Tel-Aviv University
The Lester & Sally Entin Faculty of Humanities
The Shirley & Leslie Porter School of Cultural Studies

# THE PROSODIC DEVELOPMENT OF HEBREW-SPEAKING HEARING IMPAIRED CHILDREN

**Thesis submitted for the degree of**
**"Doctor of Philosophy"**

by

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This work was carried out under the supervision of

**Dr. Outi Bat-EL**

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# ABSTRACT

The dissertation presents a study of the prosodic development of Hebrew-speaking hearing impaired children. The focus of the study is the gradual development of the prosodic word (number of syllables) and syllable structure in the speech of Hebrew-speaking hearing impaired children using a cochlear implant device. The study is supported by quantitative data and assumes a hierarchical representation of the prosodic word (Nespor and Vogel 1986, Selkirk 1984).

The study examines the effect of the rehabilitative device on the acquisition process. For this purpose, it compares the development of the children with cochlear implants to two other types of Hebrew-speaking populations: hearing children (based on Ben-David 2001, Adam 2002) and hearing impaired children with hearing aids (based on data collected in this study).

The participants of the study were six monolingual Hebrew-speaking hearing impaired children using cochlear implant devices (3 boys and 3 girls). The study follows the developmental stages of the children a few months after the implantation, i.e. from the appearance of their first words, until the stage in which all phonological units considered in the study were produced correctly.

The group of the hearing impaired children with hearing aids consisted of four children (2 boys and 2 girls). However, data collection of the hearing aid users was less homogenous and started at different stages of the children’s phonological development (see discussion in §4.1.2).

Data collection was based on spontaneous speech as well as object and picture naming. Children were encouraged to produce spontaneous speech during natural play with different toys and objects. The naming task was conducted by using a constant set of pictures and objects, which the children were encouraged to name. The structured naming test allowed controlling the size and scope of the sample in terms of word choice, the number of syllables and the segment inventory in the words. The data in the spontaneous test and the naming test were recorded and transcribed orthographically and phonetically by a speech therapist (the author),

using the format of Child Language Data Exchange System (CHILDES; Brian MacWhinney and Catherine Snow 1985). The transcription and data analysis were carried out by using two tools in the CHILDES system: the CHAT (Codes for the Human Analysis of Transcripts) and the CLAN (Computerized Language Analysis). The CHAT is a transcription and coding format while the CLAN is an analysis program.

The data were analyzed in terms of the relevant prosodic units: the prosodic word, the syllable, and the sub-syllabic units (onset and coda). Consonants were analyzed in relation to the prosodic structure.

The study provides a detailed qualitative picture of the developmental processes of the fourteen hearing impaired children, supported by quantitative profiles among and within the children. Findings were discussed in terms of two quantitative parameters: the target parameter, which evaluates the ratio of target words that fit the structure characterizing a certain stage (regardless of whether they were produced with this structure); the production parameter, which evaluates the ratio of words produced with the structure characterizing this certain stage.

The study reveals that with respect to the development of the prosodic word, as well as the development of the syllable (i.e. onset and coda), the acquisition path of the implanted children is very similar to that of Hebrew-speaking hearing children as well as to hearing impaired children using hearing aids. Also, the comparison between my findings and those of typically developed children speaking different languages revealed the same tendencies in the prosodic aspects as well as in the segmental aspects.

As for **the prosodic word development**, I found monosyllabic words in the initial stage, whose syllable was selected from the target word mostly on the basis of segmental preferences. The minimal word stage, where words are maximally disyllabic, was the next stage, as expected. A further increase in the number of syllables in the word up to the pre-final and final stages was also apparent.

**The development of the syllable structure** followed most of the stages reported in the literature on the development of the onset and the coda in the speech of hearing children. However, onset development starts with a stage that is rarely mentioned in the literature, which I call as ‘consonant–free words stage’, i.e. a short period characterized by the production of words consisting only of vowels. Coda development starts, as expected, with syllables without codas. However, contrary to reports on coda development in Hebrew, a missing coda is compensated by a long vowel. These two special phenomena are broadly discussed in §7.3.

The discussion and implications section brings my dissertation to an end. In this final part, I deal with the relation between the rate of development and variability within subjects. Two background variables of the hearing impaired subjects are discussed: age of identification and intervention of the hearing loss (i.e. age of hearing aid fitting, and age of implantation). The findings indicate that as long as the age of hearing aid fitting as well as the age of implantation is early, the rate of development is very similar to that of hearing children. However, age of hearing aid fitting is much more crucial for early development of the prosodic word. Moreover, when the age of implantation is beyond 18 months, other variables may play a role in children’s speech acquisition, thus causing greater variability among children. Such variables may include objective factors (e.g. electrode location at the cochlea) as well as subjective factors (e.g. child’s cognitive abilities, his/her self motivation, parental involvement, the amount of rehabilitation a child receives etc.). The unique phenomena of the hearing impaired children relate to the prosodic developmental stages, i.e. consonant-free words and long vowels, are also discussed.

To conclude, the findings of the study shed light on the prosodic development of hearing impaired children in general, and of cochlear implant users specifically. The findings are very encouraging since they bring us to the conclusion that cochlear implant users follow the same developmental milestones of prosodic development which hearing children follow. Finally clinical applications are derived.

The dissertation is organized as follows: the introduction in part I includes a review of the theoretical framework of Prosodic Phonology (§1.1) with reference to Modern Hebrew (§1.2). The development of the prosodic structure is then describe, following the developmental stages of the prosodic word (§2.1) and the syllable structure (§2.2) of typically hearing children. The characteristics of hearing impaired children (§3.1), and their speech production (§3.2), are then provided accompanied by a discussion on two main rehabilitative devices of this population (§3.3), i.e. hearing aids (§3.3.1) and cochlear implants (§3.3.2). Part II provides information regarding the subjects and the methods of assessment (§4). Part III includes the findings sections. I provide an analysis of the development of the prosodic word in the speech of the implanted children, and show that it is similar to that of hearing children (§5). The development of the syllable structure is then provided (§6). The stages of onset development (§6.1) as well as coda development (§6.3) are discussed with regard to hearing children speaking Hebrew as well as other languages. I continue with a discussion of the relation between rate of acquisition and variability within subjects (§7.2), as well as discussion on two special phenomena, i.e. consonant-free words (§7.3.1) and long vowels (§7.3.2), which do not appear in the speech of typically hearing children. The concluding remarks include clinical implications.

## ACKNOWLEDGEMENTS

This dissertation has enabled me to combine my various areas of interest. As a speech and language pathologist, who has been working for many years at integrated schools of hearing impaired children as well as at the rehabilitative department of a public hospital, I was very interested in studying hearing impaired children in general and cochlear implant children in particular. The need for a theoretical anchor for my clinical work led me to an introduction to the theory of prosodic phonology, which opened the doorway to a new and interesting area. The relationship with my supervisor, Dr. Outi-Bat-El, enabled me to combine these different areas: her broad knowledge of the theoretical framework together with my clinical experience allowed me to investigate and understand the clinical findings in the speech of hearing impaired children. It is therefore no wonder that my gratitude for this dissertation goes first and foremost to Outi Bat-El, my supervisor, who agreed to get into an area, which was new to her and to study the speech of a population she had not encountered before, i.e. implanted children. I am indebted to Outi for her deep interest in everything I did, her willingness to know more about this population and about my clinical experience as well as her willingness to be involved in every step of my research. I would like to thank her specifically for her deep confidence in me and my work emphasizing the importance of a professional contribution to the clinical field. I highly appreciate her for the high standard she has always set, and for directing me to attain my own goals alongside a high quality of work. Her careful and critical reading of numerous drafts of each chapter has improved my work significantly. I cherish Outi’s love of data, and her faith in the importance of explaining the findings. Her enthusiasm with the study of phonology has inspired me and affected my attitude, undoubtedly contributing to my clinical work.

The research of the speech of hearing impaired population, specifically implanted children, presented in this work would not have been possible without the contribution of Dr. Tova Most from Tel-Aviv University. My first exposure to the research of the hearing impaired population was in Tova Most's courses. She accompanied me in my studies towards my first and second degrees and was the supervisor of my M.A. thesis. Her comments and queries about hearing impairment as well as the subjects and method of the current study improved my work significantly. I am deeply grateful for her contribution.

I was also lucky enough to be a student of Professor Yishai Tobin during my first and second degree at the Department of Communication Disorders in Tel-Aviv University. I deeply thank Professor Tobin for his comments on my proposal, his broad and deep answers to all my questions about phonetics and phonology as well as his warm support all these years.

I am also thankful to my colleagues and friends of the Tel-Aviv University Phonological Circle, who throughout the years, accompanied me on my journey, each contributing in his/her own way: To Dr. Avivit Ben-David, who helped with her professional comments and her personal experience as well as providing me with endless patience and emotional support. To Dr. Gila Tubul, who started and advanced her study with me for so many years. To Dr. Galit Adam, who introduced me to Dr.Outi Bat-El, and encouraged me to work with her. Also to Evan Cohen for his editing work, which was done so quickly and with a lot of patience for all my questions, and to Gila Zadok for her warm support.

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Special thanks to the children, who participated in the study, as well as their families. The longitudinal character of my study has enabled me "to grow up" with the children and to see their amazing progress. This was a very special experience for me as a professional person and as a human being. I want to thank the parents, who shared their emotional and professional thinking with me and who accepted me as a family member each time I came. I commend their efforts, investment and love for their children. They gave me a lot of power and faith in my academic and clinical work.

Beyond the professional support, this dissertation would not have been possible without my family's love and help. First, my gratitude goes to my parents, Shosh and Yoel, who helped me considerably by taking care of my children whenever I asked. To my sister, Sigal, who spent many hours transcribing and coding the data. To my brother, Eyal, for designing the figures as well as for his good advice. To my older brother, Yori, who believed in me. I thank them all for supporting me unconditionally, and with lots of love.

Finally I thank my two sons, Amir and Ido, who were born into a situation in which "mom is studying". Sorry for so many hours in which I was so busy with this dissertation. And my husband, Gerald, who has believed in me throughout this journey, thanks for the support and pressure not to give up during the difficult periods.

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Limor Adi-Bensaid

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Tel-Aviv, Israel

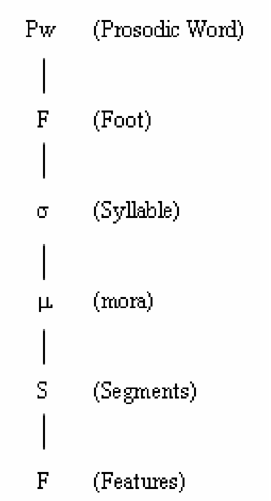
# PART I INTRODUCTION

## CHAPTER 1: THEORETICAL BACKGROUND

### 1.1. Phonological Representation

The study assumes a non-linear representation of phonological units consisting of hierarchical organization of words, feet, syllables, moras, segments and features, and sets of universal principles. The phonological units are presented in figure (1) below.

(1) The hierarchical representation of the phonological units



There are two types of phonological units, melodic and prosodic, when the latter ones are higher in the hierarchy. The melodic units are the segments, consisting of articulatory and acoustic features, which are also hierarchically organized. The prosodic units are those above the segment, i.e. the organization units consisting of the mora, the syllable, the foot and the prosodic word.[1] These units contain aspects of syllabification, stress, and word structure (suprasegmental, hence prosodic patterns) of the language.

In the following sub-sections, I expand the discussion on the phonological units mentioned above, starting with the melodic units (§1.1.1). Then I touch on every prosodic unit, going from the bottom to the top of the hierarchy (§1.1.2).

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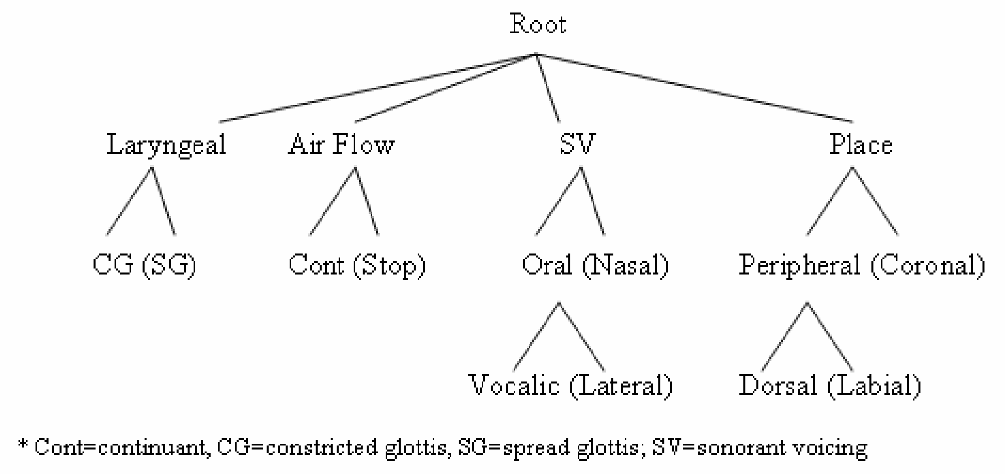
[1] The phonological hierarchy contains a higher level beyond the prosodic words (e.g. phrase, utterance), but since it is not relevant to the current study, it will not to be discussed in here

### 1.1.1. The segments

The segments are units corresponding to 'speech sounds'. Segments are assumed to be made up of independent properties called *features*. Defining segments according to their feature content allows characterizing groups of segments which behave similarly in languages (Parker 1994).

Rice and Avery (1995), following Clements (1985), McCarthy (1988) and Sagey (1986) assume that segments have internal structure and that features are grouped together under a higher level organizing node, called the root node. They propose four major constituents dominated by the root node: Laryngeal, Air Flow, Sonorant Voice (SV), and Place. Each node has a sub-tree indicating two types of relation, dependency and markedness. Each constituent has two values: marked and unmarked options. Figure (2) presents these options, with the feature in parentheses being the unmarked option for the dominating node.

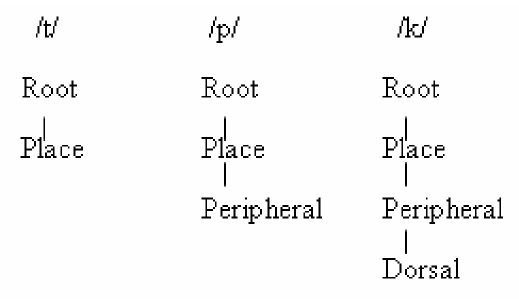
(2) The structure of the feature tree



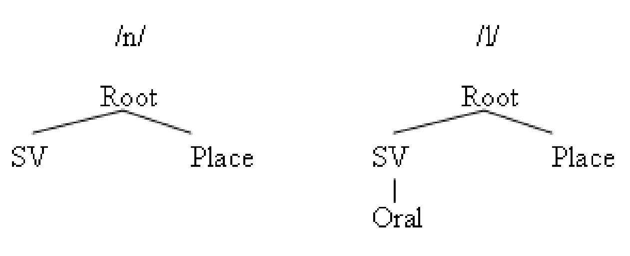
As shown in the feature tree above, the Laryngeal node organizes laryngeal features, the Air Flow node organizes stricture features that are relevant to air flow in the oral cavity, the SV node organizes those features associated with sonorant segments such as nasals, laterals etc., and the Place node organizes place features. Rice and Avery (1995) assume that redundant information does not exist in the underlying representation, i.e. the abstract phonological representation of segments.

The significance of this assumption is that the unmarked features are default features, which do not play a role in the phonology. For example: under the SV node, the feature nasal is unmarked, thus a prototypical nasal consists of the SV node only (and the relevant place of articulation). This is shown in the above figure by the parentheses around the feature. Figures (3) and (4) present a few examples of the prototypical representations of several consonants (Rice and Avery 1995)

(3) Prototypical representations of stops at three places of articulation



(4) Prototypical representations of the sonorants /n/ and /l/



The stops and the sonorants differ in that the sonorants include the SV node. The segments /t/, /n/, and /l/, do not have a coronal node, since it is the unmarked feature, thus receive one by a default rule. At the same way the unmarked segment /p/ receives labial by a default rule, and is thus represented as a having a Peripheral node only.

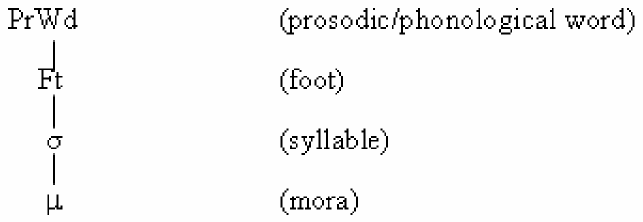
The segments' structure thus encodes constituency (or organizing nodes), and markedness (absence of unmarked features in the underlying representation).

### 1.1.2. The prosodic units and their hierarchical organization

Prosodic or suprasegmental structure includes the elements of linguistic structure that help organizing the segments. The prosodic level of phonology consists of structural elements, such as syllables, prosodic words, and phrases, which determine phonological properties such as stress and rhythm.

Studies in prosodic phonology identify hierarchical prosodic domains in language, both at the level of the word and at the higher phrasal and utterance levels (Selkirk 1984, Nespor and Vogel 1986). Since our study is concerned with the word level (and not beyond it), our discussion will focus primarily on word-level and the units below. The prosodic hierarchy, as proposed in Selkirk (1984) and Nespor and Vogel (1986), assumes the following dominance relations among the prosodic units.

(5) The prosodic hierarchy of words



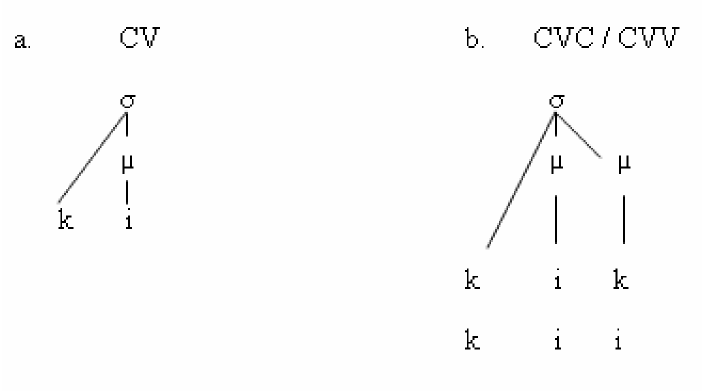
The prosodic hierarchy as shown above is composed of hierarchically organized prosodic units. According to the prosodic hierarchy, phonological words are composed of feet, feet are composed of syllables, and syllables may be composed of sub-syllabic units called moras. The phonological units of the prosodic hierarchy are discussed in detail in the following sub-sections.

