine is yours, it is ours, now let us all together put our shoulders to the wheel and make yet further advancement, yet larger advancement in the great work in which we are engaged, the great work which we all love.”

And so it is today. *The Volta Review* remains an important resource for all interested in the listening and spoken communication of individuals with hearing loss. It is still your journal, our journal. *The Volta Review* is currently accepting manuscripts on a variety of topics, including literacy skill development, speech and language development, education, early intervention, hearing technology and communication strategies, and social development. To submit a manuscript for consideration, please contact Melody Felzien, the journal’s managing editor, at periodicals@agbell.org.
To continue building the scientific knowledge base of our profession, “The Acquisition of the Prosodic Word by Children with Hearing Loss Using a Cochlear Implant,” Dr. Limor Adi-Bensaid and Dr. Tova Most present their findings of how children with hearing loss acquire spoken language. The authors analyze the rate of progress of several children who received cochlear implants in acquiring spoken Hebrew, and their results draw a direct parallel to the age of intervention and the rate of language acquisition.

The second article to be drawn from The Volta Review archives was published in 1901 and describes the “Akouphone,” an early hearing aid. Dr. Ruth Bentler, professor at the University of Iowa and a hearing aid authority, presents a commentary on advances achieved since the early days of hearing amplification. Together, the article and commentary are examples of how The Volta Review has been and continues to be a source of cutting-edge information and educational content.

To round out this issue is a thoughtful book review by Dr. Susan Keenan. The book, Literacy and Deafness Listening and Spoken Language by Lyn Robertson, Ph.D., focuses on the key areas of interest to association members. Listening and spoken language has been a hallmark subject area of The Volta Review from the start and so this book review is timely for our celebration of the journal’s anniversary.

We hope you enjoy this issue, and please don’t hesitate to contribute to The Volta Review.

Sincerely,

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The Acquisition of the Prosodic Word by Children with Hearing Loss Using a Cochlear Implant

Limor Adi-Bensaid, Ph.D., and Tova Most, Ph.D.

The present study describes the development of the prosodic word in the speech of children with hearing loss who use a cochlear implant and are acquiring Hebrew language. The speech of 6 children, ages 1.5 to 2.8 years, was recorded. Data collection started 2 to 4 months after receiving the implant, when the first words were produced, and continued until each child had completed acquisition of the prosodic aspects of words. The analysis of these children’s speech was compared to those of children with typical hearing. The contribution of cochlear implants to the early development of spoken language is revealed by the similarities to hearing children in the development of the prosodic word as well as the rate of progress. The rate of progress was shown to be affected by the age of implantation as well as by the age of identification and onset of intervention.

Introduction

Stages of prosodic acquisition by children with typical hearing have long been documented in many different languages (e.g., Fikkert, 1994, for Dutch; Demuth, 1994, for Sesotho; Demuth & Fee, 1995, for English and Dutch; Ota, 1998, for Japanese; Grijzenhout & Joppen, 1999, for German; Demuth, 2001, for Spanish; Ben-David, 2001, and Adam, 2002, for Hebrew; Demuth & Johnson, 2003, for French). All these studies describe the stages of
prosodic word\(^1\) development in terms of the number of syllables, syllabic structure, and foot\(^2\) structure. Throughout typical phonological acquisition, children gradually increase the number of syllables produced in a word and syllabic complexity as their language grows. All the above studies describe the development of the prosodic word according to prosodic phonology, which identifies hierarchical prosodic domains in language both at the level of the word and higher phrasal and utterance levels (Selkirk, 1984; Nespor & Vogel, 1986). The following section describes prosodic hierarchy and the relationship among prosodic units.

**Theoretical Background**

The theory of prosodic phonology asserts that words consist of prosodic units that are hierarchically organized.\(^3\) Prosodic hierarchy, as proposed in Selkirk (1984) and Nespor and Vogel (1986), assumes a dominant relationship among prosodic units. Figure 1 represents the prosodic hierarchy of a word (Adi-Bensaid & Bat-El, 2004).

The prosodic hierarchy shown in Figure 1 is composed of hierarchically organized prosodic units. According to the prosodic hierarchy, 1) phonological words are composed of feet, 2) feet are composed of syllables, and 3) syllables\(^4\) may be composed of subsyllabic units called **moras**.

The mora is the lowest level in the prosodic hierarchy. It represents the notion of syllable weight and constitutes the rhyme of a syllable.\(^5\) Light syllables (e.g., ki) have one mora (the nucleus /i/), while heavy syllables (e.g., kik) have two moras (the nucleus /i/ and the coda /k/) (Hyman, 1985; Hayes, 1986).

A syllable can be composed of one or two moras. Some languages permit both monomoraic and bimoraic syllables (e.g., English, Arabic), while others do not permit codas and long vowels, thus allowing only monomoraic syllables (e.g., Swahili and Sensotho).

Syllables are linked to feet. Feet are binary and can be composed of two syllables, yielding a disyllabic foot (e.g., **bait** [house]), or of one syllable composed of two moras, yielding a monosyllabic bimoraic foot (e.g., **lev** [heart]).

\(^1\)In this article, the term **prosodic word** refers to the phonological structure of a word in terms of the number of syllables and stress position. It is usually parallel to the **morphologic word**, which consists of a base and affixes.

\(^2\)The foot is a phonological unit that rhythmically organizes syllables (e.g., the word **buba** [doll] contains two syllables, which are linked to one foot).

\(^3\)Prosodic phonology refers also to phrases, which is beyond the scope of this paper.

\(^4\)The syllable is generally thought to consist of three main constituents: the onset (the initial consonant), the nucleus (usually the vowel), and the coda (the final consonant). The latter two, i.e., the nucleus and the coda, are dominated by the rhyme. Thus, in the monosyllabic word **yad** [hand], /y/ is the onset, /a/ is the nucleus, and /d/ is the coda. Also, /ad/ is the rhyme of the word.

\(^5\)Syllable weight is determined by the rhyme; thus, the mora relates to the nucleus and the coda only.
Feet with one syllable (or mora) are considered degenerate. Feet contain strong and weak positions, reflecting the rhythmic pattern of the language. Feet can be iambic, where the strong (stressed) syllable is the rightmost one (e.g., *mi* *ta* [bed]), or trochaic, where the strong (stressed) syllable is the leftmost syllable (e.g., *du* *bi* [teddy bear]). (Note: The stressed syllable is in **boldface** throughout this article.)

Feet are linked to a prosodic word. The prosodic word represents the highest level of the prosodic hierarchy relevant to this discussion. Words must contain at least one foot, and since feet are usually binary, the minimal word contains two syllables or two moras (McCarthy & Prince 1986, 1990, 1991).

**Stages of Prosodic Development**

Stages of prosodic acquisition are defined in terms of the number of syllables used, syllable structure, and foot structure. Children with typical hearing gradually increase the number of syllables in a word and produce syllables of greater complexity as their language grows. The present study follows the increase in the number of syllables produced in words of children with hearing loss acquiring spoken Hebrew, referring to the theory of prosodic phonology as reviewed above. The following section describes the stages of prosodic acquisition of children with typical hearing as proposed by Ben-David (2001) and Adam (2002).

1. During the **pre-minimal word stage** (age 1.2), children usually produce the final syllable in words with ultimate stress\(^6\) (e.g., da for *yalda* [girl]). When the target word has penultimate\(^7\) or antepenultimate stress,\(^8\) children produce both the stressed and the final syllables of the target words (e.g., ima for *ima* [mother], *nana* for *banana* [banana], and *tefo* for *telefon* [telephone]). The children’s outputs, whether monosyllabic or disyllabic, are faithful to both the stressed and the final syllables of the target. This is

\(^{\text{6}}\)Ultimate stress is a stress on the final syllable of the word (e.g., *buba* [doll]).
\(^{\text{7}}\)Penultimate stress is a stress on the pre-final syllable of the word (e.g., *maftex* [key]).
\(^{\text{8}}\)Antepenultimate stress is a stress on the pre-pre-final syllable of the word (e.g., *olobus* [bus]).
explained by their perceptual salience, as opposed to the use of non-final unstressed syllables (Ingram, 1974; Peters, 1977, 1983; Echols, 1987; Echols & Newport, 1992). This stage is also reported in other languages (Demuth & Fee, 1995, for English and Dutch; Fikkert, 1994, for Dutch; Grijzenhout & Joppen, 1999, for German; Demuth & Johnson, 2003, for French).

2. During the minimal word stage (age 1.4), the children’s outputs are maximally disyllabic regardless of stress pattern. In other words, at this stage children typically produce only two syllables for polysyllabic target words with a different stress pattern. For target words with ultimate stress, children typically produce the final syllable and the one adjacent to it (e.g., giya for ugiya [cookie], fefo for melafefon [cucumber]). For target words with penultimate stress, they produce the final and the stressed syllable, as in the earlier stage. The minimal word stage is also reported for other languages such as Dutch (Fikkert, 1994), Spanish (Demuth, 2001), Japanese (Ota, 1998), and Sesotho (Demuth, 1994).

3. During the pre-final stage (age 1.7), children start producing three syllables of the target words (e.g., otobus for otobus [bus], atana for matana [gift]). In the case of quadrisyllabic target words, children typically produce only three syllables, usually deleting the first syllable of the word (e.g., aziza for televizya [television], tototam for ipopotam [hippopotamus]).

4. During the final stage (age 2.2), the children produce all four syllables of the target words. However, segmental errors often occur.

Adam (2002) reports an additional earlier stage, the initial stage, during which the correspondence between monosyllabic production and disyllabic target words is not always prosodically determined. In some words, the children produce the stressed syllable (e.g., ba for bambi [Bambi]) and in others, the final unstressed syllable (e.g., ta for savta [grandma]). However, in some cases they do not produce the stressed or final syllable but rather the unstressed, non-final one (e.g., ka for kaduy [ball] and kapit [teaspoon]).

Hearing Loss and Speech Production

The phonological development of children with hearing loss acquiring spoken language has been described in detail in the literature for many languages (Dodd, 1976; Oller, Jensen, & Lafayette, 1978; Gold, 1980; Binnie, Daniloff, & Buckingham, 1982; Abraham, 1989; Dodd & So, 1994; Meline, 1997; Tobin, 1997; Huttunen, 2001). However, these studies usually describe phonological development not as developmental stages (as described above), but rather in terms of phonological processes. The documentation has usually described processes at the word level, such as the deletion of the unstressed, initial syllable of a word (e.g., Dodd, 1976; Binnie et al., 1982; Tobin, 1997); processes on the syllable level, such as vowel insertion, cluster reduction, and final
consonant deletion (e.g., Oller et al., 1978; Binnie et al., 1982; Abraham, 1989; Dodd & So, 1994; and Huttunen, 2001); as well as processes on the segmental level, such as vowel substitution, fronting, stopping, and place and manner of articulation replacements (e.g., Oller et al., 1978; Huttunen, 2001). The phonological processes described here reflect the typical speech production of children with hearing loss that can be influenced by many factors (i.e., type of the sensory device, such as hearing aids or cochlear implants, onset age of rehabilitation, duration of use of the sensory aid, etc.).

The following section describes the speech production of cochlear implant users in comparison to those using other rehabilitative devices, as well as the factors that influence their performance.

**Cochlear Implants and Speech Production**

The cochlear implant (CI) is the most advanced sensory aid known today and provides an alternative form of assistance for people with hearing loss who might obtain little or no help from conventional hearing aids (Parisier & Chute, 1991). The CI provides electrical stimulation to the auditory nerve, bypassing the usual transducer cells that are absent or are nonfunctional in the cochlea of a person with severe-to-profound hearing loss. The nerve impulses travel along the auditory pathways to the cortical level and are interpreted by the brain as sound (Parisier & Chute, 1991).

Most of the studies on the speech production of children with severe hearing loss suggest significant improvement after receiving a CI in comparison to the use of other sensory aids (Tye-Murray & Kirk, 1993; Tobey, Geers, & Brenner, 1994; Sehgal, Kirk, Svirsky, Ertmer, & Osberger, 1998). Several studies examined the speech production of children with hearing loss using CI, tactile aids, and conventional hearing aids. These studies dealt primarily with the segmental features of the phonological system. They showed that the speech production of children using a CI was better than that of children using tactile aids (Osberger et al., 1991; Geers & Tobey, 1992; Tye-Murray & Kirk, 1993; Tobey et al., 1994; Sehgal et al., 1998) and conventional hearing aids (Geers & Tobey, 1992; Tobey et al., 1994; Kirk, Diefendorf, Riley, & Osberger, 1995). CIs appear to be associated with more rapid changes in phoneme production as well as greater improvement across various speech features, such as place and manner of articulation (Geers & Tobey, 1992; Blamey, Barry, & Jacq, 2001; Ertmer & Mellon, 2001).

The prosodic aspects of the speech of CI users have been studied as well (Kirk & Hill-Brown, 1985; Tobey et al., 1991; Tobey & Hasenstab, 1991; Tobey et al., 1994). These studies showed that auditory information via the CI device also appears to help improve the speech production of non-segmental aspects of users’ speech with hearing loss. This likely occurred as a result of the spectral, intensity, and timing information provided by the CI device helping
children to acquire several critical speech features, such as vocal duration, vocal intensity, pitch control, and spectral properties of many speech sounds (Kirk & Hill-Brown, 1985; Tobey et al., 1994).

The findings on the speech production achievements of children who use CIs in comparison to those of children with typical hearing are, however, controversial. The findings of Chin and Pisoni (2000), among others (Serry & Blamey, 1999; Ertmer & Mellon, 2001; Carter, Dillon, & Pisoni, 2002), emphasized the CI’s efficiency as opposed to looking at other rehabilitative devices and comparing performance to children with typical hearing. Chin and Pisoni (2000) demonstrated that a number of segmental correspondences appeared in a fashion similar to those used in early developmental stages by children with typical hearing. Blamey, Barry, Bow, and others (2001), on the other hand, demonstrated that the group of children with CIs lagged behind children with typical hearing at all test intervals, and their rate of development over a 6-year period was slower than that of children with typical hearing at a similar stage of development. The children in their study were 5 years old or younger when they received the CI, and data were collected for 4 years following receipt of the implant.

Indeed, there is a large amount of individual variability in the speech production development of CI recipients. Many factors can affect the performance of children with hearing loss, which in turn affects the rate and quality of language acquisition (Ertmer et al., 2002; Ertmer, Leonard, & Pachuilo, 2002; Chin, 2003; Peng, Spencer, & Tomblin, 2004). Some of these factors include age of receiving the implant and duration of CI use.

Recent studies suggest that early age of implantation has an important influence on the speech development of children with hearing loss. More specifically, children who receive a CI at a younger age appear to develop better speech skills than children who receive a CI at an older age (Osberger, Maso, & Sam, 1993). The advantage of receiving a CI early is realized in speech perception (Yaremko, 1993; Waltzman & Cohen, 1998), as well as in speech production (Tye-Murray, Spencer, & Woodworth, 1995; McCaffrey, Davis, MacNeilage, & von Hapsburg, 1999; Ertmer & Mellon, 2001; Ertmer, 2001). These studies support the contention that receiving an implant before 2 years of age promotes both faster and more efficient spoken language acquisition.

Many of the studies dealing with the population of CI users also indicate the importance of duration of use of the implant. The speech production of CI users generally improves over the years following receipt of the implant, with segmental and non-segmental pattern accuracy increasing significantly the longer the experience with the CI device (Kirk & Hill-Brown, 1985; Tobey & Hasenstab, 1991; Geers & Tobey, 1992; Serry & Blamey, 1999; Blamey, Barry, Bow, et al., 2001; Chin, Tsai, & Gao, 2003; Tobey, Geers, Brenner, Altuna, & Gabbert, 2003; Peng et al., 2004). Steady progress over time in segmental and non-segmental performance may reflect the children’s increasing ability to use information coded by the implant to guide or refine their speech production.
In a previous study, Adi-Bensaid and Bat-El (2004) reported on preliminary findings on the development of the prosodic word of one child with a CI. The goal of the current study is to describe the developmental stages of prosodic word acquisition of a group of children with hearing loss who use a CI, and to compare those stages with those of the case study reported previously and to those of children with typical hearing who speak Hebrew as well as other languages.

**Method**

**Participants**

Six children with hearing loss using a CI participated in the present study (subjects A1 to A6). There were 3 boys and 3 girls ranging in age from 1.5 to 2.8 years (M = 1.8, SD = 0.6) at their first recording session. All the children had prelingual, profound, bilateral sensorineural hearing loss. Their unaided thresholds were above 110 dB HL in both ears (this level represents the mean pure tone average of 500, 1,000, and 2,000 Hz). All the children received unilateral CIs: 3 children had Nucleus 24 devices, 2 had MED-EL Combi 40 devices, and one had a Clarion C2 device. The ages of the children when they received the CI ranged from 1.0 to 2.5 years (M = 1.75, SD = 0.5) (for age of implantation of each child, see Table 1). They all used binaural hearing aids from early childhood, prior to receiving the CI. The children were learning spoken Hebrew and were only exposed to spoken language communication. They were all educated from an early age at the MICHA center in Tel-Aviv, Israel. The MICHA Society for Deaf Children is a national early intervention agency that provides educational and (re)habilitation services for young children (ages 0-7 years) with hearing loss and their families. All the children had hearing parents and no identified additional developmental challenges. Table 1 includes the background information of the children.

**Procedure**

The examiner met with each of the 6 children individually. Data collection started 2 to 4 months after the children received the CI and at the point when the first words were produced (after activation). During the initial recordings, each child produced very few words (fewer than 10), most of them by imitation. Data collection continued until the end of phonological development – that is, until the child had completed acquisition of the prosodic aspects of the words (number of syllables, onsets, codas, and complex onsets) and all the segments in the language, apart from sibilants that might be acquired in Hebrew by the age of 6 years old (Jedwab, 1975; Ben-Zvi, 1991; Gabay, 1996; Ben-David, 2001).
Table 1. Background information of the children studied who use cochlear implants (N=6)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sex</th>
<th>Etiology of deafness</th>
<th>Onset age* of profound hearing loss</th>
<th>Age* of hearing aid fitting and onset of intervention</th>
<th>Age* of implantation</th>
<th>Age* at first recording</th>
<th>Age* at last recording</th>
<th>Number of recordings</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>M</td>
<td>Unknown</td>
<td>Congenital</td>
<td>0;5</td>
<td>1;2</td>
<td>1;5</td>
<td>3;5</td>
<td>38</td>
</tr>
<tr>
<td>A2</td>
<td>F</td>
<td>Unknown</td>
<td>Congenital</td>
<td>0;6</td>
<td>1;0</td>
<td>1;6</td>
<td>3;1</td>
<td>21</td>
</tr>
<tr>
<td>A3</td>
<td>F</td>
<td>CMV Virus Infection</td>
<td>1;0</td>
<td>1;3</td>
<td>1;9</td>
<td>2;1</td>
<td>5;1</td>
<td>32</td>
</tr>
<tr>
<td>A4</td>
<td>M</td>
<td>Genetic</td>
<td>0;3</td>
<td>0;10</td>
<td>2;0</td>
<td>2;4</td>
<td>4;11</td>
<td>29</td>
</tr>
<tr>
<td>A5</td>
<td>F</td>
<td>Genetic</td>
<td>0;1</td>
<td>0;3</td>
<td>1;9</td>
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<td>4;3</td>
<td>27</td>
</tr>
<tr>
<td>A6</td>
<td>M</td>
<td>Unknown</td>
<td>1;2</td>
<td>1;8</td>
<td>2;5</td>
<td>2;8</td>
<td>5;6</td>
<td>30</td>
</tr>
</tbody>
</table>

*Age is presented as year;month.
The data for each participant were collected by a speech language pathologist during a 30-45 minute recording session every month (see Table 1 for the number of recordings of each child). The elicitation was based upon spontaneous speech, picture and object naming, and imitation.