### 1.1.2.1. The Mora

The mora is the lowest level in the prosodic hierarchy. It is a sub-syllabic unit representing the notion of syllable weight, thus constitutes the rhyme of a syllable. Light syllables have one mora (6a), while heavy syllables have two moras (6b) (Hyman 1985, Hayes 1986). Languages differ in which segments they regard as moraic. Universally, vowels are associated with moras (Hayes 1995). Short vowels are associated with one mora, whereas long vowels and diphthongs are associated with two moras. In English, as in many other languages, the coda consonant is also associated with a mora. In other languages (such as Swahili and Sesotho), it is not

(Hayes 1989, Tranel 1991). In Hebrew the mora is not relevant, since there is no evidence for the significance of the syllable's weight. However, as shown in §7.3.2, the early stages of coda development, where a missing coda is compensated by a long vowel, suggest reference to a mora.

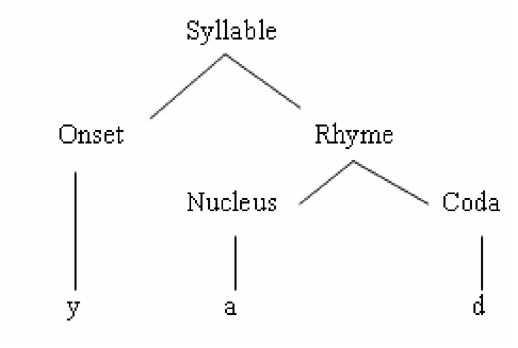
(6)



### 1.1.2.2. The Syllable

Reference to sub-syllabic units regardless of the mora assumes the traditional representation of syllable structure given below for the Hebrew word *yad* 'hand'.

(7) The structure of a syllable



The syllable is generally thought to consist of three main constituents: the onset, the nucleus, and the coda, where the latter two are dominated by the rhyme. The *nucleus* is essential unit of the syllable. The nucleus, which is considered to be the *syllable peak*, may consist of a vowel or diphthong or, in some languages a nasal consonant, a liquid such as [l] or [r] (e.g. English), or even an obstruent such as [t] or [s] (e.g. Berber). Languages prefer vocalic nuclei, and therefore a language may have only vocalic nuclei, or vocalic and consonantal, but no language has only consonantal nuclei. This preference follows the sonority scale given in (9) below.

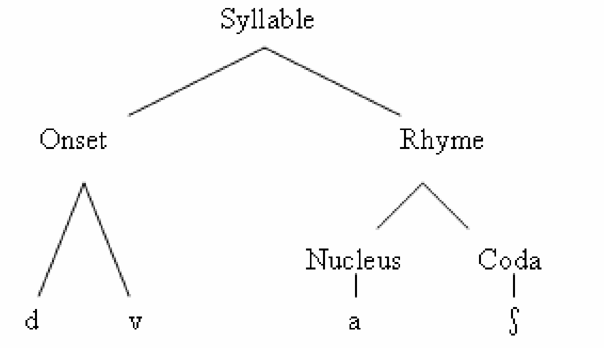
Syllables may contain a consonant (or consonants) to the left of the nucleus, which are referred to as the onset. The onset is obligatory in some languages (e.g. Arabic) and optional in others (e.g. Hebrew). Languages prefer syllables with onset, such that these are languages where all the syllables have an onset (obligatory), and others where some syllables have an onset and others do not (optional). However, there are no languages with only onsetless syllables.

A consonant (or consonants) to the right of the nucleus is referred to as the coda. Languages prefer syllables without a coda, such that these are languages where all the syllables have no coda (obligatory), and others where some syllables have a coda while others do not (optional).

Syllabic structure is determined language specifically, although some aspects of this structure are universal and found in all languages. For examples, as noted above, all languages have onsets, but not all languages permit codas, thus syllables with codas are considered to be marked while syllables with onsets are considered to be unmarked (Clements and Keyser 1983). Further, as in figure (8), onsets (a) and codas (b) may involve a complex branching structure, thus generating consonant clusters.[2]

(8) Syllabic structure

a. Syllabic structure of the word *dvaʃ* 'honey' (complex onset)



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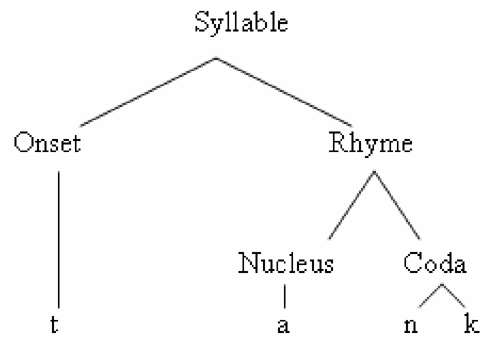
[2] A complex nucleus is also a possible structure in many languages such as English and Dutch, and it is achieved by long vowels or diphthongs. However, since vowel length, like diphthongs, is not contrastive in Hebrew, it will not be discussed in the current study.

b. Syllabic structure of the word *tank* 'tank' (complex coda)



Complex syllable margins (onset and coda) are marked, such that some languages do not allow it (e.g. Standard Arabic). In addition, not all sequences of segments may appear in such structure.

When onsets or codas occur in a syllable, particularly in branching structures, they are governed by a higher order property of language known as the *Sonority Sequencing Principle* (Steriade 1982, Clements 1990). Sonority refers to a resonant property that corresponds with the degree of constriction. The Sonority Sequencing Principle states that the sonority rises from the syllable edges towards the nucleus, i.e. the onset segments of a syllable maximally rise in sonority towards the nucleus, and coda segments fall in sonority away from the nucleus. In other words, the segments of a syllable are arranged in sequence, from the most constricted to the most unconstricted as they reach the vowel peak, and following the peak, the sequence is the reverse (Hooper 1976, Lowenstamm 1981, Steriade 1982, Clements 1990, Kenstowicz 1994).

The Sonority Sequencing Principles derives from the *sonority hierarchy*. It is a ranked-ordering of the sonority values of sound classes on a numerical scale. The sonority hierarchy from the most to the least sonorous segments is presented below.

(9) The sonority hierarchy

Low vowels > high vowels> glides> liquids> nasals> voiced fricatives
> voiceless fricatives> voiced stops> voiceless stops

This scale can be applied to any given language to calculate the difference in sonority between sequences of segments, though many languages do not show evidence to the details of the scale.

The most harmonic syllable is the one with the most sonorous rhyme and the least sonorous onset, i.e. the onset of a syllable should be less sonorous than the final segment of the preceding adjacent syllable, and the sonority slope between these two segments should be the greatest, in order to achieve maximal contrast between syllables.

Below (10) is the typology of syllable position with respect to sonority values:

(10) a. Onset: Stop > Fricative > nasal > Liquid > Glide
b. Coda: Glide > Liquids > Nasal > Fricative > Stop

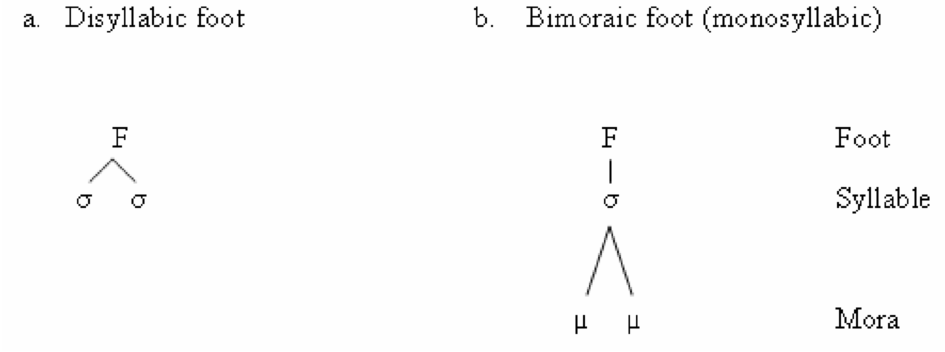
The relation between the moraic structure of syllable (6) and the more traditional structure in (7) minimally varies among languages.

In some languages the coda is moraic, and a CVC syllable is thus bimoraic (e.g. English, Arabic). In other languages only CVV syllables are bimoraic, while a CVC is monomoraic (e.g. Swahili, Sesotho) (McCarthy 1979). Moreover, in a few languages some segments in coda position are non-moraic, while others are moraic, usually sonorants, which are cluster to vowels on the sonority scale (e.g. Spanish) (Hyman 1985).

### 1.1.2.3. The Foot

Syllables are dominated by feet. It is assumed that the unmarked foot is binary either on the syllable level (11a) or moraic level (11b).

(11) Disyllabic and bimoraic feet

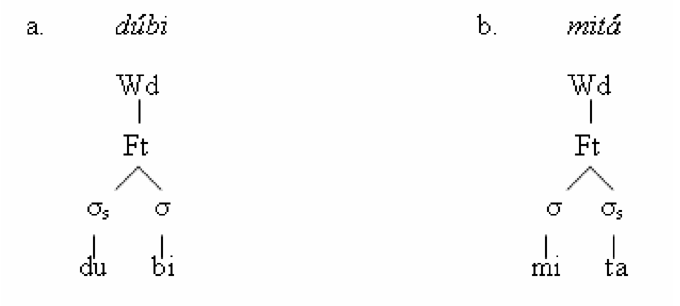


a. Disyllabic foot b. Bimoraic foot (monosyllabic)

A binary foot contains a strong and a weak positions, reflecting the rhythmic pattern of the language. Feet can be iambic, where the strong (stressed) syllable is the rightmost one (e.g. *mitá* 'bed'), or trochaic, where the strong (stressed) syllable is the leftmost syllable (e.g. *dúbi* 'teddy bear'). A monosyllabic foot (i.e. a degenerate foot) appears mostly in words with an odd number of syllables and exhaustive footing, i.e. when all the syllables in a word are parsed into feet ([σ] [σσ] or [σσ] [σ]).

Figure (12) demonstrates the structure of the trochaic foot of the word *dúbi* 'teddy bear' (a), and the iambic foot of the word *mitá* 'bed' (b). Subscript "s" indicates the strong syllable in a foot, while weak syllables are not marked.

(12) Trochaic and iambic feet



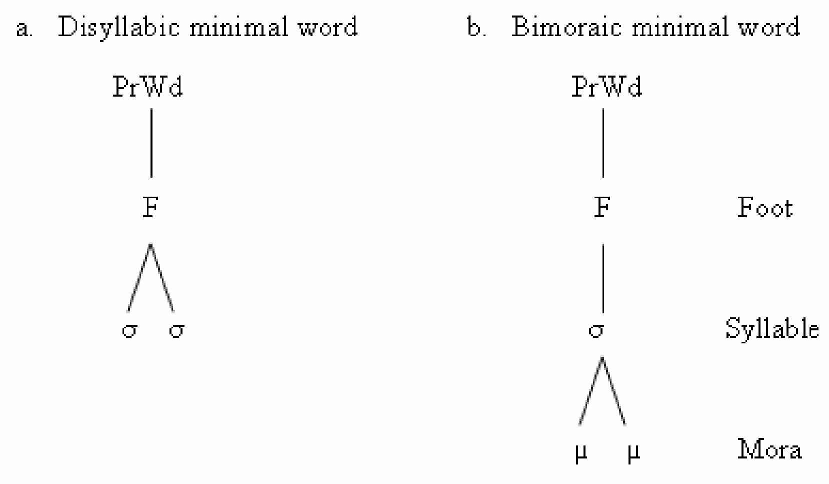
a. *dúbi* b. *mitá*

Allen and Hawkins (1980) claim that the foot structure in a child's speech reflects that in his/her target language. Thus, children acquiring English exhibit a trochaic foot while children acquiring French exhibit an iambic foot (see Rose 2002). Hayes' (1995) study of foot typology suggests that in quantity insensitive languages, i.e. languages in which syllable weight does not play a role in the stress system (like Hebrew), the unmarked foot is trochaic.

### 1.1.2.4. The Prosodic Word

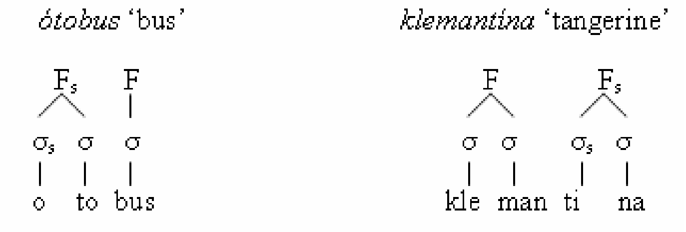
Feet are linked to a prosodic word. The prosodic word represents the highest level of the prosodic hierarchy relevant to our discussion. Words must contain at least one foot, and since feet are usually binary (13), the minimal word contains two syllables (a) or two moras (b) (McCarthy and Prince 1986, 1990, 1991).

(13) The minimal words



A prosodic word has only one primary stress. It may dominate one or more feet, but only one of these feet is strong, the foot dominating the primary stressed syllable. Below is a demonstration of the prosodic structure of two Hebrew words (secondary stress, associated with a strong syllable in a weak foot, is ignored).

(14)



The prosodic hierarchy, in conjunction with the principle stating that feet are binary, predicts that the minimal size of the prosodic word is the syllabic (or moraic) foot (McCarthy and Prince 1986, 1990, 1991). Indeed, this restriction is seen in the content words of many languages (function words, which are not independent prosodic words, are thus exempt). In English, for example, we find bimoraic words like ti:k ‘teak’, tɪk ‘tick’, ti: ‘tea’, but not monomoraic content words like *tɪ. The minimal word plays a major role in the course of acquisition. There is a stage during the prosodic development, where the maximal (though not necessarily minimal) size of the child’s words is a binary foot, either monosyllabic bimoraic (CVC or CVV) or disyllabic (Fikkert 1994, Demuth and Fee 1995 and Demuth 1995, 1996b for Dutch and English, Garrett 1998 for Spanish, Demuth 2003 for French, Ota 1998 for Japanese, Ben-David 2001 and Adam 2002, 2003 for Hebrew).

### 1.2. Modern Hebrew Phonology

Modern Hebrew (also known as Israeli Hebrew and Ivrit) is the first language for the native Jewish population in Israel, and the second language for the native Arab population and the new immigrants. It consists of two major ethnic dialects: the first is known as Sephardic and is used by Jews of African-Asian descent and the second is known as Ashkenazi, and is used by Jews of European-American descent.

Modern Hebrew belongs to the Northwest Semitic sub-branch of the Afro-Asiatic language family. Its morphology is characterized by the Semitic type non-concatenative structure, especially in the verbal system (Bat-El 2002). However, since the children in the study do not yet exhibit morphological paradigms, the morphology of Hebrew is not relevant here.

In this section, I briefly describe the phonological patterns in Modern Hebrew, focusing on the segmental and the prosodic units of the Hebrew phonological system parallel to §1.1.

#### 1.2.1 The segmental inventory

The Semitic affiliation of Hebrew is manifested mainly in its morphology. Its phonology, in particular its segmental inventory and more so the syllable structure, does not display typical Semitic characteristics.

(15) Modern Hebrew consonants (Berman 1978, Laufer 1992)

|  | Bilabial | Labi-dental | Dental-alveolar | Palato-Alveolar | Palatal | Velar | Uvular | Pharyngeal | glottal |
|---|---|---|---|---|---|---|---|---|---|
| Stops | p b |  | t d |  |  | k g |  |  | ʔ |
| Fricatives |  | f v | s z | ʃ ʒ$^1$ |  | x | ʁ$^3$ | ħ$^2$ ʕ$^2$ | h |
| Affricates |  |  | c | č$^1$ ǰ$^1$ |  |  |  |  |  |
| Nasals | m |  | n |  |  |  |  |  |  |
| Liquids |  |  | l |  |  |  |  |  |  |
| Glides |  |  |  |  | y |  |  |  |  |

[1] The symbol *c* represents the voiceless dental-alveolar affricate *t͡s*, the symbol *č* represents the voiceless palato-alveolar affricate *t͡ʃ*, and the symbol *ǰ* represents the voiced palato-alveolar affricate *d͡ʒ*
The consonants *ʒ,č,ǰ* occur in loan words (e.g. *gaʁáʒ* 'garage', *čips* 'potato chips', *ǰiʁáfa* 'giraffe'), and may also result from voicing assimilation (e.g. *xeʒbón* 'mathematics'), see §1.2.4.1.

[2] The consonants *ħ* and *ʕ* occur in the speech of some Sephardic pronunciations (i.e. Jews of Yemenite descent). See discussion below. However, none of the children in the study adopted the /ʕ/ pronunciation, while the /ħ/ was pronounced by two children during a transitional stage before producing /x/ (see the segmental inventory of children A1 and A6 in the Appendix 8a).

[3] There is a disagreement whether the Israeli rhotic is a uvular fricative /ʁ/, a velar fricative /ɣ/, or a uvular trill /R/ (Chayen 1973, Ornan 1996, Schwarzwald 1985). Laufer (1984, 1992) and Bolozky (1972) claim that it is a liquid consonant, either a sonorant approximant, or a uvular trill. In my study, I will use the uvular fricative /ʁ/.

There are five phonemic **vowels** in Modern Hebrew: /i, e, a, o, u/. Phonetically, only *o* is tense, but this is not phonologically significant.

(16) The vowels in Modern Hebrew (Berman 1978)

| | Front | | Back |
|---|---|---|---|
| High | i | | u |
| | e | | o |
| Low | | a | |

Bolozky (1999) argues that the Hebrew *e* may be characterized as a phonetically unmarked vowel, or a "minimal" vowel in his terms. He explains that it is minimal in that it is the vowel most likely to split phonotactically 'impermissible' consonant clusters, i.e. it is the default epenthetic vowel, and the first to undergo elision facilitating pronunciation. It is used to split up unpronounceable consonant cluster (e.g. *avá**d*** +***ti*** 'I worked' → *avá**det**i*; cf. *katá**v**+**ti*** 'I wrote' → *kata**vt**i*), to split up identical consonants (e.g. *za**lel**án* 'glutton'; cf. *ka**mc**án* 'miser'), and also to split up clusters that would have violated the sonority hierarchy (e.g. ***yl**adím* 'children' → ***yel**adím;* cf. ***kl**avím* 'dogs').

While *e* is considered to be the "minimal" vowel of Hebrew, *a* is the most prominent vowel. Acoustic analyses indicate that among the five vowels in Hebrew, the *a* has the longest duration. This finding is reported in Amir's study (1995), who examined the acoustic features of the vowels of Modern Hebrew speakers (males and females adults as well as pre-adolescent boys and girls). He found a correlation between vowel height and vowel duration: the lower the vowel, the longer the duration. Thus, the vowel *a* was found to be distinctively longer than the other four vowels. This finding was found for all the subjects: adults and pre-adolescent speakers, males and females.

Also, *a* is the most sonorous vowel of the five, it is the least marked phoneme in the five-vowel system (Bolozky 1999), and is also by far the most frequent vowel in the language (Plada 1958/1959, Bolozky 1990).

Vowel length, a historically significant feature of Biblical Hebrew phonology, is not contrastive in Modern Hebrew. That is, the phonological distinction between long and short vowels (or alternatively tense and lax vowels) is lost, and all five vowels of Modern Hebrew (see table (16) above) are pronounced in a manner close to their tense, cardinal-vowel counterparts.