All sessions were recorded using a high-quality audio recorder, a Panasonic microcassette recorder model RQ-L10. The recorder was placed close to the child’s seat so that the signal-to-noise ratio obtained was highly efficient. All the recordings were transcribed each month by this paper’s first author. Five audiotape recording sessions of each child were selected at random, and a second examiner transcribed the sample recordings independently. The fact that there was a high level of agreement between the examiners regarding the transcription reflected a high degree of inter-judged measurement reliability.

The results and analysis below refer to the level of the prosodic word (number of syllables and stress). All phenomena were analyzed and compared with typical acquisition processes.

**Results**

The analysis of the prosodic word development of the children in this study is presented below. We also followed the stages of development of children with typical hearing, noting any discrepancies encountered.

**The Initial Stage: Monosyllabic Word Productions**

During the initial stage, the children’s vocabulary consisted mostly of monosyllabic words (156/203 = 76.84%), regardless of the number of syllables in the target word. Table 2 presents monosyllabic word productions for a polysyllabic target word at the initial stage. The table shows that the children preserved one of the target syllables, be it the final stressed syllable, the final unstressed syllable, the initial stressed syllable, or the initial unstressed syllable. Thus, there was no unified prosodic feature – i.e., stress or position in the word – characterizing the syllable selected from the target word. In fact, the prosodic aspects that usually play a role in target production relationships – i.e., stress and word-final syllables – did not always apply.

**The Pre-Minimal Word Stage: Preservation of the Final and Stressed Syllables**

We did not detect any sign of the pre-minimal stage in the prosodic development of our subjects. However, remnants of the pre-minimal word stage in some of the children’s speech were observed during the minimal word stage. For example, child (A1) produced monosyllabic words for target disyllabic ones, as well as disyllabic words. Here is an exhaustive list: pa for leroad (alone), i: for jeli (mine), pa for nafal (fell), mo for linoγ (a proper name), and kok for listot (to drink). The crucial property of these target words is that they
Moreover, it seems that there was a tendency to preserve target words with penultimate stress rather than those with ultimate stress. In other words, throughout the minimal word stage, children tended to preserve both syllables of disyllabic target words with penultimate stress (94.8%) more often than disyllabic target words with ultimate stress (83.5%). Thus, when they omitted syllables, it was usually the weak syllable in the words with ultimate stress.

The Minimal Word Stage: Binary Foot

Table 3 presents a sample of words produced by the children during the minimal word stage for polysyllabic target words. Table 4 presents the quantitative data of syllable deletion in trisyllabic target words.

As can be seen from the tables, the children selected the last two syllables from the target word, one of which is stressed. In target words with ultimate stress, the children produced the final stressed syllable and the penultimate unstressed syllable – i.e., biyo for kubiyyot (blocks), fefon for melafefon (cucumber) (deleting 70% of the antepenultimate syllables as opposed

---

**Table 2.** Target: *polysyllabic words*; Production: *monosyllabic words*

<table>
<thead>
<tr>
<th>Target words with ultimate stress</th>
<th>Stressed</th>
<th>Unstressed</th>
<th>Stressed</th>
<th>Unstressed</th>
<th>Age* (Child)</th>
</tr>
</thead>
<tbody>
<tr>
<td>limoy</td>
<td>mo:</td>
<td></td>
<td></td>
<td></td>
<td>1;9 (A1)</td>
</tr>
<tr>
<td>nigmay</td>
<td>ma</td>
<td></td>
<td></td>
<td></td>
<td>1;9 (A1)</td>
</tr>
<tr>
<td>bubu</td>
<td>ba, ba:</td>
<td></td>
<td></td>
<td></td>
<td>1;5 (A2)</td>
</tr>
<tr>
<td>tsaov</td>
<td>o:</td>
<td></td>
<td></td>
<td></td>
<td>2;8 (A6)</td>
</tr>
<tr>
<td>motsets</td>
<td>mo</td>
<td></td>
<td></td>
<td></td>
<td>1;9 (A1)</td>
</tr>
<tr>
<td>baokbu</td>
<td>ba:</td>
<td></td>
<td></td>
<td></td>
<td>1;9 (A1)</td>
</tr>
<tr>
<td>balon</td>
<td>ba:w</td>
<td></td>
<td></td>
<td></td>
<td>2;1 (A1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Target words with penultimate stress</th>
<th>Stressed</th>
<th>Unstressed</th>
<th>Stressed</th>
<th>Unstressed</th>
<th>Age* (Child)</th>
</tr>
</thead>
<tbody>
<tr>
<td>maini</td>
<td>i, i:</td>
<td></td>
<td>ma</td>
<td></td>
<td>1;9 (A1)</td>
</tr>
<tr>
<td>etsba</td>
<td>ba</td>
<td></td>
<td>ma</td>
<td></td>
<td>2;4 (A4)</td>
</tr>
<tr>
<td>ain</td>
<td>a</td>
<td></td>
<td>a</td>
<td></td>
<td>2;0 (A5)</td>
</tr>
<tr>
<td>alo</td>
<td>a:</td>
<td></td>
<td>a:</td>
<td></td>
<td>2;1 (A1)</td>
</tr>
<tr>
<td>boi</td>
<td>be</td>
<td></td>
<td>be</td>
<td></td>
<td>2;2 (A3)</td>
</tr>
<tr>
<td>bait</td>
<td>ba:, a</td>
<td></td>
<td>ba:, a</td>
<td></td>
<td>2;0 (A5)</td>
</tr>
<tr>
<td>ima</td>
<td>ma</td>
<td></td>
<td>ma</td>
<td></td>
<td>1;8 (A1)</td>
</tr>
<tr>
<td>ine</td>
<td>i:</td>
<td></td>
<td>i:</td>
<td></td>
<td>1;9 (A1)</td>
</tr>
</tbody>
</table>

*Age is presented as year;month.

all have ultimate stress. Moreover, it seems that there was a tendency to preserve target words with penultimate stress rather than those with ultimate stress. In other words, throughout the minimal word stage, children tended to preserve both syllables of disyllabic target words with penultimate stress (94.8%) more often than disyllabic target words with ultimate stress (83.5%). Thus, when they omitted syllables, it was usually the weak syllable in the words with ultimate stress.
In target words with penultimate stress, the children produced the penultimate stressed syllable and the ultimate unstressed syllable – i.e., *nana* for *banana* (banana), *dolet* for *tarnegolet* (hen) (deleting 83% of the antepenultimate syllable as opposed to 4.5% of the penultimate and 12.5% of the ultimate syllables). Finally, in target words with antepenultimate stress, the children produced the antepenultimate stressed syllable with the ultimate unstressed one – i.e., *tola* for *toko* *kolad* (chocolate) (deleting 80% of the penultimate syllables as opposed to 20% of the antepenultimate and 0% of the ultimate syllables).

### Table 4. Syllable deletion in trisyllabic target words

<table>
<thead>
<tr>
<th>Trisyllabic target words</th>
<th>Syllable deletion from $\sigma_3\sigma_2\sigma_1$</th>
<th>$\sigma_1$</th>
<th>$\sigma_2$</th>
<th>$\sigma_1$</th>
<th>$\sigma_2$</th>
<th>$\sigma_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate (wws) - $\sigma_3\sigma_2\sigma_1$</td>
<td>96</td>
<td>68</td>
<td>70%</td>
<td>28</td>
<td>29%</td>
<td>1</td>
</tr>
<tr>
<td>Penultimate (wsw) - $\sigma_3\sigma_2\sigma_1$</td>
<td>88</td>
<td>73</td>
<td>83%</td>
<td>4</td>
<td>4.5%</td>
<td>11</td>
</tr>
<tr>
<td>Antepenultimate (sww) - $\sigma_3\sigma_2\sigma_1$</td>
<td>20</td>
<td>4</td>
<td>20%</td>
<td>16</td>
<td>80%</td>
<td>--</td>
</tr>
</tbody>
</table>

Age is presented as year;month.
<table>
<thead>
<tr>
<th>Target</th>
<th>Production</th>
<th>Age* (Child)</th>
<th>Target</th>
<th>Production</th>
<th>Age* (Child)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trisyllabic target words</strong></td>
<td></td>
<td></td>
<td><strong>Quadrisyllabic target words</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aviγon</td>
<td>‘airplane’</td>
<td>avio:</td>
<td>2;7 (A1)</td>
<td>akογdiyon</td>
<td>‘accordion’</td>
</tr>
<tr>
<td>jεγutim</td>
<td>‘toilet’</td>
<td>jeuti:</td>
<td>2;7 (A1)</td>
<td>laαvoda</td>
<td>‘to work’</td>
</tr>
<tr>
<td>ταγνεgol</td>
<td>‘rooster’</td>
<td>tanegol</td>
<td>2;9 (A2)</td>
<td>laγfεγαot</td>
<td>‘necklaces’</td>
</tr>
<tr>
<td>matana</td>
<td>‘present’</td>
<td>atana</td>
<td>3;10 (A3)</td>
<td>ipopotam</td>
<td>‘hippopotamus’</td>
</tr>
<tr>
<td>mitγiya</td>
<td>‘umbrella’</td>
<td>mitiγia</td>
<td>2;9 (A2)</td>
<td>sufγaniya</td>
<td>‘doughnut’</td>
</tr>
<tr>
<td>sukaγya</td>
<td>‘candy’</td>
<td>kuαya</td>
<td>3;10 (A3)</td>
<td>leitγαot</td>
<td>‘bye’</td>
</tr>
<tr>
<td>lemala</td>
<td>‘above’</td>
<td>lemaya</td>
<td>2;7 (A1)</td>
<td>naalaim</td>
<td>‘shoes’</td>
</tr>
<tr>
<td>xatula</td>
<td>‘cat’</td>
<td>xatuya</td>
<td>2;7 (A1)</td>
<td>mitkaleax</td>
<td>‘takes a shower’</td>
</tr>
<tr>
<td>enaim</td>
<td>‘eyes’</td>
<td>enaим</td>
<td>2;9 (A2)</td>
<td>mefαxedet</td>
<td>‘scared’</td>
</tr>
<tr>
<td>jiγafa</td>
<td>‘giraffe’</td>
<td>jiafa</td>
<td>2;9 (A2)</td>
<td>yomuledet</td>
<td>‘birthday’</td>
</tr>
<tr>
<td>liftoax</td>
<td>‘to open’</td>
<td>liftoax</td>
<td>3;10 (A3)</td>
<td>mispaγaim</td>
<td>‘scissors’</td>
</tr>
<tr>
<td>γakevet</td>
<td>‘train’</td>
<td>yabeβet</td>
<td>3;5 (A4)</td>
<td>taγnegoleτ</td>
<td>‘hen’</td>
</tr>
<tr>
<td>ambuγgeγ</td>
<td>‘hamburger’</td>
<td>aguge</td>
<td>3;10 (A3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>telefon</td>
<td>‘phone’</td>
<td>teyeфo</td>
<td>2;7 (A1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ambulans</td>
<td>‘ambulance’</td>
<td>abulas,</td>
<td>2;7 (A1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>otobus</td>
<td>‘bus’</td>
<td>otobu</td>
<td>2;7 (A1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>muzika</td>
<td>‘music’</td>
<td>muzika</td>
<td>3;0 (A2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Age is presented as year;month.
The Pre-Final Stage: Preservation of Three Syllables of the Word

During the pre-final stage, the children expanded the number of syllables produced to three in both trisyllabic and quadrisyllabic target words. Table 5 presents trisyllabic word productions for trisyllabic and quadrisyllabic target words at the pre-final stage.