Although vowel length is not a phonemic feature in Modern-Hebrew, vowels are generally lengthened under stress or in word-final position. Moreover, in rapid speech, these five vowels, if unstressed, may even be reduced to schwa.

**Diphthongs** are infrequent in Hebrew. The most common are *ui* (e.g. *banúi* 'built', *macúi* 'found', *kalúi* 'toasted'), and *ei* (e.g. *tei* 'tea', *axʁéi* 'after', *ein* 'there is no'). However, *ei* is often pronounced as *e* by some of the speakers (i.e. *te*, *axʁé*, and also *en)* (Plada 1958/1959). Other diphthongs are *ai* (e.g. *banái* 'builder', *dai* 'enough'), and *oi (*e.g. *noi* 'beauty'). I adopt Laufer's (1990) claim that diphthongs in Hebrew consist of sequence of a vowel plus a glide. This is supported by the fact that the glide holds a prosodic position otherwise occupied by a consonant. For example, in the pattern CaCuC, the final C can be either a consonant (e.g. *katúv* 'written') or a glide (e.g. ʁ*acúy* 'desirable'). *uy* appears mostly in this pattern; while *ay* appears as an agentive suffix (e.g. *banáy* 'builder').

### 1.2.2. The prosodic units

The inventory of prosodic structures found in Hebrew is relatively restricted.
My main concern in this chapter is the prosodic structure of words in terms of the syllable structure, number of syllables, and the stress pattern.

### 1.2.2.1. Number of syllables and stress patterns

Most Hebrew words consist of two to four syllables, but, as shown in (17), the language includes structures that vary from minimal monosyllabic to quadrisyllabic words. Five and six syllable words are mainly loan words (e.g. *kaʁikatúʁa* ‘caricature’, *tʁigonométʁiya* ‘trigonometry’) and a few native suffixed words (e.g. *maʃmautiyót* ‘significant fm.pl.’).

As for the stress pattern, most Hebrew nouns have either ultimate or penultimate stress with a great degree of lexicalization (Bat-El 1993, Melčuk and Podolsky 1996, Graf 2001). Antepenultimate stress exists in loan words, and it is much less common. Section 1.2.3 describes the stress system of Hebrew.

Table (17) below presents examples of nouns with a different number of syllables and with different stress patterns.[3]

(17) Number of syllables and stress

| Number of Syllables | Stress pattern | | | | | |
|---|---|---|---|---|---|---|
| | Ultimate | | Penultimate | | Antepenultimate | |
| 1σ | yad | ‘hand’ | | | | |
| | mic | ‘juice’ | | | | |
| 2σ | yaldá | ‘girl’ | óto | ‘car’ | | |
| | xamóʁ | ‘donkey’ | dúbi | ‘teddy bear’ | | |
| 3σ | ugiyá | ‘cookie’ | maxbéʁet | ‘notebook’ | télefon | ‘phone’ |
| | kubiyá | ‘cube’ | miʃkéfet | ‘binoculars’ | ótobus | ‘bus’ |
| 4σ | melafefón | ‘cucumber’ | mixnasáim | ‘trousers’ | siméʈʁiya | ‘symmetry’ |
| | ipopotám | ‘hippopotamus’ | ofanáim | ‘bike’ | kosmétika | ‘cosmetics’ |

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[3] The prosodic structure of Hebrew verbs is much more restricted than that of nouns. This is manifested in the number and type of syllables as well as in the stress pattern. However, since the verbs are not relevant to the current study, the prosodic characteristics of the Hebrew verbal system is not discussed here (see Adam 2002).

### 1.2.2.2. Syllable structure

The most common syllables in Hebrew are **CV** (e.g. *bu.bá* ‘doll’, *me.lu.ná* ‘kennel’) and **CVC** (e.g. *ba.lón* ‘ballon’, *max.bé.ʁet* ‘notebook’).

There are also **VC** structures, i.e. syllables without onsets (e.g. *od* ‘more’*, ax.báʁ* ‘mouse’), and consonant-free syllables lacking both an onset and a coda i.e. **V** (e.g. *í.ne* ‘here’*, o.fa.ná.im* ‘bike’, *a.ga.lá* ‘cart’, *ʃa.á* ‘hour’).

Hebrew permits complex onsets, mostly biconsonantal in word-initial position (e.g. *dli* ‘bucket’, *glída* ‘ice cream’, *ʃlulít* ‘puddle’) (Rosen 1973, Bolozky 1972, 1978, Bat-El 1989). In fact, Modern Hebrew allows a wide variety of clusters in onset position, as long as they do not violate the sonority scale (Bolozky 1972, 1978, Laufer 1991, Bat-El 1994). Tri-consonantal clusters are rare, appearing only in loan words (e.g. *spʁey* ‘spray’, *ʃpʁic* ‘squirt’). In such cases, the first consonant is typically a sibilant (Laufer 1992).

Complex codas are rather rare, appearing mostly in loan words (e.g. *ta**nk*** ‘tank’, *ba**nk*** ‘bank’), and in the past tense feminine singular form of verbs, where the final segment is a suffix (e.g. *yaʃá**nt*** ‘you slept fm.sg.’, *halá**xt*** ‘you went fm.sg.’). Words with three consonants in coda position are even rarer, and once again, are in loan words (e.g. *tekst* ‘text’). Since complex codas are rare in Hebrew, they are ignored in the current study.

All of the consonants in table (15) above may appear in onset position. However, due to spirantization in Tiberian Hebrew (the source of most native words) (see §1.2.4.2. below), there are only a few word-initial *v* and *f*. They can be found in loan words (e.g. *fízika* ‘physics’, *fonétika* ‘phonetics’, *viʁtuáli* ‘virtual’), as well as in truncated imperatives (e.g. *ftax* ‘open! ms.sg.’) (Bat El 2002).

As mentioned above, Modern Hebrew has onsetless syllables, such as *oʁ* ‘light’, *ma.éʁ* ‘fast’, *ó.to* ‘car’, and *na.a.lá.im* ‘shoes’. In careful speech, a glottal stop /ʔ/ and, to a lesser extent, a glottal fricative /*h*/ might appear in the onset (*ʔoʁ, ma.héʁ/ma.ʔéʁ, ʔó.to, na.ʔa.lá.ʔim)*. In the current study, the transcription does not include the glottals, unless there is no doubt that the child produces it.

A simple coda is a common component in the syllable structure of Modern Hebrew without special constraints on the consonants appearing in this position (except *ʔ,ħ,ʕ*). Even so, following the postvocalic spirantization (§1.2.4.2), the stops *p* and *b* are infrequent and appear mostly in loan words (e.g. *ǰip* ‘jeep’, *pab* ‘pub’).

### 1.2.3. The stress system

Stress in Hebrew nouns is mostly ultimate or penultimate (Berman 1978, Bat-El 1993, Graf 2001, Becker 2003).[4]

There are two types of stress behavior, mobile and lexical (Bat-El 1993, Melčuk and Podolsky 1996, Graf 2001). Nouns with mobile stress are mostly native. Here, stress shifts to the end when a suffix is added. Within this group there are stems with ultimate stress (e.g. *gamád* - *gamadím* ‘dwarf sg.-pl.’), and others with penultimate stress (e.g. *náxal* - *nexalím* ‘river sg.-pl.’). Lexical stress, characterizing mostly loan nouns and acronym words, remains in the same position on the stem when a suffix is added (e.g. *magád* - *magád-im* ‘commander of a regiment sg.- pl.’, *mankál* - *mankál-im* ‘general director sg.-pl.’). Lexical stress can be ultimate (e.g. *idiót* ‘idiot’) penultimate (e.g. *léyzer* ‘laser’) and antepenultimate (e.g. *télefon* ‘phone’, *ótobus* ‘bus’, *ámbulans* ‘ambulance’), where the latter may optionally shift two syllables to the right when a suffix is added (e.g. *télefon* - *télefon*im ~ *telefónim* ‘phone sg.-pl.’, *ótobus* - *ótobusim* ~ *otobúsim* ‘bus’ *sg.*-pl.’).

Given that stress can be lexical, it may function in distinguishing between segmentally identical unrelated words (e.g. *bíʁa* – *biʁá* ‘beer-capital city’), as well as related ones (*ʁíʃon* –*ʁiʃón* ‘city-first’) (Schwarzwald 1991). In addition, proper names often exhibit variable stress (e.g. *xána* ~ *xaná* and also *dávid* ~ *davîd)* (Bat-El 2005).

Secondary stress is observed in trisyllabic forms with ultimate primary stress (e.g. *à.ga.lá* ‘cart’, *mìt.ʁi.yá* ‘umbrella’), and in forms with four syllables with penultimate primary stress in the following pattern (e.g. *tè.le.vîz.ya* ‘television’, *klè.man.tî.na*

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[4] Since the children in this study did not produce verbs, I confine the discussion on stress to nouns (see Graf and Ussishkin 2001 for stress in the verb paradigm).

‘Clementine’) (Bolozky 1982, Ussishkin 2000). Thus, stress plays a direct role in the determination of foot construction as stress (both primary and secondary) implies one foot (i.e. .[σ̣̀σ̣][σ́] and [σ̣̀σ].[σ̣́σ]) (Ussishkin 2000). However, Becker (2003) claims that there is no acoustic evidence for secondary stress in Hebrew, though this does not necessarily implies that it does not have a rhythmic function in the language.

### 1.2.4. Phonological processes

In this section, I present a brief review of the phonological processes relevant for the present study.

### 1.2.4.1. Voicing Assimilation

The optional process of regressive voicing assimilation of Modern Hebrew, obligatory in rapid speech (also across words) is a general phonetic process, applying throughout the language. The following examples are of nouns, which are more relevant to the current study, but the process also exists in verbs.

(18) Voicing assimilation

| | | | | | |
|---|---|---|---|---|---|
| [géʃeʁ] | ‘bridge’ | [gʃaʁím] | ~ | [**k**ʃaʁím] | ‘bridges’ |
| [zakán] | ‘beard’ | [zkaním] | ~ | [**s**kaním] | ‘beards’ |
| [sagáʁ] | ‘closed’ | [sgiʁá] | ~ | [**z**giʁá] | ‘closing’ |
| [dakáʁ] | ‘stabbed’ | [dkiʁá] | ~ | [**t**kiʁá] | ‘stabbing’ |

There are two exceptions to the above process: the fricatives *x* and *v* are rather inconsistent with respect to voicing assimilation. *v* undergoes voicing assimilation (e.g. *hi***v***tíax* ~ *hi***f***tíax* ‘he promised ms.sg.’), while *x* rarely does, more so before a strident (e.g. *e***x***zíʁ* ~ *e***ʁ***zíʁ* ‘returned ms.sg.’) than before a stop (e.g. *yi***x***bóʃ* ~ *yi***ʁ***bóʃ* ‘will conquer ms.sg.’) (Bolozky 1978, 1997). This is probably because the voiced counterpart of *x* is not exactly a fricative (see table 15 note 3). *x* is, however, a regular trigger of assimilation (e.g. *hi***d***xík* ~ *hi***t***xík* ‘to repress ms.sg.’), while *v* is problematic in this respect. Until quite recently, *v* failed to trigger voicing assimilation (Barkai and Horvath 1978), probably under the influence of Russian. However, nowadays this irregularity is slowly being eliminated, and more and more speakers, in particular the younger ones, optionally produce ***k***_vaʁ_ ~ ***g***_vaʁ_ ‘already’, and ***k***_viʃ_ ~ ***g***_viʃ_ ‘road’ (Bolozky 1978, 1997), thus, eliminating the inconsistency, at least with respect to *v*.

#### 1.2.4.2. Spirantization

Hebrew exhibits a stop-fricative alternation know as spirantization, though its regularity is quite limited (Schwarzwald 1976, Ravid 1991, Adam 2002). Out of the six stops that alternate with fricatives in post-vocalic Biblical Hebrew (i.e. *p, b, t, d, k, g*), only three do so in today’s Hebrew (i.e. the alternation of *p, b,* and *k* with the fricatives *f, v*, and *x* respectively) (e.g. *maa**b**óʁet* - *a**v**áʁ* ‘ferry/passed’, *his**k**íʁ* - *sa**x**áʁ* ‘let/ rented’, ***p***_ésel_ - *me**f**asél* ‘sculpture/ is sculpting’). The alternation between stops and fricatives is motivated according to Adam (2002) by their prosodic position.

Modern Hebrew spirantization exhibits a great deal of opacity accompanied by a wide range of variation (Adam 2002). Within the same environment, there are cases where the alternation occurs (e.g. ***p***_izéʁ_ - *ye**f**azéʁ* ‘to spread’ and *ki**b**és* – ye**x**abés ‘to launder’), and others where it does not occur (e.g. ***v***_itéʁ_ - *ye**v**atéʁ* ‘to give in’ *ki**p**él* – *yeka**p**él* ‘to fold’, and also *si**b**éx* – *yesa**b**éx* ‘to complicate’). In addition, fricatives may appear in non-postvocalic positions (e.g. ***f***_iʃél_ ‘to screw up’), and stops may appears in postvocalic positions (e.g. *si**p**éʁ* ‘to tell’).

Due to the opacity of spirantization, there is a great degree of variation, in word-initial position (***p***_izéʁ_~ ***f***_izéʁ_ but *ye**f**azéʁ* ~ **ye**p**azéʁ* ‘to spread’, ***b***_itél_ ~ ***v***_itél_ but *ye**v**atél* ~* *ye**b**atél* ‘to cancel’) and also in postconsonantal position (*yik**p**óc* ~ *yik**f**óc* but *ka**f**ác* ~ **ka**p**ác* ‘to jump’, *yik**b**óʁ* ~ *yik**v**óʁ* but *ka**v**áʁ* ~ **ka**b**áʁ* ‘to bury’, and also *yis**k**óʁ* ~ *yis**x**óʁ* but *sa**x**áʁ* ~ **sa**k**áʁ* ‘to rent’) (Adam 2002).

# CHAPTER 2: THE ACQUISITION OF PROSODIC STRUCTURE

Stages of the prosodic development are described in terms of the number of syllables, foot structure, and syllabic structure (i.e. onset and coda acquisition). In the acquisition process, children gradually increase the number of syllables in a word and produce syllables of a greater complexity (both in onset and in coda position) as their language develops. The following sections discuss the development of the prosodic word (§2.1), and the development of syllabic structure (§2.2), with emphasis on the onset (§2.2.1) and coda acquisition (§2.2.2).

## 2.1. The development of the prosodic word

According to Demuth and Fee (1995), the acquisition process of the prosodic word is divided into four major stages, each of which focuses on a particular level of the prosodic hierarchy (§1.1.2). Their analysis is based on data from Dutch-speaking children (Fikkert 1994) and English-speaking children (Demuth and Fee 1995).

During the first stage of prosodic word acquisition, core syllables are produced (§2.1.1). Demuth and Fee (1995) call this stage the Sub-Minimal Word stage, where early word forms are generally CV in shape. The following stage, the minimal word stage, is characterized by foot-sized words, either monosyllabic, bimoraic or disyllabic (§2.1.2). This stage is broadly discussed in the literature and is documented in various languages. The transition to the following stage (§2.1.3) is characterized by a word with two stressed syllables, i.e. two monosyllabic feet. At the end of this stage, however, the requirement that all feet have primary stress, is gradually relaxed, and children begin to produce only one stress per prosodic word, preferring disyllabic trochaic feet. Finally, prosodically well-formed Phonological Words start appearing.

The prosodic structure of Hebrew differs from that of Dutch and English, in particular in the absence of weight contrast and thus the irrelevance of the mora (see §1.1.2.1). The development of the prosodic word in Hebrew is thus provided (§2.1.4), based on studies of typically developed children (Ben-David 2001, Adam 2002).

### 2.1.1. Core Syllables

During the initial stage of word acquisition, children produce monomoraic CV forms, containing neither coda consonants nor contrastive use of vowel length (Fikkert 1994, Demuth and Fee 1995, Demuth and Johnson 2003). Demuth and Fee (1995) call this stage the Sub-Minimal Word stage, which is characterized by CV words.

Below are a few examples provided in Fikkert (1994) (a-c) and Demuth and Fee (1995) (d-f):

(19) CV Core syllables

| | | Adult Target | | Child production |
|---|---|---|---|---|
| Dutch | a. | *klair* | ‘ready’ | *ka:, ka* |
| | b. | *da:r* | ‘there’ | *da:, da* |
| | c. | *pu:* | ‘poes’ | *pu:* |
| English | d. | *bʊk* | ‘book’ | *bʌ, bʊʔ* |
| | e. | *gərl* | ‘girl’ | *gʊ, gʊ:* |
| | f. | *bal* | ‘ball’ | *bo, ba, bo:* |

Core syllable words correspond mainly to monosyllabic targets, however, in some children’s productions they also correspond to disyllabic target words. Also, CVC forms are occasionally produced at this stage.

Johnson and Salidis (1996) report that core syllables were not dominant in Kyle’s speech (English); they comprised a substantial 41% of vocabulary produced at 11 months. The authors suggest that their presence at such a level implies that the child may have used the unmarked core syllables as a starting point in his prosodic development. As the percentage of subminimal words declines over the subsequent months, minimal words increase, peaking between 14 and 16 months. The characteristics of the minimal words are discussed in the following section.

### 2.1.2. Minimal Words

The minimal word stage is well documented in the literature and mentioned in many studies (Fikkert 1994, Wijnen, Kirkhaar and den Os 1994 – for Dutch, Demuth and

Fee 1995, Demuth 1995, 1996a, Johnson and Salidis 1996 – for English and Dutch, Garret 1998, Demuth 2001 – for Spanish, Demuth 2003 – for French, Ota 1998, 1999 – for Japanese, Demuth 1994 – for Sesotho, Ben-David 2001, Adam 2002 – for Hebrew). During this stage, children produce foot-sized words, either monosyllabic bimoraic or disyllabic. Fikkert (1994) describes these possibilities as sub-stages of the developmental process: during the initial period, the minimal words may surface as disyllabic forms [(C)VCV], while during the two further sub-stages, the minimal words can be bimoraic monosyllables containing coda (CVC) or long vowels (CVV) too. The children in her study made systematic use of coda consonants before they were able to consistently represent vowel length.

The minimal word is a dominant stage in the acquisition process. According to Ben-David (2001), it lasts longer than any other stage. This could be explained by the fact that the minimal word is the unmarked prosodic word (McCarthy and Prince 1986 and subsequent studies). The children hold on to the unmarked structure, while learning about language-specific properties such as stress pattern and syllabic structure. The transition to the higher levels is characterized by greater complexity of the syllabic structure, overgeneralization of stress placement, more attempts to react to larger phonological target words etc. (Demuth and Fee 1995, Demuth 1996a).

There is, however, inter-language variation in the characteristics of the minimal word stage: The minimal word is the minimal and the maximal word size in the acquisition of some languages (e.g. Dutch and English), while only the maximal word size in the acquisition of others (e.g. Hebrew, Japanese, and French). In order to fulfill the minimal word requirement, Dutch and English-speaking children both delete or insert a syllable or a vowel, thus creating a disyllabic foot (e.g. *pîsœ* for *pətrÎ ʃə* ‘Patricia’ *and pi:́ja:* for *be:r* ‘beer’). In contrast, Hebrew, Japanese, and French-speaking children preserve sub-minimal target words in their productions without inserting any unit into the word (*bo* ‘come! ms.sg’ for Hebrew, *me* ‘eye’ for Japanese, and *pa* for *pẽ* ‘bread’ for French). Moreover, the French-speaking child in Demuth and Johnson’s study (2003) exhibits an extended period of time during which she reduces disyllabic target words to subminimal CV after initially having produced them as reduplicated forms $C_1VC_1V$.

### 2.1.3. Beyond Minimal Words

During the next stage, words increase in complexity at both the syllabic and word levels. At the beginning of this stage, children stress each syllable of the foot equally as in the examples below (a-b). Quadrisyllabic targets are also constructed in this way (c-d). In all these examples (a-d), the children produce two feet with equally primary stress on each. Finally, children begin to permit unfooted syllables, in other words, they produce a binary disyllabic foot with monosyllabic unfooted syllable (e).

(20) Stress-Feet – Data from Dutch

| Adult Target | | Child production |
|---|---|---|
| a. *balɔ́n* | ‘balloon’ | *[pá][pɔ́m]* |
| b. *ko:nɛ́in* | ‘rabbit’ | *[ká][kɛ́in]* |
| c. *l̂i:mo:ná:də* | ‘lemonade’ | *[mî:mo:][má:tə]* |
| d. *l̂i:mo:na:də́* | ‘lemonade’ | *[mì:mo:][má:ta]* |
| e. *ko:nɛ́in* | ‘rabbit’ | *tɔ[tɛ́inə]* |

v́ = primary stress v̀ = secondary stress

The use of quadrangular brackets is to present feet’s organization

At the end of this stage, however, the requirement that all feet have primary stress, is gradually relaxed, and children begin to produce only one stress per prosodic word, preferring disyllabic trochaic feet. This stage is reported for Dutch and English-speaking children (Gerken 1991, 1994, 1996, Demuth 1995, Demuth and Fee 1995, Carter and Gerken 1998). It seems that at this stage (around the age 2-2:6 according to Fikkert 1994 and Demuth and Fee 1995), children become aware of stress patterns, trying to stress each syllable of the foot equally. It is only later that children begin to permit unfooted (extrametrical) syllables, showing a move towards a larger Phonological Words. At this point, the children are able to consistently replicate the prosodic structure of multisyllabic target words, though they still make many segmental errors. The authors report that between 2:8-3:0, children begin to consistently produce prosodically well-formed Phonological Words.

### 2.1.4. The development of the prosodic word by Hebrew-speaking children

Ben-David's (2001) longitudinal study presents several stages in the acquisition of the prosodic word in Hebrew. All 10 children in Ben-David's study produce monosyllabic as well as disyllabic words in their first ten words. During this **initial stage** (according to Ben-David, around age 1:2), they usually produce the final syllable in words with ultimate stress (e.g. *da* for *yaldá* 'girl'). When the target word has penultimate or antepenultimate stress, the children produce both the stressed and the final syllables of the target words (e.g. *îma* for *îma* 'mother', *nána* for *banána* 'banana', and also *téfo* for *télefon* 'telephone'). The children's outputs, whether monosyllabic or disyllabic, are faithful to both the stressed and the final syllables of the target. This is explained by their perceptual salience as opposed to non-final and/or unstressed syllables (Ingram 1974, Peters 1977, 1983, Echols 1987, Echols and Newport 1992). The initial stage in Ben-David's study is also reported by Adam (2002), who names it **the pre-Minimal Word phase**.

During the next stage (according to Ben-David, around 1:4), the children's outputs give evidence for **the Minimal word phase**, a stage in which for every polysyllabic input, regardless of stress pattern, a disyllabic word is the minimal and maximal prosodic word in the children's corpus. For target words with ultimate stress, the children produce the final syllable and the one adjacent to it (e.g. *giyá* for *ugiyá* 'cookie', *fefó* for *melafefón* 'cucumber').

During the next stage (according to Ben-David, around 1:8), children start producing three syllables of the target words (e.g. *ótobus* for *ótobus* 'bus', *ataná* for *mataná* 'gift'). For quadrisyllabic target words, the children produce only three syllables, usually deleting the first syllable of the word (e.g. *azîza* for *televîzya*, *tototám* for *ipopotám* 'hippopotamus').

During **the final stage** (according to Ben-David, around 2:2), the children produce all four syllables of the target words. Segmental errors, however, often occur.

Adam (2002) provides a similar description of the stages in the acquisition of the prosodic word in Hebrew. However, she reports an additional earlier stage, in which monosyllabic words correspond to mono- as well as disyllabic target words. During this early stage of development, the correspondence between the monosyllabic production and the disyllabic target words is not prosodically determined. In some words, the children produce the stressed syllable (e.g. *ba* for ***bá****mbi* ‘Bambi’), in other words they produce the final unstressed syllable (e.g. *ta* for *sáv***ta** ‘grandma’), while in others, they produce neither the stressed nor the final syllable i.e. the unstressed and non-final syllable (e.g. *ka* for ***ka****dúʁ* ‘ball’ and ***ka****pît* ‘teaspoon’). Adam’s (2002) findings indicate that the syllables the children produce are not always the prominent ones, i.e. the final or stressed ones, but those that contain the vowels *a* or *u* (e.g. *ba* for *balón* ‘ballon’, *ka* for *kadúʁ* ’ball’*, tu* for *tutîm* ‘strawberries). She proposes that at this initial stage of acquisition, children’s productions are affected by the vowel’s segmental features rather than by the prosodic structure of the word.

The developmental stages of the prosodic word according to Ben-David (2001) and Adam (2002) are presented in the table below.

(21) The developmental stages of the prosodic word of Hebrew-speaking children

| Stages | Input | Output |
|---|---|---|
| Initial stage | σ́ | σ́ |
|  | σσ | σ́ |
| Pre-minimal word | σ́ | σ́ |
|  | σσ́ | σ́ |
|  | σ́σ | σ́σ |
| Minimal word | σ́ | σ́ |
|  | σσ́ | σσ́ |
|  | σ́σ | σ́σ |
| Pre-final stage | σσ́ | σσ́ |
|  | σ́σ | σ́σ |
|  | σσσ | σσσ |
|  | σσσσ | σσσ |
| Final stage | σσσ | σσσ |
|  | σσσσ | σσσσ |

## 2.2. The development of the syllable

It is usually claimed that the universally unmarked syllable is CV. It has been shown that CV is the preferred syllable in the early development of many languages, such as English (Ingram 1976, Salidis and Johnson 1997), Dutch (Fikkert 1994, Levelt and Van de Vijver 1998), French (Demuth and Johnson 2003), Greek (Kappa 2002), various dialects of Spanish (Macken 1978, Goldstein and Citron 2001), as well as in Hebrew (Ben-David 2001). All these studies report that children start speech production with consonant initial syllables followed by a single vowel in the nucleus.

Levelt et al. (1999/2000) describe the steps in the development of syllables types of their 12 Dutch-speaking children as follows: CV → CVC → V → VC
Only during the later stages do complex syllables start appearing (CCV, CCVC, CVCC, VCC and also CCVCC). Moreover, during the initial stages of acquisition, children insert a consonant in target words without onsets, thus producing a CV structure (e.g. *tóto* for *óto* 'car', *tápi* for *ápi* 'monkey'). However, Costa and Freitas (1998) and Freitas (1999) argue that the unmarked syllable of Portuguese children is not necessarily CV, but rather it can also be a V syllable. Theses findings are also supported by similar data for German (Grijzenhout and Joppen 1999), English (Menn 1971), Puerto-Rican Spanish (Goldstein and Cintron 2001), as well as for Hebrew (Ben-David 2001). Ben-David (2001) reports that after CV structure, VC syllables appear while syllables of the type CVC or CCV(C) are acquired later. However, both Ben-David (2001) and Adam (2002) claim that V syllables without a consonant do not exist in the production of their Hebrew-speaking children in monosyllabic target words. The children preserved the consonant in final position, thus preferring VC structures (e.g. *af* 'nose', *od* 'more', *en* 'none' – see discussion in §2.2.2.1 and §6.3.1).

### 2.2.1. The development of the onset

#### 2.2.1.1. Onset: Prosodic effects

As mentioned above, during the initial stage of acquisition, simple onsets are the unmarked preferred unit in many languages. Moreover, in some studies children fill targets' empty onsets with segmental material, thus producing the universally unmarked CV syllabic structure (Cruttenden 1978, Fikkert 1994, Lleo 1996). However, in other languages, such as English, Spanish, Portuguese, and German children leave the onset empty, staying faithful to the target (*a:gə́* for *ágwa* 'water', *adî* for *akî* 'here', Freitas 1999), or even delete the onset of the first syllable leaving it empty (*égo* for *légo* 'Lego', *alón* for *balón* 'balloon', Ben-David 2001).

In Fikkert's study (1994), all the possibilities presented above are described as parts of a developmental process which consists of three stages: during the first stage, onsets are obligatory, during the next stage, onsets can be empty, and finally other types of onset occur. She maintains that some children "skip" stages and therefore do not show the predicted patterns.

The transition from monosyllabic to disyllabic word production is characterized by adding the nucleus of the adjacent syllable at the left edge, leaving the onset of the initial syllable empty (e.g. *ba~ubá* for *bubá* 'doll', Ben-David 2001). Only after a short period does an onset appear (e.g. *ubá~bubá* 'doll'). This phenomenon also characterizes the transition from disyllabic to trisyllabic words (§6.1.3.2).

Bernhardt and Stemberger (1988) raise the question whether an onset is an obligatory element in the speech of the child. They claim that onsets are a part of the optimal syllable in the speech of young children. For some children, onsets are an obligatory part of the syllable, thus leading to epenthesis, for others they are not.

#### 2.2.1.2. Onset: Segmental effects

There is a relation between the segment's position in the syllable and its sonority level. Studies show that there is a preference for non-sonorant segments in the onset position (Clements 1990). This claim is supported in both child and adult language

(Jakobson 1968, Stemberger 1996, Pater 1997, Bernhardt and Stemberger 1998, Kager 1999). Jakobson (1968) as well as others reports that children start with plosives in onset position. The first contrast to appear is that between a vowel and a consonant, a plosive being the prototypical consonant. In this case the contrast is maximal: complete closure for plosives and a wide opening for the vowel. There is also a maximum rise in the sonority slope from the plosive (in onset position) towards the vowel (Clements 1990). The plosive, thus, is an optimal syllable onset.

Fikkert (1994) finds in her study, that during the first stage of onset acquisition, i.e. obligatory onset (see §2.2.1.1), the onset is invariably a plosive. During the next stage other types of onset start appearing. An onset can be a nasal or even an *h*. The same findings are reported in other languages for typically developed children (Fikkert 1994 - for Dutch, Freitas 1996 - for Portuguese, Barlow and Gierut 1999 - for English, Ben-David 2001 - for Hebrew, Kappa 2002 - for Greek, and Grijzenhout and Joppen (to appear) - for German) and for those with abnormal development (Tubul 2005 - for dyspraxic Hebrew speaking children).

#### 2.2.1.3. Complex onset

Complex onsets (clusters) are acquired rather late in all languages. McLeod et al. (2001) summarize the stages of cluster acquisition:

1. Deletion of both segments (e.g. *u* for 'blue').
2. Production of one of the cluster's segments (e.g. *bu* for 'blue').
3. Both segments are marked in some way (e.g. *bwu* for 'blue').
4. Both segments are used correctly (e.g. *blu* for 'blue').

Production of only one of the cluster's segment is the longest stage; however, there is controversy with regard to which element of the consonant cluster is preserved. Several recent investigations of the development of word initial clusters in West Germanic languages have demonstrated that the relative sonority of adjacent consonants plays a role (Fikkert 1994, Gilbers and Den Ouden 1994, Chin 1996, Barlow 1997, Barlow and Dinnsen 1998, Bernhardt and Stemberger 1998, Gierut

1999, Ohala 1999, Barlow 2001, Kappa 2002). These authors have argued that, for a number of children, during the stage in development when only one member of the cluster is produced, the segment with lower sonority values is the preferred element to be preserved, creating a maximal rise in sonority towards the nucleus (Clements 1990).

Goad and Rose (2001), however, argue for a second pattern of cluster reduction, which they call a **head pattern** as opposed to the **sonority pattern** discussed above.[5] The head pattern is characterized by the reduction of a cluster to the head of the target structure, which does not necessarily correspond to the least sonorous segment of the string. For example, *lʌg* for ‘slug’, *mɔ:* for ‘small’, and also *ni:d* for ‘sneezed’. In all these examples, the constituent head is the second member of the cluster, and it is this consonant that survives, regardless of its relative sonority. The authors claim that there is variability among children in the course of these two patterns. They call these children head pattern children as opposed to sonority pattern children. The latter pattern is perhaps most commonly attested, thereby accounting for the fact that many investigators have remarked on the role of sonority in cluster reduction.

Pater and Barlow (2003) argue for another cluster reduction pattern, based on manner and place of articulation. They report that sometimes children favor deletion of fricatives and velars, which, in some circumstances, may conflict with a sonority-based choice. They anchor their claim on principles of Optimality Theory, i.e. the ranking of universal constraints, which determines which consonant is retained. The children in their study delete the fricative rather than the sonorant segment (e.g. *nek* for ‘snake’), as well as the dorsal (i.e. *jʌ:* for ‘glove’). A preference for a labial place of articulation can also play a similar role.

Other, less frequent phenomena in the acquisition of clusters include epenthesis, coalescence, and metathesis.

In **Epenthesis,** a vowel is inserted between the cluster’s consonants, thus creating a CV syllable shape (e.g. *pəleIt* for *pleit* ‘plate’). Epenthesis has been reported in the

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[5] For the exact definition of a” head” see Kaye et al. (1990).

speech of 2 to 3 years olds (Dyson and Paden 1983, Bortolini and Leonard 1991) as well as in older children (Olmsted 1971, Ingram et al. 1985). According to Barton et al. (1980), vowel epenthesis is strong evidence that the child has segmented a cluster into its component parts. They explain that the use of epenthesis is a strategy of the children to facilitate articulating a consonant sequence. According to this claim, epenthesis is due to motoric difficulty in sequentially producing two nearby articulations. An alternative view for epenthesis relates to the linguistic system, rather than the motoric system, and deals with the markedness of syllabic structures. In other words, CV is the unmarked and preferred syllable by children rather than the CCV syllable, thus vowel epenthesis within a cluster replaces CCV with CVCV structure. **Coalescence** occurs when the reduced cluster contain a new consonant composed of features from the two original consonants. For example: *fIm* for *swim* 'swim' (the [+cont.] of /s/ co-occurs with the [+labial] of /w/). Coalescence has been reported in the speech of 2 to 3 year olds by Dyson and Paden (1983). Coalescence of a labial and a non-labial (e.g. *fun* for 'spoon') is frequently attested in child language (Smith 1973, Chin and Dinnsen 1992, Smit 1993, Barlow 1997, Pater and Barlow 2003). **Metathesis** is the reversal of the order of the segments in a word, whether or not they are adjacent. For example: *noʊs* for 'snow' (the second element in the cluster is produced as a coda). However, the number of incidences of metathesis in clusters are negligible (Olmsted 1971, Bernhardt and Stemberger 1988).

Triconsonantal clusters cause an increase in the error types available for children because of the additional consonant and its potential pairing with the other two elements. For example, the application of the process of cluster reduction can result in just one consonant or in two consonants. Smit (1993) reports that among the three elements of the cluster, children tend to retain the stop. This is true both for reduction to a single element as well as to two elements. Of course, most three element clusters are acquired later than most two element clusters. Since triconsonantal clusters are rare in Hebrew, I will not elaborate on this issue.

### 2.2.2. The development of the coda

#### 2.2.2.1. Coda: Prosodic effects

During the early stages of acquisition, children produce words without codas, regardless of their target language or their state of development (Fikkert 1994 - for Dutch, Fee 1995 - for English, Grijzenhout and Joppen 1998 - for German, Kappa 2002 - for Greek). The absence of codas during this stage is prosodic in nature rather than segmental. This is evident by the fact that a segment might be deleted in coda position while the same segment might be preserved in onset position. In fact codas are cross-linguistically marked constituents. Bernhardt and Stemberger (1998), however report that Morgan, an English-speaking child, has codas from 0; 11, even in her first word, i.e. *ʔap*$^h$ for *(ʔ)ʌp* 'up', and also *ʔat*$^h$ and *ʔaʔ* for *(ʔ)aʊt* 'out'. Their findings are similar to those of Ben-David (2001), who reports that during this early stage of coda development, coda deletion occurred for almost all of her Hebrew-speaking children's first words, except for VC target words. For example, the words *af* 'nose' and *od* 'more' are produced with the coda as opposed to *ya* for *yad* 'hand', *óze* for *ózen* 'ear', and also *babú* for *bakbúk* 'bottle'. Morgan's examples also include words with a VC structure (see in Bernhardt and Stemberger 1998 for discussion on the status of the glottal stop *ʔ*). It seems as if codas most often are not possible at the earliest periods of acquisition. However, Ben-David (2001) claims that there is no stage in the acquisition where the children produce words without a consonant, and explains it, following Tobin (1997), by the requirement to maintain communicative information (see also Nespor et al. 2003 for the importance of the consonants in speech). That is, during the stage where all other words do not have codas, VC words have codas in order to avoid words without consonants.

During the next stage of phonological development, a word-final coda consonant appears. Medial codas are deleted. Ben-David (2001) finds that when the children start producing consonants in coda position, they do so first in the final stressed syllable of the word (e.g. *yad* 'hand', *babúk* for *bakbúk* 'bottle' but *bái* for *báit* 'house', *óze* for *ózen* 'ear'). During the following stage, codas in the final unstressed syllable also appear (e.g. *báit* ‘house’, *ózen* ‘ear’), and only a few months later do children start producing coda consonants in non-final syllables of the word (e.g. *bakbúk* ‘bottle’). Kappa (2002) mentions that medial codas of the target words are not realized in the Greek-speaking children’s output until a very late stage of phonological development (about the age 3:5). Moreover, regarding the accuracy of production, Shahin (2003) finds that word medial codas are poorly produced compared to word-final codas in her 22 Arabic-speaking children.