The data in Table 5 show the transition from the minimal word stage to the pre-final stage – i.e., from maximally disyllabic forms, where the children increased the number of syllables they produced for target words with different kinds of stress patterns. As shown in the table, the children produced trisyllabic forms for trisyllabic and quadrisyllabic target words.

Table 6 presents syllables preserved in trisyllabic target words with different stress patterns. The numbers in Table 6 show the same tendencies for the children in the current study for each individual child (A5 is an exceptional case) as well as for all the children as a group. In other words, each child tended to preserve three syllables of polysyllabic target words both with ultimate and non-ultimate stress.

As mentioned above, the children preserved three syllables of the target words during the pre-final stage. Deletion of syllables, if they occurred, appeared in target words with ultimate stress (30%) more often than in words with non-ultimate stress (23%). The Wilcoxon Signed Ranks Test showed a significant difference between trisyllabic target words with ultimate stress and trisyllabic target words with non-ultimate stress ($Z = 1.992, p = 0.046$).

The Final Stage: Preservation of Four Syllables of the Word

Table 7 presents the final stage of prosodic word development. As can be seen from the table, the children’s forms were fully faithful to the target during the final stage – i.e., their words were prosodically correct in terms of the

Table 6. Preservation of all the syllables in trisyllabic target words with different stress patterns

<table>
<thead>
<tr>
<th>Ultimate stress (wws)</th>
<th>Non-ultimate stress (wsw) (sww)</th>
<th>Child (Age*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>Production</td>
<td>Target</td>
</tr>
<tr>
<td>47</td>
<td>39</td>
<td>83%</td>
</tr>
<tr>
<td>47</td>
<td>33</td>
<td>70%</td>
</tr>
<tr>
<td>181</td>
<td>121</td>
<td>67%</td>
</tr>
<tr>
<td>69</td>
<td>42</td>
<td>61%</td>
</tr>
<tr>
<td>93</td>
<td>81</td>
<td>87%</td>
</tr>
<tr>
<td>72</td>
<td>45</td>
<td>63%</td>
</tr>
</tbody>
</table>

*Age is presented as year;month.
number of syllables. Note that the development of the syllable structure and the segmental makeup of the word had not yet reached its final state.

The Relationship Between Rate of Development and Age of Intervention

Figure 2 shows the relationship between the age of hearing aid fitting of the children in this study and the rate of development – i.e., the time it took each

![Figure 2](image.jpg)

**Figure 2.** The relationship between the age of hearing aid (HA) fitting and rate of development
child to reach the final stage of prosodic word acquisition (the time between the initial access to sound and the final stage).

As can be seen from Figure 2, the earlier the age of hearing aid fitting, the shorter the rate of word development ($R = 0.95, p < 0.01$).

The Relationship Between Rate of Development and Age of Implantation

Figure 3 presents the relationship between the age of implantation and the rate of prosodic word development, or the time it took each child to reach the final stage of word acquisition (the time between the initial and the final stage).

As can be seen from Figure 3, children A1 and A2 demonstrated that the earlier the child received the CI, the quicker the rate of word development. As for children A3, A4, and A5, there is variability depending upon the subject. Child A3 received her CI when she was 1 year and 9 months old, and it took her 33 months to reach the final stage. However, child A5 received her CI when she was 1 year and 9 months old (approximately the same age as child A3), but it took her only 17 months to reach the final stage of word acquisition; and child A4 received his CI when he was 2 years old (after A3), and it took him only 20 months to reach the final stage of word acquisition. In other words, the rate of acquisition of children A4 and A5 is better than that of child A3, and is much more like that of children A1 and A2, who received CIs at an earlier age.

The effect of the two variables – age of hearing aid (HA) fitting and age the CI was received – show an interesting reciprocal influence. Table 8 presents the age of HA fitting and the age the CI was received of each child as well as their age at the final stage of prosodic word development.

Children A3 and A5 received their CIs almost at the same age (with a difference of only 5 days), but child A5 reached the final stage of prosodic word development.

**Figure 3.** The relationship between age of implantation and rate of development
development much earlier than child A3. The age of HA fitting, however, showed that child A5 had received her HA device much earlier than child A3. Moreover, child A4 received his CI later than child A3, but he reached the final stage before she did. This might also be due to earlier HA fittings.

Children A1 and A2 showed the same relationship. Although child A2 received the CI before child A1 (a difference of 2 months and 10 days), child A1 reached the final stage of prosodic word development before child A2. Once again, the age of HA fitting might provide an explanation – i.e., child A1 received his hearing aid earlier than child A2. As for child A6, both his age of HA fitting and age when he received a CI were later than the ages of the other children, and by the end of the study he still had not reached the final stage of prosodic word development.

**Discussion**

The present study followed the developmental stages of prosodic word acquisition by children with hearing loss who use a CI and who are acquiring spoken Hebrew, compared to those of children with typical hearing who speak Hebrew as well as children exposed to other languages. This study reveals that with respect to the development of the prosodic word, the acquisition paths of the children with CIs are very similar to those of the child reported by Adi-Bensaid and Bat-El (2004) as well as pass through the same prosodic stages as the children with typical hearing.

**The Initial Stage**

Studies on early language development indicate that the first words children produce are, in most cases, monosyllabic and coda-less (see Ingram, 1989, for English; Fikkert, 1994, for Dutch; Demuth & Fee, 1995, for Dutch and English; Garret, 1998, for Spanish; Grijzenhout & Joppen, 1999, for German; Ben-David, 2001, and Adam, 2002, for Hebrew). The findings of the current study confirm those of the above-mentioned reports. The initial stage in our

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**Table 8. The influence of age of hearing aid (HA) fitting and age of implantation**

<table>
<thead>
<tr>
<th>Child</th>
<th>Age* of HA fitting</th>
<th>Age* of implantation</th>
<th>Age* at the final stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0;5</td>
<td>1;2</td>
<td>2;9</td>
</tr>
<tr>
<td>A2</td>
<td>0;6</td>
<td>1;0</td>
<td>2;11</td>
</tr>
<tr>
<td>A3</td>
<td>1;3</td>
<td>1;9</td>
<td>4;10</td>
</tr>
<tr>
<td>A5</td>
<td>0;3</td>
<td>1;9</td>
<td>3;4</td>
</tr>
<tr>
<td>A4</td>
<td>0;10</td>
<td>2;0</td>
<td>3;11</td>
</tr>
<tr>
<td>A6</td>
<td>1;8</td>
<td>2;5</td>
<td>Has not finished</td>
</tr>
</tbody>
</table>

*Age is presented as year;month.
study was characterized by monosyllabic words, whose syllables were not always selected from the target word with prosodic consideration.

In light of the above data, the following questions should be addressed: What are the factors that influence the selection of a specific syllable of the target word? Are these factors related to prosodic cues, segmental cues, or perhaps a combination of both?

Studies on early development show consistent preference for the input’s stressed syllable (Garret, 1998) and/or final syllable (Berman, 1977; Echols, 1988; Faingold, 1990; Fikkert, 1994). This preference is due to the perceptual salience of the final and/or stressed syllable compared to the non-final and/or unstressed syllable in the word. However, the absence of prosodic preference shown in the data of this study has also been reported in other studies of typically developing French-, Spanish-, and Hebrew-speaking children (Macken, 1979, for Spanish; Boysson-Bardies, 1996; Demuth & Johnson, 2003, for French; and Ben-David, 2001, and Adam, 2002, for Hebrew). Adam (2002) notes that these forms (i.e. monosyllabic words without prosodic preference) could be a result of segmental effects. Based on Levelt’s work (1994), Adam proposes that the children’s production during the initial acquisition stages is affected by the vowels’ features rather than by the syllables’ prosodic properties. The only vowels the children in Adam’s study produced at this stage were [a] and [u], with these vowels being faithful to those of the target syllables they chose to produce, with a preference for [a] over [u] – e.g., ka for *muzika* (music), as well as for *kaduy* (ball); and, also, ba for *balon* (balloon), *bambi* (Bambi), and *buba* (doll). It should be noted that the [a] is considered to be easier to produce since it does not require manipulation of the articulators as does the [u] (e.g., lip rounding and tongue elevation) (Ladefoged, 2001).

Similar to Adam, we also believe that during the initial stage of acquisition, the children select a syllable of the target word on the basis of segmental rather than prosodic considerations. However, it appears that the preference for a certain syllable in a word is determined by both vowels and consonants. In other words, the children in the current study selected one syllable of the target word, preferring its consonant and/or vowel content to that of the vowel or consonants of the neighboring syllables.

Generally, a syllable with a labial consonant ([b] or [m]) (which are the first to be acquired) is preferred to a syllable without a labial (e.g., pa is preferred to ya in *paya* [cow], bi is preferred over du in *dubi* [teddy bear], and ba is preferred over ets in *etsba* [finger]). When both syllables have labials, the vowels come into play. In these cases, a syllable with the vowel [a] is preferred over a syllable with the vowel [u], as demonstrated in Adam’s study (e.g., ba is preferred over bu in *buba* [doll] and in *bakbuk* [bottle]). It is only when neither syllable has a labial consonant that the role of stress emerges and the selected syllable is the stressed one. Thus, [ɔ:] is preferred to [tsa] in
tsaov (yellow), [i:] rather than [ne] in ine (here), and [a:] rather than [lo] in alo (hello).

Although segmental preference has hierarchical organization, variability might appear among the children, and when more than one aspect plays a role in a specific word, different productions are possible. For example, in the case of maim (water), while most children chose the ma, which is the stressed syllable with the labial [m] as well as the vowel [a], one child (A1) chose the second syllable im, which is the unstressed syllable (while omitting the [m] since it is in the coda position).

The Pre-Minimal Stage

As stated in the introductory section, children developing typically produce monosyllabic words for target words with ultimate stress (σσ → σ) and disyllabic words for target words with penultimate stress (…σσ → σσ) (see footnotes 6 and 7) during the pre-minimal stage. It seems as if the children in this study skipped the pre-minimal word stage. We claim, however, that this discrepancy does not indicate deviation from the typical path of spoken language acquisition. In fact, remnants of the pre-minimal word stage in the children’s speech were observed during the minimal word stage, supporting our claim that the children had not skipped a stage. Throughout the minimal word stage, children tended to preserve both syllables of disyllabic target words with penultimate stress more often than disyllabic target words with ultimate stress. Thus, when they omitted syllables, it was usually the weak syllable in words with ultimate stress. This phenomenon, which occurred throughout the following stages, is also reported in the literature (Taelman, 2004). Moreover, we should bear in mind that the stages reported in Ben-David (2001) and Adam (2002) are based on studies of more than 10 children. This relatively wide range allowed the detection of all stages, but given the time intervals between sessions, not each and every stage was necessarily detected in each child. That is, the fact that we do not have data regarding a particular stage does not necessarily mean that the children skipped a stage; we might very well have missed this stage.

The Minimal Word Stage

As noted in the introduction, there is a stage in the acquisition of many languages during which the prosodic word equals a binary foot – i.e., children’s words are composed of either two monomoraic syllables or one bimoraic syllable (CVC or CVV) (Fikkert, 1994, Wijnen, Krikhaar, & Den Os, 1994, Demuth & Fee, 1995, Demuth, 1995, 1996a, 1996b, and Salidis & Johnson, 1997, for Dutch and English; Garret, 1998, for Spanish; Rose, 2000, and Demuth & Johnson, 2003, for French; Ota, 1998, for Japanese; Ben-David, 2001, and Adam, 2002, for Hebrew).
During the minimal word stage, the children in this study produced words that were maximally disyllabic. This restriction was valid for various types of target words: disyllabic, trisyllabic, and even quadrasyllabic words. However, in contrast with the initial stage, where the segments played a role in the selection of the syllable of the target word, the prosodic properties – i.e., the stress patterns and the word edge – were dominant in the minimal word stage. In most cases, the children selected the last two syllables of the target word. As a rule, the final and the stressed syllables were preserved.

The Pre-Final Stage

During this stage, the children expanded the number of syllables to three, for both trisyllabic and quadrasyllabic target words. For quadrasyllabic target words with penultimate and ultimate stress, the children produced the ultimate, the penultimate, and the antepenultimate syllables of the words – i.e., the last three syllables – kaeax for mitkaleax (take a shower), paγai for mispaγaim (scissors), kodiyo for akoγdiyon (accordion), itγao for leitγaot (bye). Thus, in most cases the selection of certain syllables in a word was related to prosodic effects and influenced by the stress patterns of the word, as well as adjacency. However, segmental considerations may have interfered. The data included a few examples where adjacency was not maintained: nayai for naalaim (shoes), yavoda for laavoda (to work), [a]eγot for [a]γeγaot (necklaces), and also ipota for ipopotam (hippopotamus). In all these examples, it seems that the final stressed, the penultimate, and the first syllable were selected while the second syllable was ignored. Similar forms were found in Ben-David’s (2001) study of typically developing children (e.g., agolet for taγnegolel [hen], adiyon for akoγdiyon [accordion]). We assume that this inconsistency with regard to syllable preference, meaning that selecting either the antepenultimate syllable or the first one, is a result of prosodic and segmental effects. When the antepenultimate syllable was onsetless, the children either deleted this syllable or shifted the onset of the first syllable to the adjacent antepenultimate position – e.g., nayai: for naalaim (shoes) and yavoda for laavoda (to work). In addition, when two syllables had identical consonants, the children deleted one of the identical syllables (haplology) – e.g., ipota for ipopotam (hippopotamus). Finally, in [a]eγot for [a]γeγaot (necklaces), there was a deletion of an onset-less pre-final syllable. In general, the children abided by adjacency with the exception of onset-less syllables and two adjacent (near) identical syllables.

Adam (2002) reported that during this stage of development, the children in the study augmented the number of syllables they produced, but only if the target forms bore penultimate stress. For example, a child in Adam’s study produced akevet for yakevet (train) and pijama for pijama (pajama) (target words with penultimate stress) but tiya for mitγiya (umbrella) (target word with ultimate stress).
**The Final Stage**

During this stage, the children in this study produced all four of the syllables of the target word just as children developing typically do. Moreover, the children who received their CI earlier reached this stage at the same rate as children with typical hearing. The following comparison between the children receiving CIs early, A1 and A2, and the children with typical hearing included in Ben-David’s (2001) study reflects the findings represented in Table 9.

Children A1 and A2 had a slightly later start than children Carmel and Maayan, but they certainly caught up towards the end of their language development. As shown in Table 9, children A1 and A2 reached the final stage at almost the same age (and even a little earlier) as Carmel and Maayan, who were the last children to reach this stage in Ben-David’s (2001) study. Moreover, it only took children A1 and A2 16 and 18 months, respectively, to progress from the onset of the initial stage to the final one, much less than it took Maayan (21 months). The present results support previously reported findings. For example, Hannah, who uses a CI as reported by Ertmer and Mellon (2001), exhibited similar findings to this study in relation to rate of development. Hannah’s transition from one stage to another (in the latest stages of language development) was more rapid than that seen in infants with typical hearing. Ertmer and Mellon suggest that Hannah’s rate of development bears evidence to the fact that children who receive a CI at a young age may not need as much vocal practice at each stage than younger infants and toddlers with typical hearing appear to require.

**Conclusion**

In summary, it can be seen that children who use CIs from an early age follow the same stages of development as children with typical hearing. Moreover, the advantage of receiving a CI at an earlier age is clearly evident,

<table>
<thead>
<tr>
<th>Child</th>
<th>Initial stage*</th>
<th>Reached final stage*</th>
<th>Time (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing (Ben-David, 2001)</td>
<td>Carmel</td>
<td>1;1</td>
<td>2;1</td>
</tr>
<tr>
<td></td>
<td>Maayan</td>
<td>1;3</td>
<td>3;0</td>
</tr>
<tr>
<td>Implanted (present study)</td>
<td>A1</td>
<td>1;5</td>
<td>2;9</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>1;5</td>
<td>2;11</td>
</tr>
</tbody>
</table>

*Age is presented as year;month.
and children progress at a similar rate or possibly faster in comparison with children who have typical hearing.

As previously mentioned, receiving a CI at an early age has a significantly positive influence on the speech development of children with hearing loss. The fact that children who receive a CI at a younger age develop better speech skills than children who receive a CI at an older age is widely documented in the literature (e.g., Osberger et al., 1993; Yaremko, 1993; Tye-Murray et al., 1995; Ertmer & Mellon, 2001; Ertmer, 2001). However, other variables affect this development, such as early identification and early age of hearing aid fitting. Yoshinaga-Itano (2002) mentions that children with early-identified hearing loss (within the first 6 months of life) who receive early intervention have demonstrated language development within the low average range of development during the first 4 to 5 years of life. Their language development is significantly better than children identified at a later age (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998; Stevens 2002). In fact, early-identified children have better speech intelligibility (Apuzzo & Yoshinaga-Itano, 1995; Yoshinaga-Itano, Coulter, & Thomson, 2000), better language development and vocabulary knowledge (Yoshinaga-Itano et al., 2000), and better social-emotional development (Yoshinaga-Itano, 2002).

The results of the present study support this notion. In other words, receiving a CI at an early age and early identification and intervention with hearing aids (prior to implantation) played a crucial role in the development of the children in this study. It should be noted, however, that since our study only included 6 children, it is difficult to make a broad generalization. Examining the findings reported in the literature, we assume that other factors might be involved. Many demographic variables have been identified in the literature as potentially affecting the development of spoken language in children who use CIs. These include, among others, the age of the onset of deafness (Fryauf-Bertschy, Tyler, Kelsay, & Gantz, 1992), the age the CI is activated (Kirk, Miyamoto, Lento, et al., 2002; Kirk, Miyamoto, Ying, Perdew, & Zuganelis, 2002), the duration of device use (Blamey, Barry, Bow, et al., 2001), the communication mode (Chin & Kaiser, 2002; Kirk, Miyamoto, Ying, et al., 2002), and fundamental differences in rapid phonological coding and verbal rehearsal processes used in working memory (Cleary, Pisoni, & Kirk, 2002; Pisoni, 2003–2004). Future research should consider these variables.

The findings of the present study may also have important implications for clinical use. The analysis of the data suggests trends that show the order of the prosodic development to be similar to those of children with typical hearing. Fee (1997) suggested that prosodic stages provide a model for the assessment and treatment of children with delayed phonological development, and we believe that this is also true for the assessment and treatment of children with hearing loss. In their evaluation procedure, clinicians should determine the prosodic stage of the child’s speech and gradually lead him or her through the subsequent stages.
Acknowledgment

We want to thank Professor Outi Bat-El, from the Linguistic Department of Tel-Aviv University, Israel, for her valuable comments and suggestions.