#### 2.2.2.2. Coda: Segmental effects

Children prefer the continuant manner feature and the unmarked coronal place feature for the input’s final consonant. For example, Kappa 2002 (Greek data) reports *pos* for *fos* ‘light’, *kákis* for *sákis* ‘proper name’ (preservation of the fricative), and also *totón* for *kaltsón* ‘tights’ (preservation of the nasal). Fikkert (1994) reports that a large percentage of the final consonants in her Dutch-speaking children’s productions are fricatives (about 60%), while a much smaller percentage are plosives (about 25%). In fact, the fricatives are favored in syllable-final position over other consonant types, and they sometimes replace other types of consonant in coda position (e.g. *paχ* for *pat* ‘pad’). During the next stage, sonorant consonants start appearing, first nasals, then liquids, and finally stops (Fikkert 1994, Fikkert and Freitas 1997).

#### 2.2.2.3. Complex coda

There is much less information in the literature about the development of complex codas. For most children, at first, only one consonant is possible within any particular coda, while extra consonants are deleted (Bernhardt and Stemberger 1998).

Word-final clusters are generally reported to appear earlier than word-initial clusters (Dodd 1995, Watson and Scukanec 1977). This is also reported in Paul and Jennings (1992), who find that CVCC occurred more frequently than CCVC in their subjects between the ages 1;6-2;10 and also in Dodd (1995), who finds that CVCC structures appear between ages 1;9 and 2;0, and CCVC structures appear between ages 1;10 and 2;4. It should be mentioned, however, that these data were found for English-speaking children and the language-specific distribution of complex codas might play a role in this issue.

There is also insufficient data regarding which consonant in a coda cluster is preserved. Bernhardt and Stemberger (1998) emphasize great variability among children. This variability is presented by Ohala (1994, 1995, 1996), who claims that, in final clusters, English-speaking children tend to preserve the most sonorous consonant in the cluster (e.g. *dus* for ‘dust’), i.e. final fricative-stop clusters tend to be reduced to the fricative, while Fikkert (1994) argues that in her Dutch-speaking children, final clusters tend to be reduced by preserving the obstruent.

Final clusters are rare in Hebrew and are found in borrowed nouns (e.g. *paʁk* ‘park’, *bank* ‘bank’, *čips* ‘potato chips’), denominative verbs derived from borrowed nouns (e.g. *giʃpénk* ‘to approve’ from *guʃpánka* ‘approval’; Bolozky 1978, Bat-El 1994), and in the verb with the suffix *-t* (e.g. *axált* ‘you ate fm.sg.’, *yaʃánt* ‘you slept fm.sg.’). Accordingly, word-final clusters hardly ever appear in the children’s speech, at least not during the stages of development studied here.

# CHAPTER 3: HEARING IMPAIRMENT

## 3.1. General characteristics of hearing impaired population

*Hearing impairment* is a generic term for any disorder of hearing, regardless of cause, type, or severity. It refers to a subnormal ability to detect sound and it includes all degrees of hearing loss: from very mild to profound, with deafness being the extreme form of the impairment (Bess and Humes 1990).

### 3.1.1. The variables influencing the auditory function

Defining the impact of a hearing impairment is influenced by the many factors involved in the hearing loss itself and in the hearing impaired patient. The extent to which hearing impairment influences the auditory function of the hearing impaired person depends on two main groups of factors: Auditory factors and individual patient factors. These two groups of factors are composed of several variables:

*Auditory variables* (§3.1.1.1) include the degree of hearing impairment, the type of hearing loss, the hearing loss contour, and whether the hearing loss is monaural or binaural (Kretschmer and Kretschmer 1978, Quigley and King 1982, Stach 1988).

*Individual patient variables* (§3.1.1.2) include the age of onset of impairment, the age of auditory rehabilitation, the mode of communication, the hearing status of the parents, the socioeconomic status of the family, the IQ level of the person, and whether there are other problems involved (Kretschmer and Kretschmer 1978, Quigley and King 1982, Stach 1988, Mayne et al. 2000).

#### 3.1.1.1. Auditory variables

*The degree of hearing impairment* is the primary descriptive variable for the hearing impaired population. Hearing impairment is usually presented as the average of the Hearing Threshold Level (HTL) for the three frequencies considered to be most necessary for the perception of speech: 500, 1000, and 2000 Hz. According to ANSI (1969) (American National Standard Institute), the degree of sensitivity loss is classified on the basis of the following levels: normal hearing (10-15 dB), slight hearing loss (16-25 dB), mild hearing loss (26-40 dB), moderate hearing loss (41-55 dB), moderately severe hearing loss (56-70 dB), severe hearing loss (71-90 dB), and profound hearing loss (91 dB plus) (Katz 2002). In general, the more severe the hearing impairment is, the greater the expected impact on the person's auditory function is. However, since more variables are involved, it is not always true. In other words, these terms serve as a means for consistently describing the degree of sensitivity loss across patients but they do not necessarily describe their everyday function.

*Type of hearing loss* refers to the location of the lesion in the ear: whether the damage is in the outer or middle ear (conductive hearing loss), in the cochlea or the auditory nerve (sensorineural hearing loss), both of them (mixed hearing loss), or in the auditory nerve pathways from the brain stem to the auditory cortex (central hearing loss) (Paul and Quigley 1990). A conductive hearing loss simply reduces the volume of the incoming signal. It is usually medically treatable either by medication or surgery. Although too much attenuation makes the hearing of speech difficult, it can easily be overcome by increasing the intensity level of the speech (Stach 1998).

Sensorineural hearing loss has some effects on hearing including: a reduction in the cochlear sensitivity, a reduction in frequency resolution, and a reduction in the dynamic range of the hearing mechanism. It cannot be treated medically. Therefore, these patients are treated through the use of sensory aids (hearing aids and cochlear implants). These devices provide some auditory information to the hearing impaired population and will be discussed in detail in sections § 3.3.1 and §3.3.2.

*Hearing loss contour/curve* refers to the description of the shape of the audiometric configuration. In general, hearing loss contour can be defined as the thresholds of hearing sensitivity, as a function of pure tone frequency. For example: a high-frequency curve means hearing loss is restricted to the high-frequency region of the range while a low-frequency curve means hearing loss is restricted to the low-frequency region of the range. One should note, however, that the speech frequencies are generally described as the pure-tone average of thresholds at 500, 1000, and

2000Hz. The shape of the hearing loss combined with the degree of the loss provides a useful description of hearing sensitivity. These variables affect the audibility of the acoustic variables of the speech sounds i.e. their perception (Stach 1998).

*Monaural/binaural hearing loss* refers to whether one (unilateral) or two (bilateral) ears are impaired.

#### 3.1.1.2. Individual patient variables

*The age of onset of impairment* refers to the age at which an individual acquires a hearing loss i.e. a hearing loss that is acquired at birth or before language acquisition (congenital or prelingual hearing loss) as opposed to a hearing loss that is acquired after the development of language (postlingual impairment). The more severe the impairment is, the more crucial the age of onset becomes for the development of language. The language development of a child, who became hearing impaired at birth or shortly thereafter is usually slower than that of a child, who lost his hearing after language acquisition (Paul and Quigley 1990).

*The age of auditory rehabilitation* refers to the age when the impairment is identified and an intervention program is initiated. The intervention refers to the rehabilitation of hearing such as the fitting of sensory aids and auditory training. The earlier the rehabilitation is, the better the prognosis of language acquisition is (Bess and Humes 1990).

*The hearing status of parents and siblings* is an important variable. Actually, the form of language and communication to which the hearing impaired child is exposed in infancy and early childhood can be quite different for the deaf child of deaf parents than for the deaf child of hearing parents.

Another variable is *the mode of communication* of the child; either oral communication which emphasizes spoken language as the primary communication mode, or total communication which combines spoken and sign language. In fact, the heterogeneity of the population of hearing impaired children and the various factors contributing to the development of communication have made it difficult to directly assess the effect of the communication mode on early language. It had been suggested that research on communication modality should be "more descriptive than prognostic" (Carney and Moeller 1998 p. S61).

A complete description of a hearing impaired individual should also include the *socioeconomic status of the family*. The effect of the family's socioeconomic status was examined by Hart and Risely (1995). They reported that mothers of a lower socioeconomic status spoke differently and less frequently to their children than mothers of a higher socioeconomic status. In addition, the children of a lower socioeconomic status were observed to use fewer and less varied words than children of a higher socioeconomic group.

*Other problems* involved. It is generally estimated that one third of all children with a hearing impairment have at least one additional handicapping condition that has educational impact. Some of these conditions include visual impairment, brain damage or injury, mental retardation, epilepsy, learning disabilities, and emotional/behavioral problems. Clearly, such variables might affect the auditory function of the hearing impaired person and influence his/her achievements (Bess and Humes 1990, Mayne 2000).

### 3.2. Speech production characteristics of hearing impaired children

Proper function of the auditory system is required for normal development of speech perception and production**.** In the course of language development, children receive their linguistic input from the speech of others, which serves as their target. In addition, their own auditory feedback allows them to correct their speech, until it matches the target (Borden, 1979, Northern and Downs 1991, Stoel-Gammon and Kehoe 1994, Wallace et al. 2000, Kuel 2000, Obenchain et al. 2000).

Auditory deprivation arising from hearing loss during the early stages of life affects the different aspects of language development, including the patterns of speech production (Lee and Canter 1971, Pressnell 1973, Quigley and King 1982, Wood 1984, Levitt et al. 1987, Madison and Wong 1992, McGarr and Osberger 1978, Oller et al. 1978, Tobin 1997). The speech production of hearing impaired children is characterized by a variety of segmental and suprasegmental errors.

The following subsections describe the speech production of hearing impaired children: In §3.2.1, phonological processes in the speech of hearing impaired children are described, both on the word, syllable, and segmental levels. In §3.2.2, the suprasegmental characteristics of their speech are described.

### 3.2.1. Phonological processes in the speech of hearing impaired children

The phonological development of hearing impaired children has been described in detail in the literature (Dodd 1976, Oller et al. 1978, Gold 1980, Binnie et al. 1982, Abraham 1989, Dodd and So 1994, Meline 1997, Tobin 1997, Huttunen 2001). The characteristics of their speech are usually described in terms of phonological patterns. These patterns contain processes on the word level, the syllable level, and the segmental level.

Processes on the *word level* include the deletion of the unstressed, initial syllables of the word (e.g. [nánʌ] for *banána*, [mátoʊ] for *tomáto*) (Dodd 1976), and longer duration of the word than normal (Binnie et al. 1982).

*Processes on the syllable level* include vowel insertion to break up clusters (Binnie et al. 1982, Tobin 1997), cluster reduction (i.e. preference for a singleton consonant) (Oller et al. 1978, Abraham 1989, Dodd and So 1994, Meline 1997), syllabification of word-final consonants (Binnie et al. 1982), final consonant omission (Oller et al. 1978, Abraham 1989, Dodd and So 1994, Tobin 1997, Huttunen 2001), and initial consonant deletion (Dodd and So 1994, Tobin 1997). The above processes are shown in table (22) below.

(22) Phonological processes on the syllable level

| Process | Examples | Reference | Language |
|---|---|---|---|
| Vowel insertion to break up clusters | [səpæʃ] for *splæʃ* ‘splash’ | Binnie (1982) | English |
| | [gevina] for *gvina* ‘cheese’ | The current study | Hebrew |
| Cluster reduction | [hæd] for *hænd* ‘hand’ | Dodd (1976) | English |
| | [ta] for *star* | Oller et al. (1978) | English |
| | [til] for *ptil* ‘cord’ | Tobin (1997) | Hebrew |
| Syllabification of word-final consonants | [lifə] for *lif* ‘leaf’ | Binnie (1982) | English |
| Final consonant omission | [da] for *dad* ‘daddy’ | Oller et al. (1978) | English |
| | [mai] for *maim* ‘water’ | The current study | Hebrew |
| Initial consonant deletion | [uj] for *puj* ‘cup’<br>[i] for *si* | Dodd and So (1994) | Cantonese |
| | [uba] for buba ‘doll’ | Ben-David (2001) | Hebrew |

*Processes on the segmental level* may affect both vowels and consonants. The most common vowel errors are the following (see also table (23) below): C*entralization* – central vowels are preferred (since they require the least precision and control of the tongue height and position); *Neutralization* – overuse of a schwa vowel /ə/ (as a results of difficulties in adjusting tongue position); *Tense-lax substitutions* – e.g. *i* →*ɛ, u* →*ʊ* as well as *vowel substitutions* (e.g. front vowels are substituted with back vowels); *Reduction of diphthongs* – complex diphthongs are monophthongized as well as *diphthongization* - a vowel which becomes a diphthong (as a result of a timing deficit); *Nasalization of vowels* (as a result of a timing deficit of the closure of the velopharyngeal airway).

(23) Phonological processes in the segmental level- vowels

| Process | Examples | Reference | Language |
|---|---|---|---|
| Centralization | [a:] for *oʁ* ‘light’ | The current study | Hebrew |
| Neutralization | [talə] for *talo* ‘house’ | Huttunen (2001) | Finnish |
| | [mə] for *mIlk* ‘milk’ | Dodd (1976) | English |
| Laxing | [pɛl] for *pil* ‘elephant’ | Tobin (1997) | Hebrew |
| Vowel substitution | [tu:nu] for *ty:ny* ‘pillow’ | Huttunen (2001) | Finnish |
| Reduction of diphthongs | ay → a | Huttunen (2001) | Finnish |
| | [tʃu] for ʃou ‘show’ | Dodd (1976) | English |
| Diphthongization | a → ay | Smith (1975) | English |
| Nasalization | a → ã | Tobin (1997) | Hebrew |
| | [næ̃m] for læmb ‘lamb’ | Oller et al. (1978) | English |

The consonant production of hearing impaired children is characterized by a variety of errors including place and manner of articulation replacement (Huttunen 2001), stopping, assimilation, final devoicing (Oller et al. 1978, Dodd and So 1994, Meline 1997, Tobin 1997), spirantization (Abraham 1989, Dodd and So 1994), liquid deviations (Meline 1997), fronting (Huttunen 2001), backing (Dodd and So 1994), omission in different positions of the word (i.e. initial, medial and final position). Thus, hearing impairment may influence the production of the critical sound features: place of articulation, manner of airflow, and voicing.

The above processes are shown in Table (24) below.

(24) Phonological processes on the segmental level - consonants

| Process | Examples | Reference | Language |
|---|---|---|---|
| Place of articulation replacement | [s] with [ʃ] | Huttunen (2001) | Finnish |
| Manner of articulation replacement | plosives with nasal release [p$^n$], [k$^n$] | Huttunen (2001) | Finnish |
| Fronting | [telk:ɑ] for *kelk:a* ‘sledge’ | Huttunen (2001) | Finnish |
|  | [d̪ʌ̃n] for ‘gun’ | Oller et al. (1978) | English |
|  | [dad] for *dag* ‘fish’ | The current study | Hebrew |
| Stopping | [tu] for ‘shoe’<br>[d̪Ipə] for ‘zipper’ | Oller et al. (1978) | English |
|  | [tu] for *sus* ‘horse’<br>[ap] for *af* ‘nose’ | The current study | Hebrew |
| Assimilation | [næ̃m] for ‘lamb’ | Oller et al. (1978) | English |
| Final devoicing | [flak] for ‘flag’ | Oller et al. (1978) | English |
| Omissions | [uba] for *buba* ‘doll’<br>[mano] for *manof* ‘lever’ | The current study | Hebrew |

In fact, some of the phonological processes in the above list are similar in their quality and frequency of occurrence to those of hearing children, while others might be deviant or even normal but appear in a high incidence in hearing impaired children compared to typical phonological systems (Huttenen 2001).

Indeed, a number of studies have shown that even children with profound hearing loss have often the same processes as those used by young hearing children during the phonological acquisition period (West and Weber 1973, Oller and Kelly 1974, Dodd 1976, Oller et al. 1978, Abraham 1989), and by hearing, language-delayed children

(Compton 1970, Ingram 1971, Oller 1973). Meline (1997), for example, describes the phonological patterns of hearing impaired children with different degrees of hearing loss. His findings indicate that the phonological processes of the hearing impaired subjects were similar in frequency of occurrence to those of children with normal hearing. The three phonological processes are: final consonant deletion, gliding of liquids, and cluster reduction.

Other studies, however, describe both normal and deviant phonological processes in the speech of hearing and hearing impaired children (Dodd 1976, Dodd and So 1994, Huttunen 2001). Ingram (1976) referred to the phonological system of hearing impaired children as deviant and not delayed, and concluded that the speech of the hearing impaired is unique; "…there appear to be certain characteristics that set the hard of hearing apart from both normal and deviant children…several factors indicating that hard-of-hearing speech has a nature of its own." (Ingram 1976:123).

Dodd and So (1994) describe the phonological abilities of Cantonese-speaking children with hearing loss in terms of their consonant, vowel, and tone inventories. They found that all children exhibited some phonological processes that are typical of the phonological development of Cantonese-speaking hearing children. However, in addition to the normal developmental processes, all but two children (both profoundly impaired) used at least one of four unusual processes, i.e. processes used rarely, if at all, by hearing children acquiring Cantonese. These processes include: spirantization, initial consonant deletion, backing, and consonant epenthesis to preserve a CVC syllable structure. Dodd (1976) assumes that hearing impaired children acquire at least partially a rule-governed phonological system. These researchers claim that the hearing level may account, in part, for the differences among studies. They assume that the findings indicate a significant relationship between hearing loss and the number of errors. In general, subjects with greater hearing loss produced more phonological processes (Huttunen 2001). However, severity of hearing loss alone was not a perfect predictor of speech performance. As was discussed in §3.1.1, other important variables include age of onset of hearing loss (i.e. prelingual vs postlingual), use of sensory aids, and environmental surrounding (e.g. educational setting) are important factors which affect the speech production of hearing impaired children and their phonological processes (Smith 1975, Geers and Moog 1992, Meline 1997, Yoshinaga-Itano 2000).

### 3.2.2. The prosodic characteristics of the speech of hearing impaired children

Suprasegmental errors are found in the *intonation* and *stress pattern,* which affect the prosody and the rate of the spoken utterance (Boothroyd et al. 1974, Osberger 1978, Parkhurst and Levitt 1978, Rosenhouse 1986, Frank et al. 1987). Many investigators report that hearing impaired children use inappropriate variation in fundamental frequency (Smith 1975). They speak at a much slower rate than speakers with normal hearing, thus prolongation of speech segments often occurs, resulting in rhythm distortions (Nicolaidis 2004). Intonation problems such as monotonous speech as well as rising pitch reflect poor control and coordination of laryngeal and phonatory processes (McCarr and Osberger 1978).