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*Prosodic Word and Cochlear Implants* 29


Commentary

Hearing Aid Innovation: 100+ Years Later

Ruth Bentler, Ph.D.

Introduction

Innovations in hearing aids have spanned the last two centuries. The value of audibility to successful communication has never been questioned, and the primary goal of each new innovation has been to enhance that audibility in more and more environments. The importance is even more obvious in the pediatric population. We have known for years that there exists a strong association between word knowledge and reading comprehension, and verbal intelligence (Anderson & Freebody, 1981; Thorndike, 1973). Most children with hearing loss are at a disadvantage when it comes to acquiring this word knowledge, or language base. For them audibility is reduced, limiting exposure to potential language-learning opportunities. Since adults already have a language base from which to draw, their interest in novel technologies is often related to appearance, sound quality, or even cost. While those factors are important to hearing aid success, they are certainly less consequential to the pediatric patients with hearing loss whose access to speech and language may be compromised. For them, innovations in hearing aid technology may hold opportunities for improved access to their worlds.

From the very early ear trumpets to the “scientifically-based” akouphone, all early designs had their limitations, as was noted by J.A. Kenefick in his 1901 article in The Volta Review (see Appendix). Today’s hearing instruments still do, but many of the limitations of the early electronic hearing aids, including frequency response, bandwidth, distortion, and size, have been resolved. In the style of Dr. Kenefick, let’s consider how far we have come in the past 100 years.

Cultivating the Moral Courage

Hearing aids are not perfect. In fact, of the approximately 37 million people in the U.S. who have hearing loss, only about 20% choose to wear hearing aids. This is a significant oversight. The technology is there, the solutions exist, but access remains an issue. It is not only the responsibility of the hearing aid manufacturer to create devices that are both effective and appealing, but it is also the responsibility of those who work with children with hearing loss to ensure that they are provided with the support they need to succeed.

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aids. Unfortunately, even those 20% aren’t all thrilled with their decision, as it has been estimated that a significant number of hearing aids are confined to dresser drawers! Why is that? Many theories have been promoted, including low self-perceived handicap, personality traits, cost, stigma, and so on. Except for a few studies to the contrary, understanding personality characteristics has not led to the anticipated understanding of hearing aid acceptance (Cox et al., 2005; Bentler et al., 2008). We do know that individuals who are more self-motivated to obtain hearing aids are often more satisfied (Hickson et al., 1999). Another group of investigators found that the degree of embarrassment from wearing hearing aids correlated directly with hearing aid satisfaction (i.e., “more embarrassed” results in less satisfaction) (Stock et al., 1991). Even the cost of the hearing aid has been shown to be both positively related to hearing aid success and satisfaction (Hosford-Dunn & Halpern, 2000) and negatively correlated to hearing aid satisfaction (Van Vliet, 2002). And, although it may be tempting to counsel our patients to buck up (thus cultivating that moral courage), persons with depression, or those who report less control and more obsession with their plight, show higher levels of satisfaction (Gatehouse, 1994). In any event, counseling our patients (and/or their parents) does result in improved outcomes (Palmer, 2005). Counseling includes measuring expectations, situations, and other individual needs relative to hearing health care. It also includes providing ample information relative to how the ear works, how the hearing aid works, and ways the patient might optimize success.

So As to Completely Cover It…

Hearing aid styles have evolved, in part, due to the demand of the public to make the prostheses as invisible as possible. Fortunately, the components needed to build the devices have also been miniaturized to accommodate that demand. From the large electronic body and desk-top hearing aids at the turn of the 20th century to the micro-sized ear-level hearing aids at the turn of the 21st century, few patients complain about the size of current devices anymore. In fact, many patients simply don’t care as long as the device affords the anticipated benefit. Today, most styles of hearing aids accommodate most degrees and configurations of hearing loss. Behind-the-ear (BTE) styles account for well over 50% of hearing aids sold in the United States, due to the miniaturization of this style. Referred to as the “open fit” style, the micro-BTE hearing aids can be configured with the receiver in the ear canal, or in the case itself. The use of an occluding earmold is optional with this style; more typical is the use of a dome or tulip inserted into the ear canal, which helps appease the age-old complaint of “occlusion effect.” Other styles, such as the in-the-ear (ITE), in-the-canal (ITC), and even completely-in-the-canal (CIC) hearing aids, account for the rest of the market. Older styles, such as body and eyeglass hearing aids, are rarely found in the
United States these days, although some manufacturers are willing to fabricate these styles upon request.

Increased Number of Wave Gatherers to Increase Transmission

A primary goal of hearing aids is to amplify sounds at each frequency to improve audibility for the wearer’s hearing loss configuration while also considering listening comfort. This has been accomplished very successfully in the past 10 years. Issues of bandwidth and distortion have been virtually eliminated, and current fitting prescriptions and schemes are useful for placing the majority of the environmental input into the dynamic range of the hearing aid user. Amplitude compression provides comfort and audibility for most inputs, soft to loud. Frequency compression (or lowering) provides access to inputs of any frequency, by moving the inaudible inputs to lower frequencies for better perception. Volume control wheels are now optional. Most hearing aids are equipped with a datalogging feature, to provide the managing audiologist with some access to the wearing time and environments of their patient, both pediatric and adult. This feature allows for storing use time, environment type (quiet, noise, speech, music, etc.), battery life, preferred settings, and so on. Perhaps the most innovative of the modern “wave gatherers” have been the advancements in directional microphone and digital noise reduction technologies.

Directional microphones have been used in the recording industry for over 75 years. Although the first implementation of this feature in hearing aids 40 to 50 years ago was met with only limited enthusiasm, the re-emergence of their use was timed to coincide with the availability of digital signal processing (DSP), thus increasing the usefulness of this technology. The rationale for using directional microphone systems in hearing aid design is based on different spatial properties of speech and noise. Assuming the hearing aid user is able and willing to turn towards the direction of the communication partner (typically in front) and that the noise is positioned on the sides or to the rear, the effect of the directional microphone is to provide a slight delay of the input to the rear microphone port or inlet. By the time the same input reaches the front port or inlet, the sound will be out of phase with itself, and subsequently cancel itself. All of this is carefully achieved by strategically placing the microphone ports from 3 to 10 mm apart on the case of the hearing aid, providing just enough delay so that the sound will be 180 degrees out of phase at the diaphragm. Figure 1 shows a more traditional design of directional microphones.

This design is still used in many BTE and ITE hearing aids. Figure 2 shows a more recent design. In this case, two microphones (non-directional or omnidirectional) are placed side-by-side, with the specific inlet spacing desired. Instead of using a screen or some other damping element to delay the rear input, the microphones are wired together and an electronic delay
is applied to the input of the rear microphone. An advantage of the latter design is that the algorithm for determining its function can be controlled by the DSP chip. That is, the electronic delay can vary depending upon variables such as noise location, level, presence, or absence of speech, and so on. This is referred to as an adaptive directional scheme. Regardless of whether two omnidirectional microphones are used or not, there are always at least two ports in a directional microphone system. And in either case, the use of automatic directionality can be achieved. In this case, the directional feature will switch off or on, depending upon the algorithm employed by the manufacturer. Oftentimes, the primary factor is the level of the background “noise”.

The efficacy and effectiveness of the directional microphone has been studied extensively. In a critical review of the evidence to support its use in adults (Bentler, 2005), it was noted that directional microphones do offer additional advantage over amplification alone. That advantage appears to be optimized by a user-controlled switch and training regarding environment-specific use. More recent investigations to determine the reasons for lack of benefit in real world environments have suggested that listeners don’t always find themselves in those environments to optimize benefit, and they
often object to the increased internal noise that is inherent in the directional design (Wu & Bentler, In Press). Despite the concern over the potential loss of incidental learning opportunities, directional microphones have even been shown to be efficacious with the pediatric population as well (Stiles et al., 2008).

The second innovation to see much marketing success is the digital noise reduction (DNR) feature. This feature has the general goal of reducing the level of signals identified as noise. Yet how this is actually accomplished varies dramatically across manufacturers. One of the biggest issues in this application is defining the noise. Noise is typically classified as such by the hearing aid’s digital processor and any one (or more) of the following three reduction schemes is activated.

**Classic DNR** is generally designed to provide less than target gain in any channel for any signal identified as noise. While earlier algorithms were confined to noise classification based on envelope modulation rate and depth, current DNR algorithms can base noise classification on overall level, center frequency, spectral tilt, and other acoustic parameters included in the estimation and activation algorithm. Within any channel, once the input is classified as noise or exceeds some signal-to-noise ratio (SNR) threshold based on a pre-determined decision rule, the gain will be reduced. The amount of gain reduction and how fast this reduction will occur depends on the manufacturer-specific decision rule.

**Impulse Noise Reduction** is currently used to provide relief from transient sounds, such as a door slamming, the rattling of dishes, or even computer keystrokes. One-third of environmental noise experienced by hearing aid users have transient duration and are considered to be annoying (Keidser et al., 2007; Chalupper & Powers 2007). Several manufacturers have developed noise reduction algorithms to target non-speech inputs and reduce the annoying impact of such sounds. These algorithms first calculate the temporal properties with a very short processing delay (< 1 ms) in order to minimize reaction time to the transient sounds. Next, envelope features are extracted and factors such as steepness of the envelope slope (relative to that of a speech signal) are used to activate the gain reduction. This gain reduction necessarily occurs extremely quickly in order to suppress the transient signals.