The contribution of the segmental and suprasegmental errors to the **speech intelligibility** of hearing impaired subjects is investigated in many studies (Hudgins and Numbers 1942, Markides 1970, Smith 1975, McGarr and Osberger 1978, Maassen and Povel 1984, Carter et al. 2002, Nicolaidis 2004, Huttunen and Sorri 2004). The term speech intelligibility refers here to the degree to which a speaker's intended message can be recovered by other listeners (Kent et al. 1989), or the comprehensibility of the specifically linguistic information encoded by a speaker's utterances (Samar and Metz 1991). The intelligibility scores are usually manifested by using either phoneme, syllable or sentence recognition test judgments of inexperienced/naïve listeners or of experienced speech pathologists. Carter et al. (2002) used the McGarr Sentence Intelligibility Test (McGarr 1983) to evaluate the speech intelligibility of the 24 implanted children of their study. The children were asked to repeat sentences and naïve listeners were asked to transcribe the utterances. Significant correlations were found between prosodic accuracy and speech intelligibility, indicating that the children who produced more intelligible speech on the McGarr task also tended to reproduce the prosodic elements of the words correctly. Also, previous researchers reported a high negative correlation between the frequency of segmental and suprasegmental errors and intelligibility, i.e. on average, the higher the incidence of segmental errors is, the poorer the intelligibility of the speech is (Smith 1975, McGarr and Osberger 1978).

### 3.3. Rehabilitative devices of hearing impaired children

As stated in §3.1.1.1, sensorineural hearing loss has some effects on hearing including:

a. A reduction in the sensitivity of the cochlear receptor resulting in *higher threshold levels* than normal.

b. A reduction in the *dynamic range* of the hearing mechanism: The dynamic range is defined as the usable range of sounds between the threshold of detection and uncomfortable loudness. Normally-hearing people have a dynamic range that may exceed 100 dB. In profound hearing impairment, this range is much narrower (seldom more than 30dB and can be as narrow as a few dB). Dynamic range is decreased with increasing hearing loss, and it can vary with frequency.

c. A reduction in *speech discrimination*: Threshold elevation alongside low tolerance (uncomfortable loudness) results in the reduced discrimination ability of the child with sensorineural hearing loss. Consequently, sounds that are discriminable to a person with normal hearing may sound the same to the hearing impaired child.

d. An increase in *noise susceptibility:* Background noises interfere with the hearing of hearing impaired child. The noises masked the speech sounds thus resulting in low speech discrimination.

However, sensorineural hearing loss cannot be treated medically. Therefore, as mentioned above, hearing impaired patients are treated through the use of sensory aids: mainly hearing aids and cochlear implants. These devices are used in order to provide feedback via a sensory system that facilitates the development of spoken communication skills.

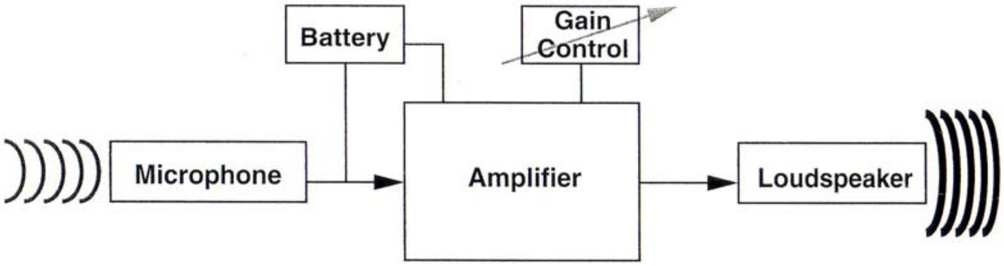
The following subsections elaborate on the characteristics of two types of rehabilitative devices: hearing aids (§3.3.1) and cochlear implants (§3.3.2) in relation to the characteristics of sensorineural hearing loss.

### 3.3.1. Hearing Aids (HA)

A hearing aid represents the most common form of sensory assistance. It serves as a personal amplification system adapted to the patient with hearing loss.

A hearing aid is an electronic amplifier which has three main components: a microphone, an amplifier, and a loudspeaker.

Figure 25: A Schematic representation of the components of a hearing aid



The microphone is a vibrator that moves in response to the pressure waves of sounds. As it moves, it converts the acoustical signal into an electrical signal. The electrical signal is boosted by the amplifier and then delivered to the loudspeaker. The loudspeaker then converts the electrical signal back into an acoustical signal to be delivered to the ear. A battery is used to provide power to the amplifier (Stach 1988).

The hearing aid accomplishes its task by amplifying the sounds of speech. Amplification, however, carries several limitations, in relation to the characteristics of sensorineural hearing loss:

*Threshold Elevation*: Hearing aid cannot provide profoundly deaf children with full audibility of the speech of the environment. Providing more than 60 dB of amplification results in acoustic feedback or whistling of the hearing aid. Since hearing aid has amplification limitation, it is not very useful for people with profound hearing loss, i.e. hearing loss greater than 90dB, since it enables the child to hear most of the sounds around her/him (Boothroyd 1998).

*Reduced dynamic range*: Another limitation of hearing aid arises from the reduced dynamic range of hearing impaired children: speech amplification might cause a feeling of discomfort for the child, hearing his own speech and the speech of others. Hearing aid is also limited in solving problems of *reduced discrimination*, which characterizes the hearing impaired patient. Even with the best, most carefully selected and adjusted hearing aid, discrimination is limited because the damage to the hearing mechanism is such that the aid cannot provide the child with all the sensory evidence that is needed for normal speech perception.

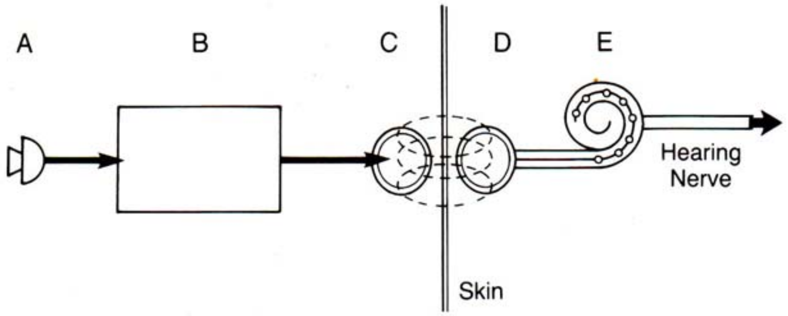
And finally, hearing aid is limited in providing clear hearing and speech discrimination with background noise, since it amplifies both the signal and the noise, generating masking that may degrade speech comprehension.

### 3.3.2. Cochlear Implants (CI)

The cochlear implant is the most advanced sensory aid known today, and provides an alternative form of assistance for hearing impaired people, who obtain little or nothing from conventional hearing aids. The cochlear implant provides electrical stimulation to the auditory nerve, bypassing the usual transducer cells that are absent or nonfunctional in a deaf cochlea. The nerve impulses travel along the auditory pathways to the cortical level, and are interpreted by the brain as sound (Parsier and Chute 1991).

Cochlear implant systems have a few basic components: a microphone, a signal processor, a transmitter, a receiver, and electrodes.

Figure 26: A schematic of the components of a cochlear implant system



The components of the cochlear implant system: (A) Microphone, (B) Processor, (C) Transmitter, (D) Receiver, and (E) Electrodes. Adapted from Pfingst (1986).

The sound is received by an external microphone (A), which converts the acoustical signal into electrical variations and sends them to the signal processor (B). The processor transforms the electrical input and shape of electrical stimuli (C). This information is then transferred from the processor to the implanted system to excite the neurons of the auditory nerve (D-E). The transfer of information can happen either directly by wires through the skin or, more typically, across the skin by some form of inductive coupling.

The physical and physiological differences between acoustic and electrical activation of the auditory nerve cause different perception abilities. Cochlear implants are different from hearing aids in that hearing aids simply amplify sound, whereas cochlear implants bypass the cochlear damage and stimulate the auditory nervous tissue directly. The potential advantages are numerous and include better high frequency hearing, enhanced dynamic range, better speech recognition, and no feedback-related problems.

*The dynamic range* (§3.3.1) is much wider with cochlear implants than with hearing aids. *The intensity resolution*, which refers to the ability to discriminate among small changes in intensity, is much better among cochlear implant users and corresponds closely to the performance of hearing subjects with acoustic stimulation. *The temporal resolution,* which refers to the ability to detect information on temporal rates, such as gap detection and modulation detection, is much better among cochlear implant users and very similar to hearing subjects (Parsier and Chute 1991).

All these variables, therefore, allow audibility of sounds (such as the sibilants) that were not accessible to that population, and thus provide greater potential for development of speech perception and production skills in comparison to other rehabilitative devices (Parsier and Chute 1991, Tobey et al. 1994, Chin and Pisoni 2000).

In the following section, the speech production of cochlear implant users is discussed and compared to the speech production of hearing impaired children, who use other sensory aids.

### 3.4. Speech production of cochlear implant users

Most of the studies on the speech production of hearing impaired children suggest significant improvement following cochlear implantation, in comparison to other sensory aids. Several studies examined the speech production of hearing impaired children using cochlear implants, tactile aids (i.e. sensory aids which convert sound patterns into patterns of tactile stimulation), 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 cochlear implant is better than that of children using tactile aids (Osberger et al., 1991, Geers and Tobey 1992, Tye-Murray and Kirk 1993, Tobey et al. 1994, Sehgal et al. 1998) and conventional hearing aids (Geers and Tobey 1992, Tobey et al. 1994, Kirk et al. 1995). The speech differences among children using these three devices were introduced in detail in Tobey et al. (1994). These researchers used two types of elicitation procedures: imitation and spontaneous speech. Their findings showed significant improvement in the imitative and spontaneous speech production skills of the children using the three devices after training. However, the cochlear implant users accomplished the most significant improvement compared to that of the children with the tactile aids and those with the hearing aids. The feedback provided by the cochlear implant influenced the consonant, vowel, and diphthong production of the children and they performed much better compared to the other children. The cochlear implant appeared 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 (also Geers and Tobey 1992, Blamey et al. 2001a, Ertmer and Mellon 2001).

The prosodic aspects of the speech of cochlear implant users have been studied as well (Kirk and Hill-Brown 1985, Tobey et al. 1991, Tobey and Hasenstab 1991, Tobey et al. 1994). Studies showed that auditory information via the cochlear implant device may be useful for improving the speech production of non-segmental aspects of hearing impaired users. The spectral, intensity, and timing information provided by the cochlear implant device helps in acquiring several critical speech features, such as vocal duration, vocal intensity, pitch control, intonation, and spectral properties of many speech sounds (Kirk and Hill-Brown 1985, Tobey et al. 1994).

Most relevant to the present study is the study of Carter et al. (2002), who examined the ability of 24 English-speaking implanted children to imitate the stress patterns and the correct number of syllables in nonsense words, given a repetition task. Their findings showed a relatively high accuracy in these prosodic properties; the children were able to produce the correct number of syllables as well as the primary stress position in almost two-thirds of their imitations of nonsense words. Moreover, the errors with respect to the number of syllables revealed a pattern similar to that of hearing children, i.e. a tendency to delete rather than add syllables, and a better performance in words with initial stress, compared to words with non-initial stress (Fikkert 1994, Demuth 1995, 1996a, Gerken 1994, 1996 among others).

Recent studies suggest that an early **age of implantation** has an important influence on the speech development of hearing impaired children. More specifically, children who receive a cochlear implant at a younger age might develop better speech skills than children who receive a cochlear implant at an older age (Osberger et al.1993). The advantage of an early age of implantation is realized in speech perception (Yaremko 1993, Waltzman and Cohen 1998), as well as in speech production (Tye-Murray et al. 1995, McCaffrey et al. 1999, Ertmer and Mellon 2001, Ertmer 2001). These reports support the contention that implantation before 2 years of age promotes both faster and more efficient language acquisition skills.

Many of the studies dealing with the cochlear implant population indicate the importance of **duration of use** of the implant. The speech production of cochlear implant users improves over the years following implantation and the segmental and non-segmental patterns' accuracy increases significantly with more experience with the implant device (Kirk and Hill-Brown 1985, Tobey and Hasenstab 1991, Geers and Tobey 1992, Serry and Blamey 1999, Blamey et al. 2001b, Chin et al. 2003, Tobey et al. 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.

The findings on the speech production achievements of cochlear implant users in comparison to those of hearing children, however, are controversial. Chin and Pisoni (2000) findings among others (Serry and Blamey 1999, Ertmer and Mellon 2001, Carter et al. 2002) emphasised the cochlear implant's efficiency as opposed to other rehabilitative devices as well as to normal hearing. They demonstrated that a number of segmental correspondences appeared similar to those used in early developmental stages by hearing children. Blamey et al. (2001b), on the other hand, demonstrated in their study that the group of implanted children lagged behind children with normal hearing at all test intervals, and their rate of development over a 6 year period was slower than that of normally-hearing children at a similar stage of development. The children in their study were 5 years old or younger at the time of implantation and data was collected for 4 years post-operation.

Indeed, there is a large amount of individual variability in the speech production development of cochlear implant recipients. Ertmer et al. (2002b), for example, described the vocal development of 2 young children with cochlear implants. Diane was implanted at 28 months, while Michael received his implant on the age of 10 months. The two children participated in an intervention program with the emphasis on increasing consonant and vowel inventories, and encouraging the use of voice to express communicative needs. Although both Diane and Michael demonstrated advances in vocal development after implantation, important differences were noted between the children. Diane achieved the canonical level much more rapidly than Michael, whose progress was delayed in comparison to Diane’s. His performance indicates that implantation during the first year of life does not guarantee an advantage over implantation during the second or third years of life. As indicated in §3.1.1.2, many factors might affect the performance of the hearing impaired child affecting the rate and the quality of language acquisition (Ertmer et al. 2002a, 2002b, Chin 2003, Peng et al. 2004).

# PART II: METHOD

## CHAPTER 4: RESEARCH METHOD

### 4.1. Subjects

The empirical basis of this study is drawn from the speech of 10 monolingual hearing-impaired Hebrew-speaking children, 5 boys and 5 girls, ranging in age from 1.5 to 3.5 years at their first recording session (see details in (27) and (28) below). All children had prelingual hearing impairment, with bilateral sensorineural hearing loss, and they all used hearing aids from early childhood. All children use oral communication only, have hearing parents, and no developmental problems. They were all educated from an early age at the Central Institute for the Deaf (Micha) in Tel-Aviv Israel.

The subjects were divided into two groups according to the type of their hearing device: group A, consisting of 6 children (3 boys and 3 girls) using a cochlear implant device (CI), and group B, consisting of 4 children (2 boys and 2 girls), using bilateral conventional hearing aids (HA). The two subsections below provide the relevant information on each group, accompanied by details on each child.

#### 4.1.1. Group A: Cochlear implant users

All the implanted children (group A) had a profound hearing loss in both ears prior to implantation. Their unaided thresholds prior to implantation were above110 dB in both ears (this level represents the mean pure tone average of 500, 1000, and 2000Hz). They were fitted with binaural personal conventional hearing aids for a short period early in their childhood. Their hearing aids improved their auditory awareness to environmental and speech sounds. However, they received a cochlear implant because they derived negligible benefit from the conventional hearing aids and had no functional hearing. They were all implanted at the Speech and Hearing Clinic of the Sheba Medical Center in Ramat-Gan, Israel, and after implantation, their auditory thresholds for speech improved. Thus more speech sounds became audible to them and they were able to detect, discriminate, identify and understand more speech stimuli. In fact, after implantation the hearing of all the children became more functional.

(27) Background information of the implanted children (N=6)

| Subject | Sex | Etiology of deafness | Onset age of profound hearing loss | Age of hearing aid fitting | Age of implantation | Age at 1st recording | Age at last recording | No. of record. |
|---|---|---|---|---|---|---|---|---|
| A1 | M | Unknown | Congenital | 0;5.0 | 1;2.10 | 1;5.0 | 3;4.24 | 38 |
| A2 | F | Unknown | Congenital | 0;6.0 | 1;0.0 | 1;5.27 | 3;1.6 | 21 |
| A3 | F | CMV | 1;0.0 | 1;3.0 | 1;9.6 | 2;1.4 | 5;0.16 | 32 |
| A4 | M | Genetic | 0;3.0 | 0;10.0 | 2;0.7 | 2;3.23 | 4;11.5 | 29 |
| A5 | F | Genetic | 0;1.14 | 0;3.0 | 1;9.11 | 1;11.20 | 4;2.24 | 27 |
| A6 | M | Unknown | 1;2.0 | 1;8.0 | 2;5.13 | 2;8.12 | 5;6.9 | 30 |

X;Y.Z= Year, Month, Day
M= male F=female

### 4.1.2. Group B: Hearing aid users

All subjects had severe hearing loss. They were all fitted with hearing aids early in their childhood and they were also able to detect, discriminate, identify and understand more speech stimuli using their hearing aids (for their aided thresholds, see table (28) below).

Since it was very difficult to find children using conventional hearing aids in the one word stage (and who were not candidates for cochlear implantation), data collection of group B was less homogenous and started at different stages of the phonological development of each child. In order to determine the linguistic stage of the subjects, the HCDI (The Hebrew Communicative Development Inventory) for hearing impaired subjects was conducted for each child. The original version of the HCDI (Maital et al. 2000) is an adaptation of the MCDI – MacArthur Communicative Development Inventory (for English) (Fenson et al. 1993). It is a reliable and sensitive measure of lexical development and emergent grammar of infants and toddlers. The parents of group B responded to the questionnaire of the HCDI version for hearing impaired children, which enabled determining the linguistic stage of each child: Child B1 had a 130 word vocabulary at the beginning of the study, and at the end of the follow-up, he has completed his phonological development. Child B3 had a 200 word vocabulary at the beginning of the study, and he also finished his phonological development at the end of the study. Child B4 had a 50 word vocabulary at the beginning of the study, and dropped out of the study after 14 months, following her implantation. Child B2 had a 70 word vocabulary at the beginning of the study, and dropped out of the study after 18 months, after leaving the city.

(28) Background information for the children with hearing aids (N=4)

| Subject | Sex | Etiology of deafness | Onset age of profound hearing loss | Age of hearing aid fitting | Mean unaided PTA Thresholds | Mean aided PTA Thresholds | Age at 1st recording | Age at last recording | No. of record. |
|---|---|---|---|---|---|---|---|---|---|
| B1 | M | Genetic | 0;4.0 | 0;6.0 | 80 | 35-40 | 1;5.21 | 2;11.7 | 14 |
| B2 | F | Genetic | 0;3.0 | 0;4.0 | 90 | 50 | 3;2.4 | 4;8.26 | 15 |
| B3 | M | Unknown | 2;5.0 | 2;8.0 | 80 | 30 | 3;5.0 | 4;8.6 | 11 |
| B4 | F | Unknown | 0;10.0 | 1;0.0 | 75 | 35 | 2;9.23 | 3;11.0 | 11 |

X;Y.Z= Year, Month, Day
M= male F=female
PTA = Pure Tone Average Threshold are in dB HL

## 4.2. Procedure

Data collection of the CI group started 2 to 4 months after implantation, from the beginning of the first words (see §4.2.1.4 below for the definition of a word). During the initial recordings, each child produced very few words (fewer than ten), most of them by imitation (see §4.2.1 below for elicitation procedures). Data collection continued till the end of the phonological development, i.e. until the child had completed the 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 the sibilants that might be acquired in Hebrew by the age of 6:0 years old (Jedwab 1975, Ben-Zvi 1991, Gabay 1996, Ben-David 2001). Only one child (A6) was dropped from the study before the end of his phonological development, because he stopped cooperating with the clinician.

The data presented in this study were collected by the author for each subject during a 30-45 minute recording session every month, (see tables (27) and (28) for number of recordings of each child). Data collection of one child (A1) was conducted more frequently and he was recorded twice a month. The elicitation was based on spontaneous speech (§4.2.1.1), picture and object naming (§4.2.1.2), and imitation (§4.2.1.3).

All sessions were recorded using a high quality audio recorder, a Panasonic microcassette recorder model No. RQ-L10. The recorder was placed close to the children, so that the signal-to-noise ratio obtained was highly efficient. Five audiotape recording sessions of each child were selected at random, and a second examiner independently transcribed the sample records. The agreement between the examiners regarding the transcription reflected a high degree of inter-judged measurement reliability.

### 4.2.1. Phonological sampling

Phonological sampling has been a frequent topic of discussion in the literature (Andrews and Fey 1986, Dinssen and Elbert 1984, Elbert and Gierut 1986, Grunwell 1985, Stoel-Gammon and Dunn 1985), with different opinions offered in terms of sample type and elicitation procedures. Bernhardt and Holdgrafer (2001a) suggest that data sampling should be collected both in connected speech contexts and in constructed word lists in order to provide sufficient and reliable data. Moreover, studies show no differences among naming, imitation and spontaneous speech sampling analysis (Horsely 1995, Bernhardt and Holdgrafer 2001b, Kehoe and Stoel-Gammon 2001, Ben-David 2001, Tubul 2005).

As stated, data collection was based on spontaneous speech, picture and object naming, and imitation.

#### 4.2.1.1. Spontaneous speech sampling

An experienced speech therapist played with the child in a quiet room, using toys and objects, which encouraged him/her to produce spontaneous speech. The production of the children was recorded and transcribed orthographically and phonetically by a speech therapist after the recording sessions. Utterance were considered words according to the criteria present by Dromi (1987) and Vihman and McCune (1994) (see §4.2.1.4 for the definition of a word). Utterances that did not meet these criteria were excluded from the sample and were not analyzed.

The use of spontaneous speech samples has great importance in the study of phonological development. It may be more representative of a child's daily performance, allowing the evaluation of prosodic factors such as rate, rhythm, intonation etc., allowing the evaluation of conversational intelligibility and permitting the examination of the phonology-semantics and the phonology-morphosyntax interfaces (Bernthal and Benkson 1988, Bernhardt and Holdgrafer 2001a).

However, the use of spontaneous speech as the only tool for data collection is not sufficient for the research of hearing children, let alone hearing impaired children (Bernhardt and Holdgrafer 2001a). Moreover, spontaneous speech is insufficient for the analysis of the production of young hearing impaired children, production which is characterized by poor intelligibility thereby hindering analysis (Obenchain et al. 2000, see also §3.2). To obtain a wide and representative sample of the speech production of the subjects, we also used the naming test sampling.

#### 4.2.1.2. Naming test sampling

A constant set of pictures and objects was introduced to the children during each recording session, and they were encouraged to name them (for the list of the words, see Ben-David 2001). The structured naming test allows controlling the size and scope of the sample in terms of word choice, the number of syllables and the segment inventory in the words. Moreover, it enables a fairly reliable comparison between the adult target and the child's production, thus increasing inter-child reliability on repeated elicitations over time, through the use of a standardized procedure (Bernthal and Benkson 1988, Bernhardt and Holdgrafer 2001a). The children were introduced to the entire set of objects and pictures during every session throughout the recording period, but they did not always react to them verbally, especially during the initial recordings. When a child correctly produced a word (compared to adult target words) in three consecutive sessions, it was no longer presented to him/her. This criterion was inducted to maintain the child's cooperation throughout the study. The words in the naming test were recorded and transcribed orthographically and phonetically by a speech therapist (the author) after the recording sessions, in the same manner as the transcription of the spontaneous speech.

#### 4.2.1.3. Imitation sampling

Imitation was another way of encouraging the children to talk. The imitation method was used only when a child did not name a picture or an object. The therapist gave the child a model of the word and asked him/her to repeat it. Since studies have demonstrated that imitated productions did not differ significantly from spontaneous productions (Horsely 1995), the children were encouraged to imitate single words (albeit not always successfully). This elicitation type enabled us to broaden the scope of the children's samples, especially during the initial stages, when the children did not attempt to produce a variety of word shapes in the sample collected. Imitation sampling ensured an adequate sample size.

#### 4.2.1.4. Definition of a word

At this stage of language development, it is often difficult to differentiate between a real word and a sequence of sounds that can not be identified as a word, which are produced by the infant. As Dore et al. (1976) report, the two most frequently used criteria in the literature for identifying early words are the approximation of the child's forms to adult words and the consistent use of specific sounds in relation to objects and/or situations.

Based on the definition of a word as given in Dromi (1987) and Vihman and McCune (1994), the satisfaction of one or more of the following criteria was required in the current study in order to define an utterance as a real word:

a. Phonological resemblance to an adult word.
b. Repeated production of the same phonological construction in similar contexts.
c. Gestures used by the child indicating the referent for the word.

### 4.2.2. Stimulus materials

The stimulus material of the study consisted of 107 pictures and objects (for the whole list, see Ben-David 2001). The words used in this study were based on the list of pictures and objects used in the study of the phonological development of hearing Hebrew-speaking children (Ben-David 2001). Most words were tangible nouns (e.g. *óto* 'car', *banána* 'banana', *af* 'nose'), presented by either a picture or an object. All words were frequently used in the speech of Hebrew-speaking children and were introduced to hearing children and hearing impaired children in a pilot test, to confirm that they represented the object to which they were supposed to refer. Only the pictures eliciting 95% agreement among the children in the pilot test were included in the sample. All the words were introduced in their singular form in order to prevent morphological effects (Adam and Bat-El 2000). The only plural noun introduced was *pʁaxím* 'flowers', which was required in order to elicit the complex onset *pʁ*. The form *mispaʁáim* 'scissors' is ordinarily used in Hebrew only in its plural form. The pictures of *kfafá* 'glove' and *ugiyá* 'cookie' encouraged the children to produce them in their plural form (i.e. *kfafót* 'gloves' and *ugiyót* 'cookies'), productions which were accepted, since the number of syllables within the words was preserved.

Word lists for phonological sampling need to be constructed in such a way as to allow the examination of data regarding the various levels of the phonological hierarchy (Bernhardt and Holdgrafer 2001a). The following are the phonological criteria of the study's sample:

*Number of syllables in a word*: The stimulus material included target words with a different number of syllables: monosyllabic words (*dag* 'fish'), disyllabic words (*kadúʁ* 'ball'), trisyllabic words (*ótobus* 'bus') and quadrisyllabic words (*ofanáim* 'bike'). Target words longer than four syllables were not included in the study because of their low frequency in Hebrew. The use of different words with different lengths allowed the examination of the effect of the prosodic word's structure on the children's productions and the different types of errors.

*Stress*: The effect of stress on word acquisition and production was examined by using target words with different stress patterns: disyllabic target words with ultimate stress (*kadúʁ* 'ball') and penultimate stress (*péʁax* 'flower'); trisyllabic target words with ultimate stress (*mitʁiyá* 'umbrella'), penultimate stress (*ʁakévet* 'train'), and antepenultimate stress (*télefon* 'phone'); quadrisyllabic target words with ultimate stress (*melafefón* 'cucumber'), and penultimate stress (*naaláim* 'shoes'). Quadrisyllabic words with antepenultimate stress were not included in the stimulus material since they are infrequent in Hebrew in general and in children's speech in particular.

*Syllable structure*: The stimulus material included different types of syllable structures: syllables with a simple onset, with or without a coda (CVC, CV), syllables with a complex onset with or without a coda (CCVC, CCV), and syllables without an onset (V, VC). Since complex codas are rare in Hebrew, in particular in children's vocabularies, the sample included only two words with a complex coda*, či****ps*** 'potato chips' and *ámbula****ns*** 'ambulance'. All these structures appeared in different positions in the words (except for complex onsets in word medial position), for example: in the word *ába* 'daddy' the initial syllable is onsetless while in the word *bói* 'come! fm.sg.' the onsetless syllable is in final position. The initial syllable in *sáfta* 'grandma' is closed while the final syllable in *tinók* 'baby' is closed. Only simple nuclei were included in the target word sample. The status of complex nuclei in Hebrew is unclear and there are no tautosyllabic long vowels in Hebrew (Laufer 1990).

*Segments*: All the segments in Hebrew (see tables (15) and (16) in §1.2.1) were included in the target words. Our purpose was to examine the relationship between segment acquisition and phonological phenomena dealing with their position in the syllables and in the words. Therefore, each segment appeared in different syllable positions. For example: the segment *m* appeared in the word *mic* 'juice' (word initial onset), *îma* 'mother' (word medial onset of an unstressed syllable), *ámbulans* 'ambulance' (coda in the initial stressed syllable), *ambátya* 'bath' (coda in the initial unstressed syllable), *ofanáim* 'bike' (coda in the final unstressed syllable), and also one of the segments in a complex onset in *tmuná* ‘picture’. As stated, each segment appeared in various positions in the syllables, unless it did not exist in a specific position in Hebrew. For example: the segments *p* and *b* do not appear in word-final position in Hebrew.

### 4.2.3. Transcription, encoding, and data analysis

An utterances was considered a word according to the criteria detailed in §4.2.1.4 above. Only these words were transcribed and analyzed. Thus, words that didn’t satisfy one or more of the relevant criteria were excluded from the data sample.

Each recording session was transcribed orthographically and phonetically by a speech therapist using the format of Child Language Data Exchange System (CHILDES; Brian MacWhinney and Catherine Snow 1985). The transcription and data analysis were carried out by using two tools in the CHILDES system: the CHAT (Codes for the Human Analysis of Transcripts) and the CLAN (Computerized Language Analysis). The CHAT is a transcription and coding format while the CLAN is an analysis program.

#### 4.2.3.1. Transcription and coding

As stated, the CHAT system was used for transcribing and coding the data sample. It provides a standardized format for producing computerized transcripts of face to face conversational interactions.

Each audio-recorded session was transcribed and coded according to a detailed coding system, which was developed especially for the current study. Data was stored in a computerized file for further analysis. Each file (i.e. a recording session) included background information i.e. age of the child, sex, group of the child (Cochlear Implant; Hearing Aid), child’s date of birth, date of recording, encoder’s name, language of child, location (home, clinic, kindergarten), serial number of recording. After the background information, the data was transcribed and coded at the word level and at the syllable level.

For assessing reliability, 60% of the coded files were checked by a second independent transcriber who was unfamiliar with both the subjects and other details of the present study.

#### 4.2.3.2. Data analysis

The CLAN system is designed specifically for analyzing data transcribed in the format of the Child Language Data Exchange System (CHILDES). It allows conducting a large number of automatic analyses on transcribed data.

Data samples were analyzed for each child according to the following phonological levels: the prosodic word, the syllabic structure, the segments within the word.

*On the prosodic word level*, I analyzed the development of the number of syllables in a word, syllable deletion compared to the target word, stress position in a word and its effects on syllable preservation or deletion.

*On the syllabic level*, I analyzed the acquisition of the syllable constituents: preservation, deletion, or replacement of onsets and codas, cluster production, nucleus changes (vowel replacement and vowel lengthening), and the effect of segment position in a word on syllable production.

### 4.2.4. Data presentation

Prosodic level data are analyzed and presented for each child separately, and are then presented with general tendencies as a group; thus, comparison between the cochlear implant group and the hearing aid group is conducted. Then, the data of the hearing impaired children are compared to those of hearing children Hebrew-speaking and other languages.

Since no difference was found among the spontaneous sampling task, the naming sampling task, and the repetition sampling task, all types of eliciting data were analyzed and presented together.

As stated, the study is longitudinal and contains a lot of data that cannot all be presented. Therefore, examples of the children's production throughout the study are presented in the body of the study, describing each specific stage of the phonological acquisition.

All children's productions were transcribed with a phonemic transcription and were presented as follows: the phonemic transcription (IPA) of the target word is presented on the left, the translation of the word in English, the phonemic transcription (IPA) of the child's production, and then child's serial number and age. The primary stress is marked with an acute above the nucleus of the stressed syllable (e.g. 'chair' *kisé*). The consonants *h, ʔ* are not indicated in data transcription. The assumption is that glottal stops in word-initial position are not phonological but rather phonetic elements (Bolozky 1978, Laufer 1990). Thus, a word beginning with a glottal stop is transcribed with the syllabic nucleus only at the beginning of the word (e.g. the word 'daddy' was transcribed as *ába* and not as *ʔába*).

### 4.2.5. Identifying stages

It is well known that language acquisition is a gradual process, and stages of acquisition are not entirely pure. That is, at every point of the process of acquisition, we find not only the characteristics of the relevant stages, but also some remnants of the previous stage, and evidence for the following stage. The task of identifying the stages and detecting the point of transition from one stage to another is, therefore, no simple matter.

In this study, I use two quantitative parameters to identify the point of transition from stage n-1 to stage n.

a. The production parameter: The ratio of words produced with the structure characterizing stage n.

b. The target parameter: The ratio of target words that can fit the structure characterizing stage n, regardless of whether they were produced with this structure.

It is essential to see an increase in both parameters to identify transition. Increase in the target parameter alone can often be identified in stage n-1. That is, the children start responding to structures that fit stage n, although they still produce them in structures fitting stage n-1. Only when production comes in, the transition is identified.

The term ‘stage’ is used with reference to every structure independently, e.g. stages of onset development, stages in the development of the prosodic word, etc.

For example, during the first four sessions, child A1 responded only to monosyllabic target words, which fitted his initial state, although he was introduced to the pictures/objects corresponding to polysyllabic target words. During the 5th session, he started responding to a few disyllabic words, which he produced as monosyllabic, and during the 10th session, he started producing disyllabic words. During the last session of the initial state (the 11th), he responded to three disyllabic target words, one of which was monosyllabic. During the following session (the 12th), he responded to sixteen disyllabic target words, four of which were monosyllabic. The great increase in the number of target words that can fit the stage (from 3 to 16), and the increase in the number of productions that fit the stage (from 66% to 75%) allow us to identify the 12th session as the beginning of the minimal word stage. The transition between the initial stage and the minimal word stage of child A1 is presented in table (29) below.

(29)

| Child A1 | | A1 Productions | | | |
|---|---|---|---|---|---|
| | | | Disyllabic target words | | |
| Period | Age | Total productions | Target parameter | Production parameter | |
| 1st meeting | 1;5 | 2 | 0 | 0 | 0% |
| 2nd meeting | 1;7.11 | 2 | 0 | 0 | 0% |
| 3rd meeting | 1;7.25 | 4 | 0 | 0 | 0% |
| 4th meeting | 1;8.16 | 1 | 0 | 0 | 0% |
| 5th meeting | 1;8.23 | 3 | 1 | 0 | 0% |
| 6th meeting | 1;9.14 | 2 | 0 | 0 | 0% |
| 7th meeting | 1;9.21 | 4 | 1 | 0 | 0% |
| 8th meeting | 1;10.11 | 5 | 2 | 0 | 0% |
| 9th meeting | 1;11.15 | 3 | 0 | 0 | 0% |
| 10th meeting | 2;0.6 | 9 | 3 | 2 | 66% |
| 11th meeting | 2;1.12 | 18 | 3 | 2 | 66% |
| 12th meeting | 2;1.19 | 30 | 16 | 12 | 75% |

These two parameters are also used for comparison among stages. At various points throughout the study I present quantitative data which show that the structure characterizing stage n gets higher percentage in stage n than in stage n-1 in both the production and the target parameters.

# PART III FINDINGS

## CHAPTER 5: THE DEVELOPMENT OF THE PROSODIC WORD

This chapter documents and analyses the development of the prosodic word in the speech of the hearing impaired subjects with CI. It follows the stages reported in the literature on the development of the prosodic word in the speech of hearing Hebrew-speaking children (see §2), starting with the initial stage (§5.1) in which words are monosyllabic and where reference to prosodic cues, such as stress and the position of the syllable within the word, are scarce. It then continues to the minimal word stage (§5.2), where the words produced by the children are maximally disyllabic, and the syllables selected from the target word are the stressed and final syllables, or the stressed/final and pre-final syllables (in cases where the final syllable is stressed). In the following pre-final stage (§5.3), the children expand the number of syllables to three, and at the end, in the final stage (§5.4), they produce all the syllables in quadro-syllabic target words. Findings are presented with general tendencies of all the implanted children as a group, and are compared to typical development of hearing children speaking Hebrew and other languages.

Each section contains data of some of the children as well as analyses and discussion according to the theoretical background presented above (§1) and in comparison to the typically developmental hearing children.

### 5.1. The initial stage: monosyllabic word productions

#### 5.1.1. Surface structure of the children's production

It has been reported in studies on early language development, that the first words children produce are, in most cases, monosyllabic and codaless; see Ingram (1989a) for English, Fikkert (1994) for Dutch, Demuth and Fee (1995) for Dutch and English, Garret (1998) for Spanish, Grijzenhout and Joppen (1999) for German, Ben-David (2001) and Adam (2002) for Hebrew. The findings of the current study confirm those of the above reports. During the initial stage, the vocabulary of the CI children included mostly monosyllabic words, regardless of the number of syllables in the target word.

Monosyllabic production, characterizing the initial stage, is frequent. However, it raises the question: what are the factors which 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? In the following sub-section, I will discuss this issue and try to answer these questions in relation to different types of target words.

### 5.1.2. The relation between the children's production and the target words

Most target words to which the children responded were monosyllabic, a few were disyllabic, and even fewer trisyllabic, although the children were shown the entire set of pictures and toys, which also included target words with three and four syllables.

#### 5.1.2.1. Monosyllabic target - monosyllabic production

The table below provides a sample of the children's productions for monosyllabic target words. Unless otherwise specified, the quantitative data refer to tokens. Within a stage different productions of the same target word are counted as different tokens, and the number of target words token is the same as the production tokens. For example, in (30) below there are four production tokens for the word *pil* 'elephant'; *mi, pe, pi*, and *i:* and thus also four target word tokens.