**Fast filtering** is a third noise reduction approach for improving listening in noise. One common method is the Wiener filter. The Wiener filter, named after Missouri-born mathematician Norbert Wiener, was developed in the early 1940s and first published in 1949. The original application was to remove the stationary noise from the speech signal, for telecommunication purposes. A number of hearing aid manufacturers utilize some form of the Wiener filter in their noise-reduction feature. To implement the Wiener filter in practice, one has to be able to estimate the power spectra of the original image as well as the additive noise.
Most products today utilize some or all of these noise reduction approaches. To date, classic DNR has been shown to have little impact on the speech perception abilities of the adult user (Bentler, 2005); the feature has been shown, however, to improve listening ease (e.g., Bentler et al., 2008b). The impulsive noise reduction scheme has been found to increase hearing aid user satisfaction (Keidser et al., 2007). The fast filtering approach is difficult to study in isolation, but in combination with the other approaches has been shown to enhance sound quality and listening comfort (Ricketts & Hornsby, 2005). Relative to children with hearing loss, a combined scheme (using classic and fast filtering) has been shown to improve sound quality, with no negative impact on novel word learning or speech understanding in a study of 5 to 9 year olds (Bentler et al., 2008a).

The Greatest Resonator Yet Produced?

Besides the current advantages of low or no distortion, ample bandwidth, and acceptable size and style, current digital hearing aids also come equipped with multiple memories for storing different responses, multiple channels of processing, aid-to-aid data transfer, and many other features. Still, they are not acceptable to all potential users. Thus, the search continues for additional options to drive the market. In fact, the modern hearing aid era may have just witnessed the introduction of a modern-day akouphone. Earlier this year, the Soundbite hearing system was introduced (www.sonitusmedical.com). This in-the-mouth hearing aid uses bone conduction to transmit sound, and is intended for use with unilateral deafness. The battery and actuator are worn in the mouth in a manner similar to an upper-teeth retainer. The companion component is a micro-BTE holding the DSP chip and microphone. The system is being marketed as delivering high fidelity sound through 12000 Hz. Some might consider this current product to be an innovation ahead of its time; others would look at this grasp to the past as evidence that even the earlier hearing aid efforts, such as the akouphone, recognized important physiological acoustics principles for successful sound transmission. To quote J.A. Kenefick (1901): “To all the deaf all over the globe who are looking for emancipation, I would say that there is hope that in time we may have a device that will enable us to hear, but that time has not yet been reached.” However, we keep getting closer.

References


Appendix: The Akouphone And Its Limitations

By J.A. Kenefick, M.D.

Mechanical aids to hearing devised in past years have been many and varied. The most efficient were constructed upon some well-recognized principle of physiological acoustics and were intended to reach the labyrinthine acoustic terminals by concentrating and intensifying sound waves either through the external auditory meatus or by conduction through the bones of the head or face.

No one apparatus has been found applicable to every case and the latest production in this line proves no exception to the rule. In proportion to the number of [people with hearing loss], those resorting to mechanical aids are comparatively few in number. This seems to be accounted for by two factors, namely, the conspicuousness of these instruments and the intolerance of their aid by oversensitive acoustic nerves, which are present in the great majority of afflicted individuals. The first is an objection which might be overcome by the cultivation of certain moral courage on the part of the patient while the second is a physical difficulty and as we shall see may prove a serious hindrance to the use of any mechanical aid based on the above principles.

The latest product of this kind is brought forward by Mr. Wilton R. Hutchinson, a young electrical engineer from the south, who has spent years of work and study in bringing the apparatus to its present stage of efficiency and has given us, by far, the most intense and powerful reproducer of sound and one who possibilities exceed those of all similar devices.

Without going into a description of the mechanical construction of this contrivance, the details of which are for the most part trade secrets, the instrument may be considered as a telephone whose electric force is supplied by an ingeniously compact storage battery of size volts. The transmitter is fitted with one or a series of dome or funnel-shaped resonators for the purpose of gathering in and concentrating sounds waves from all sources in its immediate neighborhood. Its receiver is so constructed that all sounds conducted to it are reproduced or retransmitted with such force and intensity as to produce a searching and sonorous wave of peculiar intensity and penetration which is magnified still more on account of the closure of the external auditory meatus by the instrument which is held so as to completely cover it. The nature of this wave which gives a saw tooth character to its tracing is not yet understood.

J.A. Kenefick, M.D., was the Assistant Surgeon to the New York Eye and Ear Infirmary. This article was originally published in 1901 in The Volta Review, Volume 3, Issue 2, and was reprinted from “Medical News” magazine. The article is a review of what was at the time a new type of hearing aid, the akouphone.
In ordinary use the storage battery is carried fastened at some convenient place about the body, while the transmitter or wave collector may be held in the lap or laid upon a table. The receiver is fitted with a handle of suitable length so that it may be held in close contact with the ear with its vibrating diaphragm directly over the external meatus. This receiver is to a certain extent under control and the intensity of its action adjusted either by manipulating the adjustment of the diaphragm or by means of a sliding switch on the handle and manipulated by the patient’s finger.

This is the outfit ordinarily recommended for the partially deaf. When used at the opera or lecture, its transmitting end is reinforced by adding an increased number of wave gatherers, its receiving end being adjusted as nearly as possible to the toleration of the patient’s auditory apparatus. When used for the instruction of [individuals with hearing loss], a special transmitter is used and the receiver again adjusted to the comfort of the subject’s hearing apparatus.

[Individuals with hearing loss] who seek mechanical aid for their affliction (commonly without the aid or advice of an aorist) come generally under one of the following headlines: 1) Those whose membrane and ossicles are intact, but functionally embarrassed by sclerosis or injury while the nerve is yet free; 2) those whose conducting apparatus is embarrassed by the absence of the ossicles or the greater part of the tympanic membrane, the nerve remaining free; 3) those in whom there has been disease involving, but not wholly destroying the labyrinthine nerve terminals; and 4) those whose deafness is caused by destruction of the nerve function somewhere in its central course.

In the first class of cases we find in the great majority of cases flaccidity of the tympanic membrane and hyperesthesia nerve terminals in the labyrinth against these new sound waves. Add to this the possibility of obstruction in the Eustachian tubes and we have with the receiver held close against the ear a condensation of sonorous waves of such intensity as to be practically unbearable. All noises in the immediate vicinity, such as the closing of a door or the shutting of a window, are here intolerable, and interfere with conversation in no uncertain way. To be sure the instrument is adjustable, but in these cases the nerve objects to the new stimulation even when at its lowest point of efficiency. It is well to remark in this connection that in some cases presenting a considerable degree of deafness, with symptoms of even labyrinthine involvement, such as vertigo and tinnitus, these alarming symptoms may depend upon purely mechanical causes and may wholly disappear after ventilation of the tympanum through the Eustachian tubes. Resort to any mechanical aid under these circumstances would be a serious mistake for such a patient.

When membrane and ossicles are both missing, and no involvement of the nerve is present, the patient being dependent entirely upon bone conduction, it would seem that the conditions were theoretically favorable for the use of the akoupohone on account of the protection afforded the nerve terminals by the intervening bone. As a rule, however, such patients seldom resort to mechanical aids as they hear the loud voice fairly well.
[In the third class of cases . . . we find perhaps the greatest field for the practical use of this apparatus in teaching . . . articulate speech.] This was recently well demonstrated before the Otological section of the Academy of Medicine, and judging from a single short lesson given to a deaf-mute of eighteen years, who had practically never heard anything, it was easily evident that the articulation and even inflection of speech could be conveyed by these means to such individuals with a greater degree of success than has ever before been attained.

To the fourth class, with central lesions, no aid can be offered.

In judging the limitation of the akouphone as an aid to hearing, the writer’s opinions are as yet based largely upon theoretical considerations and upon the practical trials of a few cases of sclerotic middle-ear catarrh from his own and his colleagues’ private practice.

This apparatus, although far and away the greatest resonator yet produced, is, from the aurist’s point of view, still crude, its present method of application being a good deal like providing an arc light for an individual with failing eyesight without any regard to the conditions of his refraction or optic nerve.

It is to be hoped that otologists everywhere will aid in developing and applying this apparatus according to the principles of their science to the end that its shortcomings may be mended and its possibilities extended.

In conclusion the writer would quote the following extracts from the pen of Mr. Alexander L. Pach, which appeared in the Silent Worker for March. Referring to the akouphone or akoulalion he says, “To all the deaf who are able I would say, if you have a vestige of hearing and are able to make a personal trial of the appliance, not once or twice, but several times in succession, do not lose your head and forget that your sense of feel is something marvelous. Take into consideration that the noise children make when you are trying to read is so intensified that, though a hearing person might not mind it, it jars you... To all the deaf all over the globe who are looking forward to emancipation, I would say that there is hope that in time we may have a device that will enable us to hear, but that time has not been reached.”
At a late meeting with the Board of Directors of the American Association to Promote the Teaching of Speech to the Deaf [currently called the Alexander Graham Bell Association for the Deaf and Hard of Hearing], it was decided to undertake, as a part of the work of the Association, the publication of a magazine. This decision was reached after careful and mature deliberation, with all conditions and interests fully set forth and considered. It was deemed that the life and future usefulness of the Association required activity and some medium of expression, some means of ready and frequent communication with and among the membership. The reports of Summer Meetings have contributed heretofore to these requirements, but as these reports have been infrequent and necessarily more or less delayed in their publication, they have but partially met the demands; nor could they be relied upon to fulfill the probably much larger requirements of the future. The great advancement in the teaching of speech to the deaf made in recent years in this country is a prophecy of yet greater advancement in the years to come. The American Association in its work of promotion has contributed in so small part to the advancement already made; it must continue in its work and continue to contribute to the movement making so strongly and so surely for better and worthier things in the education of [children who are deaf]. The establishment of a periodical, it is believed, will strengthen the work and strengthen the hands that are doing the work all over the field. The press is an engine of power, no matter what may be the cause it serves, or the movement it fosters. The Association then does wisely to enlist it in the cause of speech-teaching, availing itself of its ready facilities and large resources to the better and speedier attainment of its ends.

The primary purpose of the Association, as its full name indicates, is to promote the teaching of speech to the deaf; it will be likewise the primary purpose of the magazine, as the Association’s right hand, to promote speech-teaching in every way that is possible through such an instrumentality. Yet, this specific purpose will in no wise limit the field of the magazine, for it is recognized that teachers of the deaf must be something more than teachers of articulation,
more than instructors in a special branch or of a special subject. Teachers they
must be, trained and skilled, specialists if you will, in the part or parts of the
work they are called upon to do; but they must be also, with all the rest and
above all the rest, educators.

Speech to be speech must be more than intelligible utterance: it must be intel-
ligent utterance as well. And none realize this more than teachers of speech
themselves. Intelligibility without intelligence is but empty sound, noise – to
be heard, to die away, to leave no impress. True speech proceeds from thought,
and is the expression of thought, and to be effective of worthy ends, it must
be the instrument of a developed, disciplined, well-filled mind. But this is the
whole question, the whole problem, of education, and it is the problem that
presents itself to every teacher of deaf children who compasses in his views and
estimates the full and exact measurements of the task before him. Our maga-
zine will then address itself to teachers of speech and to teachers by speech,
but to both as, in the largest sense, educators. To this end it will aim to be an
educational magazine upon broad lines and with a scope to embrace the whole
field of educational effort. It will be technical in its matter, as it must be to be
useful to our teachers in their whole work, but technical only so far as may be
necessary; after that it will be general, recognizing that where our work ceases
to be technical, where it ceases to be articulation teaching and language drill,
at that point it ceases to be a special work, and from thence it becomes a work
purely educational in its character, taking on and pursuing the purposes and
aims, and for the most part employing the methods, common to all educational
work. In its purely technical features our work is narrow and its tendencies are
narrowing, the more necessary then that our teachers, in their study and read-
ing, should obtain glimpses from time to time of the larger work going on about
them, receiving therefrom inspiration and aid, together with all the broadening
influences and impulses prevailing in that work, that must inevitably make for
better things in their own special work. There is little questions that the cause
of speech-teaching has suffered in the past by the narrowness of views of teach-
ers who have limited their work and their art to the giving of vocal utterance.
These views and this kind of teaching are fortunately less prevalent today than
formerly, but with new teachers coming continually into the work both the
views and the practice will revive; hence the constant need of a corrective and
directive influence, and this it is hoped the magazine will provide.

The circulation of the magazine will be largely among teachers actually
engaged in the work of instructing the deaf, and to them it must look in great
part for its support and for contributions to its pages. Contributions especially
are solicited and they will be welcomed in the measure that they are thought-
ful and practical and with the purpose to point the way to the securing of
better and larger returns in the work. In so far as the magazine may circulate
outside the ranks of teachers, it will find its clientage among directors and
patrons of schools for the deaf, parents of [children who are deaf], the edu-
cated deaf, and that numerous class of large-hearted, large-minded men and
women with only their natural and generous impulses to draw them toward and to interest them in the work of the education of the deaf. All these the magazine will hope to interest more largely in speech-teaching and to give still more largely of their influence in its behalf.

The policy of the magazine will be one wholly of encouragement and cooperation. Its aim will be at all times and wherever need arises, to lend the helping hand. It will be assumed that the question of speech-teaching *per se* is a settled question: that it is the accepted purpose of our schools to give every child [who is deaf] opportunity, with a fairly prolonged trial, to learn to speak; and that the schools generally are doing at the present time and under existing conditions, all the speech-teaching that it is possible for them to do. The situation calls thus only for its own continuance and for the rendering of such aid as shall sustain the movement now making upon present lines and with the present force or momentum. The magazine will recognize that the spirit now prevalent in our schools is one entirely favorable to speech for the deaf, and to more and better speech-teaching so soon as more favorable conditions may warrant and permit. This spirit, if it exists, and there is hardly doubt of it, calls for nothing but aid and encouragement, and these the magazine will render to the full extent of its resources and powers.

It is almost as difficult to name a magazine as it sometimes is to name a child, and this writer has had experience quite recently with both difficulties. The name of the magazine, as finally settled upon, will be *The Association Review*. With the name selected, it was hardly less difficult to determine the form the publication should take. After much casting about it was decided to give it the general form and appearance of the *Educational Review*, edited by Nicholas Murray Butler, and published by Henry Holt & Co., a most valuable magazine, and one whose excellent features it is hoped we may copy in more particulars than one.

Little more needs be said, or can be said, here and now, of the character and scope and policy of the proposed magazine. The future has its story and its work, and the magazine may well be left in its successive issues to speak and to show for itself. It asks only that in your judgments you minify its shortcomings and magnify its excellencies, and that you give it, each of you, the benefit of your support and the encouragement of your good will.

I wish finally to say that as editor of the magazine I would have it that the membership of the Association should feel a proprietary interest in it; feel that it is their magazine. And feeling this individual proprietary interest in it, they should assume and feel an individual responsibility for it, for doing each and every one all that he can do to make it the success we all wish it to be. The magazine is yours, it is ours, now let us together put our shoulders to the wheel and make yet further advancement, yet larger achievement in the great work in which we are engaged, the great work which we all love.
Book Review

*Literacy and Deafness: Listening and Spoken Language*

Lyn Robertson, Ph.D.
Plural Publishing, San Diego, California
Softcover, 2009, $65.00, 304 pages

*Literacy and Deafness: Listening and Spoken Language* is a book written with a solitary purpose – to support the use of listening and speaking together as a path to literacy for children who are deaf and hard of hearing. The author, Lyn Robinson, provides an overall development model to show how children with hearing loss who learn to listen and talk can achieve high literacy levels. In a book designed for parents, educators, and other professionals in the field of deaf education, the author balances theory and research with both practical approaches and anecdotal evidence to support her premise.

A selected review of the literature, which comprises the first chapter, includes research spanning from 1916 to 2002, and leads the author to conclude that knowledge of the syntax and semantics of the chosen language and the ability to manipulate the sounds of that language form the foundation for progress in reading achievement. With the groundwork in research laid, the following chapter provides an overview of reading theory and, while not exhaustive, is more than sufficient to demonstrate the scope of approaches as well as the debate between sight-word and phonics instruction. The conclusion to be drawn from this overview is that one approach to reading is not superior to another. Rather, all of the approaches rely on knowledge of the spoken language being read. Chapter 2 is also the companion piece for Chapter 7, the focus of which is constructing meaning through reading. While Chapter 2 discusses reading theory, Chapter 7 discusses the pragmatics of learning to read and weaves research-based information together with practical aspects of reading acquisition.

Chapter 3 describes the use of sound amplification technologies. This chapter, authored by Carol Flexer, Ph.D., LSLS Cert. AVT, is roughly divided into two sections. The first describes the anatomy of listening and how it relates to literacy; the second describes the variety of amplification technologies available with the caution that for literacy development, the complete speech spectrum should be optimized. In addition to describing the variety of audiological enhancements today available, the author makes two important points. First is the value of what she terms “distance learning” or ambient input, a frequently overlooked but significant source of acquiring knowledge and honing listening skills. The second point is the author’s respectful acknowledgement that the topic of amplification can be a cultural sticking point. Flexer concludes that, for families who “desire a spoken language and literacy outcome” for
their child, technological means coupled with auditory skill development and practice raise the probability of achieving that goal.

Chapter 4, one of the most compelling chapters in the book, provides strong support for Robertson’s belief that the road to literacy is founded on listening and spoken language skills. This chapter provides an in-depth discussion of spoken language from the sounds of speech and how they are learned, to the use of spoken language and the relation it bears to literacy. The author addresses here (as elsewhere in the book) the difference between using American Sign Language versus spoken language as the primary means of communication, and how these modes of communication impact literacy differently. Robertson argues that establishing spoken language provides a means for thinking and comprehending the same language used for reading. The chapter concludes with a review of Schlesinger’s 1988 study of parental involvement and its impact on the language capabilities of children who are deaf or hard of hearing.

While Chapter 5 starts with a discussion of phonological awareness and processing capabilities, the thrust of the chapter is a review and discussion of the principles which form the basis for the work of auditory-verbal educators and therapists. The following chapter focuses on child development. Although it begins with infant screening and the related topic of early detection, a large portion of the chapter is devoted to a discussion of typical childhood development from birth to age 5. This provides an excellent overview for parents and other caregivers.

Chapter 8 relates reading to writing. The first section of this chapter reviews a study, the results of which show that a sample population of students with hearing loss demonstrated progress in written expression commensurate with their peers with typical hearing. The author explains these results using literacy theory, which views reading, writing, and spoken language as interdependent. Put another way, children who can read learn to look at language cues in print and use these cues to support both speaking and writing. This chapter also offers practical ideas for helping children learn to write.

Both Chapters 9 and 10 are essentials for caregivers of children with hearing loss. Chapter 9 focuses on educational life after the child’s early years and offers suggestions for helping children who are deaf or hard of hearing continue to find success. It ends with case studies of four adults with severe to profound hearing loss and their successes. In Chapter 10, the author describes a team approach to education and includes discussions of Individualized Education Programs (IEPs), mediation (both formal and informal), and practical pointers for communicating with the professional team comprised of educators, therapists, audiologists, and school psychologists.

Chapter 11 applies the principles of spoken language, as outlined in Chapter 4, to children whose caregivers are non-native users of English. As Robertson acknowledges, there is little information on children with hearing loss from bilingual or non-English speaking homes who are learning English as a first
language. Robertson maintains that, with appropriate technology, children with hearing loss can learn more than one spoken language and therefore have a good foundation for literacy in each of the languages.

Chapters 12 and 13 are geared toward educators. Chapter 12 reviews assessment measures, such as formal testing and formal and informal observation. Reading assessment allows for feedback, which in turn allows for more productive reading skills. Chapter 13 reviews ways to enhance the reading process and focuses on two areas: Allington’s four suggestions about reading, and what to do before, during, and after reading (a nonspecific version of the SQ3R reading method). Finally, Chapter 14 explores placement for the child with hearing loss and looks at alternate sources for education, such as music, sports, art, and dance.

The book concludes with thoughts on the auditory-verbal approach from Ling and Beebe, written almost 30 years ago, which, as the author says, completes the circle of connections between hearing and listening, listening and speaking, speaking and reading, and reading and writing. *Literacy and Deafness: Listening and Spoken Language* provides well-grounded substantiation for the author’s premise that listening and speaking provide a path to literacy, and is a valuable resource for both caregivers and those charged with the education of children who are deaf and hard of hearing and who use listening and spoken language.

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Information for Contributors to *The Volta Review*

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