(30) Target: **monosyllabic words** (CV, VC, CVC)
Production: **monosyllabic words** (CV, VC, CVC, V, V:)

| Target | | | Children's Production | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | CV | V | V: | (C)VC | Child | |
| CV | mu | 'cow sound' | mu | u | | | A1 | 1;5 |
| | | | ba | | | | A5 | 2;0 |
| | lo | 'no' | | o | o: | | A1 | 1;5 |
| | | | bo | | | | A3 | 2;5 |
| | tu | 'train sound' | | | u: | | A1 | 1;8 |
| | | | | u | u: | | A5 | 1;11 |
| | | | tu, bu | | | | A3 | 2;3 |
| | me | 'sheep sound' | be | e | | | A1 | 1;9 |
| | | | me | | | | A3 | 2;2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | pe | ‘mouth’ | me | | | | A1 | 1.11 |
| | | | | e | | | A6 | 2;8 |
| | bo | ‘come! ms.sg.’ | bo | | | | A4 | 2;5 |
| | po | ‘here’ | | | o: | | A6 | 2;10 |
| | | | po | | | | A2 | 1;7 |
| CVC | pil | ‘elephant’ | mi | | i: | | A1 | 2;1 |
| | | | pe, pi | | | | A3 | 2;2 |
| | yad | ‘hand’ | ya | | a | | A1 | 1;9 |
| | day | ‘enough’ | | | | bay, day | A1 | 2;0 |
| | | | da | | | | A2 | 1;8 |
| | xam | ‘hot’ | | | a: | | A1 | 1.11 |
| | | | | | | am | A3 | 2;4 |
| | tik | ‘bag’ | | e | | | A1 | 2;1 |
| | cav | ‘turtle’ | ta | | | | A1 | 2;1 |
| | lex | ‘go! ms.sg.’ | | | e: | | A1 | 2;1 |
| | pax | ‘bin’ | | | a: | | A5 | 2;1 |
| | dag | ‘fish’ | ba | | | | A3 | 2;5 |
| | | | wa | a | | | A5 | 2;2 |
| VC | op | ‘hop’ | | o | | | A1 | 1;5 |
| | | | bo | | | op | A5 | 2;2 |
| | | | | | o: | | A4 | 2;5 |
| | oʁ | ‘light’ | | o | a:, o: | ow | A1 | 1;7 |
| | en | ‘none’ | | | e: | | A1 | 1;8 |
| | | | | a | | | A5 | 2;1 |
| | | | | | | en | A3 | 2;2 |
| | af | ‘nose’ | | | a: | | A1 | 1;11 |
| | aw | ‘dog sound’ | wa | | | aw | A1 | 1;11 |
| | | | | | a: | | A2 | 1;8 |
| | | | | | | am | A4 | 2;4 |
| | | | | u | | ay | A6 | 2;10 |
| | an | ‘car sound’ | | | a: | | A1 | 1;11 |
| | | | | | | an | A2 | 1;7 |
| | ec | ‘tree’ | | | e: | en | A1 | 2;0 |
| | od | ‘more’ | | o | | od | A4 | 2;5 |
| | | | | | o: | | A6 | 2;10 |
| | | | | | | od | A1 | 2;1 |
| | ay | ‘ah’ | | | | ay | A1 | 2;1 |
| | oy | ‘oh’ | | | o: | | A3 | 2;2 |
| | | | yo | | | | A2 | 1;8 |
| | am | ‘for food’ | | | | am | A2 | 1;7 |

The following tables provide a quantitative view of the children’s productions of monosyllabic target words, with reference to the different types of syllables.

(31) Distribution of children’s productions

| Target | | Children’s production | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CV | | V | | V: | | VC | | CVC | |
| CV | 68 | 37 | 54% | 21 | 31% | 6 | 9% | 4 | 6% | | |
| CVC | 27 | 14 | 52% | 3 | 11% | 6 | 22% | 2 | 7% | 2 | 7% |
| VC | 85 | 8 | 9% | 21 | 25% | 28 | 33% | 28 | 33% | | |
| Total | 180 | 59 | 32.8% | 45 | 25% | 40 | 22.2% | 34 | 19% | 2 | 1% |

(32)

|  | Target |  | Production |  |
|---|---|---|---|---|
| σ with coda | 112 | 62% | 36 | 20% |
| σ without coda | 68 | 38% | 144 | 80% |
| Total | 180 |  |  |  |

Tables (31) and (32) above point towards a preference for codaless syllables. While most of the target words include syllables with a coda, i.e. CVC and VC (112/180=62%), only in 20% is the coda produced (36/180). These findings reflect the universal unmarkedness of a codaless syllable (Ingram 1989a, Fikkert 1994, Demuth and Fee 1995, Garret 1998, Grijzenhout and Joppen 1999, Ben-David 2001 and Adam 2002).

As for the onset, literature on the early acquisition of various languages report that the first syllables acquired are with an onset (thus CV, given the preference of syllables without a coda); see Ingram (1989a) for English, Fikkert (1994) for Dutch, Demuth and Fee (1995) for Dutch and English, Garret (1998) and Goldstein and Cintron (2001) for Spanish, Grijzenhout and Joppen (1999) for German, Ben-David (2001) and Adam (2002) for Hebrew. In some languages, children even insert a consonant in an onset position when the target syllable is onsetless. In our study, only a few target onsetless syllables gained an onset in the children's productions (8/85=9%). Moreover, many target syllables with an onset were produced by the children without an onset (42/95=44%). Note that the absence onset cannot be attributed to segmental effects, since we find *u* for *mu* 'cow sound', *e* for *pe* 'mouth' etc. that is, also the first acquired segments can be deleted.

While typically developed Hebrew-speaking children refrain from inserting a consonant in onset position, they hardly ever produce words without a consonant. Ben-David (2001) reports that, with the exception of one word, all words were produced with at least one consonant. Thus, during the initial stage, when most syllables were codaless, only those corresponding to target VC words had a coda. This, however, was not the case with the hearing impaired children in this study, who produced words without consonants (V and V:) in 85 out of the 180 target words

(47%). This comprises 33% of the target CVC words, 40% of the target CV words, and 49% of the target VC words. These findings are not compatible with those of Ben-David's (2001), where, as noted above, all words produced by hearing-children consisted of at least one consonant. In addition, the hearing-impaired children produced long vowels in 40 out of the 85 (88.9%) consonant-free words; 9% of the target CV words, 22% in the target CVC words, and 33% in the target VC words. In addition, long vowels were not reported in the studies of hearing children. These phenomena, i.e. consonant-free words (§7.3.1) and long vowels (§7.3.2), will be discussed in the discussion section.

#### 5.1.2.2. Disyllabic target - monosyllabic production

For disyllabic target words, as shown in (33) below, the children produced the same types of monosyllabic words, with the addition of CV: words. The target disyllabic words introduce another issue regarding the inconsistency of the syllables selected from the target word. As shown below, there is no unified prosodic feature (i.e. stress or position in the word) characterizing the syllable selected from the target word.

(33) Target: **disyllabic words** – Production: **monosyllabic words**

| Target | | Children's productions | | | | Child | |
|---|---|---|---|---|---|---|---|
| | | Final Syllable | | Non-final syllable | | | |
| | | Stressed | Unstressed | Stressed | Unstressed | | |
| | | Ultimate | | | | | |
| limóʁ | 'proper name' | mo: | | | | A1 | 1;9 |
| nigmáʁ | 'was finished ms.sg' | ma | | | | A1 | 1;9 |
| bubá | 'doll' | ba, ba: | | | | A2 | 1;5 |
| caóv | 'yellow' | o: | | | | A6 | 2;8 |
| mocéc | 'dummy' | | | | mo | A1 | 1;9 |
| bakbúk | 'bottle' | | | | ba: | A1 | 1;9 |
| balón | 'balloon' | | | | ba:w | A1 | 2;1 |
| | | Penultimate | | | | | |
| máim | 'water' | i, i: | | | | A1 | 1;9 |
| | | | | ma | | A4 | 2.4 |
| | | | | ma: | | A6 | 2;10 |
| écba | 'finger' | | ba | | | A3 | 2;2 |
| áin | 'eye' | | | a | | A5 | 2;0 |
| álo | 'hello' | | | a: | | A1 | 2;1 |
| bói | 'come! fm.sg' | | | be | | A3 | 2;2 |
| báit | 'house' | | | ba:, a | | A5 | 2;0 |
| íma | 'mother' | | ma | | | A1 | 1;8 |
| íne | 'here' | | | i: | | A1 | 1;9 |

During this early stage of development, the children produced monosyllabic words for disyllabic target words. The question is, however, which of the two syllables in the target word the children select (see §5.2.2.4 for the same issue in trisyllabic words). The table in (33) above shows that the prosodic aspects that usually play a role in target production faithfulness relations, i.e. stress, and word-final syllable do not always hold. The children preserved one of the target syllables, either the **final stressed** syllable (e.g. *mo:* for *limóʁ* 'proper name'), the **final unstressed** syllable (e.g. *ba* for *écba* 'finger'), the **initial stressed** syllable (e.g. *i* for *íne* 'here'), or the **initial unstressed** syllable (e.g. *ba* for *bakbúk* 'bottle).

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 above has also been reported in other studies of normally developing French, Spanish and Hebrew-speaking children (Macken 1979 for Spanish, Boysson-Bardies 1996, Demuth and Johnson 2003 for French and Ben-David 2001, Adam 2002 for Hebrew) and with atypically developing children (Tubul 2005 for Hebrew). Some examples from the latter two studies are given below:

(34) Target: disyllabic words – Production: monosyllabic words

| Target | | Children's productions | | | | Source |
|---|---|---|---|---|---|---|
| | | Final Syllable | | Non-final syllable | | |
| | | Stressed | Unstressed | Stressed | Unstressed | |
| bámbi | 'Bambi' | | | ba | | Adam (2002) |
| ótobus | 'bus' | | bu | | | |
| kadúʁ | 'ball' | | | | ka | |
| tapúz | 'orange' | pu | | | | |
| matós | 'airplane' | | os | | | Tubul (2005) |
| paʁá | 'cow' | | | | pa | |
| máim | 'water' | | | ma | | |
| dúbi | 'teddy bear' | | bi | | | |

Adam (2002) notes that these forms could be a result of segmental effects. Following Levelt (1994), she proposes that the children's production during the initial stages of acquisition is affected by the vowel's 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*, and these vowels were faithful to those of the target syllables they chose to produce, with a preference of *a* over *u*. Noga (1;3-1;4), for example, produced *ka* for *múzika* 'music' (final unstressed syllable), as well as for *kadúʁ* 'ball' (non-final unstressed syllable), and Or (1;4-1;5) produced *ba* for *balón* 'balloon' (non-final unstressed syllable), as well as for *bámbi* 'Bambi' (non-final stressed syllable) and *bubá* 'doll' (final stressed syllable). Unlike Adam (2002), who suggests reference to the vowels, Tubul (2005) argues that the consonants rather than the vowels play a role in this selection. Orit (4;5), for example, produced *bi* for *bisk.vít* 'biscuit' (non-final unstressed syllable) rather than *vit* (final stressed syllable) since the segment *v* did not exist in the child's repertoire of segments. We should bear in mind, however, that both Adam (2002) and Tubul (2005) base their arguments on a small database.

The data presented in my study support the above proposals, that at this stage of acquisition, the children select a syllable of the target word on the basis of segmental rather than prosodic considerations. However, the preference of a certain syllable in a word is determined by both vowels and consonants. I believe that the children in the current study select one syllable of the target word according to its consonant and/or vowel inventory compared to the vowel or consonants of the neighboring syllables. The data in (33) above show a clear preference for labial consonants in words corresponding to disyllabic target words. A syllable with a labial consonant (*b* or *m*) is preferred in all cases to a syllable without a labial. For example, *mo:* is preferred over *li* in *limoʁ́* 'proper name', *ma* is preferred over *ni* in *nigmáʁ* 'finished', *ba:w* is preferred over *lo* in *balón* 'baloon', and *ba:* is preferred over *it* in *báit* 'house'. When both syllables have labials, the vowels play a role. In these cases, a syllable with the vowel *a* is preferred over a syllable with the vowel *u* (as in Adam's study). For example, *ba* is preferred over *bu* in *bubá* 'doll' and in *bakbúk* 'bottle'. Only when both syllables have non-labial consonants, the role of the stress emerges, and the selected syllable is the stressed one. Thus, *o:* is preferred rather than *ca* in *caóv* 'yellow', *i:* rather than *ne* in *íne* 'here',and *a:* rather than *lo* in *álo* 'hello'.

The case of *máim* 'water' includes all the considerations above: both syllables in *máim* contain a labial consonant, though in the first the *m* is in onset position (*ma*), while in the second it is in coda position (*im*). The first syllable contains the preferred vowel *a* while the second syllable contains the vowel *i*. Also, the first syllable is the stressed one. Since the vowel *a* is the unmarked selection, we would expect the child to choose the first stressed syllable with the vowel *a* rather than the second unstressed syllable with the vowel *i,* as did most of the children in the study, i.e. they selected the stressed syllable *ma* which consists of a labial consonant in onset position with the preferred vowel *a.* A1 (1:9) however, choosed the second syllable, i.e. the unstressed syllable and omitted the *m* since it is in coda position (see discussion on the coda's status during this stage of development in §6.3.1 below).

This example suggests that although the segmental preference has hierarchical organization, variability among children might appear, and when more than one aspect play a role in a specific word, different productions are possible.

The above hierarchy of considerations is presented below (35)

(35)

|  | Target Shape | Selection | Examples |
|---|---|---|---|
| 2 labials | BVBV | V=a | *ba* for *bubá* 'doll' |
| 1 labial | BVCV/ CVBV | BV | *ma* for *íma* 'mother' |
| no labial | CVV/VCV | (C)V (stressed) | *i:* for *íne* 'here' |
|  |  |  | *o:* for *caóv* 'yellow' |

B=labial V=vowel C=consonant VV= two syllables

To summarize, although most Hebrew words are at least disyllabic (Bolozky 1978), at this stage the children did not try to produce target words with more than two syllables. Moreover, the initial stage is characterized mostly by monosyllabic codaless word productions (CV, V, and V:), regardless of whether the target word consists of one or two syllables. Demuth and Fee (1995), among others, report that English-speaking children begin their production with the "Core Syllable" or the "Sub-minimal word", where their words consist of a single monomoraic syllable, containing neither coda consonants nor consistent use of vowel length. At this stage, early forms are generally CV in shape. The authors report that children pass through this stage for a short period of time, when their vocabulary is very small (Demuth and Fee (1995) for English, Demuth and Johnson (2003) for French, and Fikkert (1994) for Dutch). The same is reported for Hebrew-speaking children's earliest words, as described by Ben-David (2001) and Tubul (2005). The children in my study produced early word forms with a CV shape, alongside words with VC, CVC, CV:, V: and V shapes. But in comparison to Ben-David (2001) and Tubul (2005), their productions contained either short or long vowels. This last phenomenon (i.e. long vowels) is not frequent in Hebrew and will be discussed later (§6.3.1 and §7.3.2). As for the syllable content, the CI children produced the words on the basis of segmental effects, i.e. consonant or vowel preferences. The same findings are reported in the typical development of hearing children speaking Hebrew and other languages.

#### 5.1.2.3. Transitional period to the following stage

Towards the end of the initial state, or more precisely, during the last two meetings of this stage, the children started producing a few disyllabic words, which reflected a transition to the following stage (see §4.2.5). Table (36) below presents data of disyllabic word productions for polysyllabic target words, showing the transition to the following stage (for the stages of the prosodic word of each child see appendix 8a). The data are discussed in the following section, which describes the minimal word stage (§5.2).

(36) Target: **Polysyllabic words** - Production: **disyllabic words**

| Target | | Children's Productions | Child | |
|---|---|---|---|---|
| Target words with ultimate stress | | | | |
| balón | 'balloon' | baó, baló | A1 | 2;0 |
| bakbúk | 'bottle' | aó | A1 | 2;1 |
| baybáy | 'bye' | babá, mamá | A1 | 2;1 |
| | | bebá: | A5 | 1;11 |
| aviyá | 'proper name' | aá | A1 | 2;0 |
| paʁpáʁ | 'butterfly' | papá | A5 | 2;2 |
| | | aá | A1 | 1;11 |
| adáʁ | 'proper name' | aá | A1 | 2;1 |
| imʁí | 'proper name' | íi | A1 | 2;1 |
| aʁbé | 'a lot' | abé | A3 | 2;4 |
| nafál | 'fell down ms.sg.' | apá, papá | A1 | 2;1 |
| todá | 'thanks' | dadá | A3 | 2;2 |
| kadúʁ | 'ball' | adú | A3 | 2;4 |
| ʃaón | 'watch' | yaó: | A2 | 1.9 |
| Target words with penultimate stress | | | | |
| máim | 'water' | mái, mái: | A1 | 2;2 |
| | | áim | A3 | 2;4 |
| mástik | 'chewing gum' | mái | A1 | 2;1 |
| kóva | 'hat' | pópa | A3 | 2;5 |
| dúbi | 'teddy bear' | dúbi | A3 | 2;5 |
| pípi | 'penis' | pípi | A1 | 2;1 |
| báit | 'house' | bíi | A1 | 2;1 |
| bámba | 'snack' | pápa | A1 | 2;1 |
| tíktak | 'clock sound' | títa | A3 | 2;2 |
| sáfta | 'grandmother' | áa | A1 | 2;1 |
| écba | 'finger' | éba:, bába: | A3 | 2;1 |
| éfo | 'where' | fófo | A3 | 2;2 |
| íma | 'mother' | máma | A5 | 2;2 |
| ába | 'daddy' | ába, áa | A5 | 2;2 |

The criteria of transition between the stages are defined in §4.2.5 in terms of two quantitative parameters, which identify the point of transition from stage n-1 to stage n: **the production parameter**: the ratio of words produced with the structure characterizing stage n, and **the target parameter**: the ratio of target words that can fit the structure characterizing stage n, regardless of whether they were produced with this structure. Thus, transition to the minimal word stage was determined when there was a significant increase in both parameters during the two last meetings of the initial stage. The great increase in the number of target words that fit the minimal word stage, and the increase in the number of productions that fit the stage allowed us to identify a certain session as the beginning of the minimal word stage.

## 5.2. The minimal word stage: disyllabic word productions

### 5.2.1. Surface structure of the children's production

In this subsection, I present data of the CI children that provide evidence for the Minimal Word Stage. The data show that there is a phase in children's language development in which for every polysyllabic word, a disyllabic word is the minimal and maximal prosodic word. According to McCarthy and Prince (1993), minimal words are the unmarked prosodic words provided by universal grammar.

Indeed, in many languages, there is a stage in acquisition 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, Winjnen et al. 1994, Demuth and Fee 1995, Demuth 1995, 1996 and Salidis and Johnson 1997 for Dutch and English, Garret 1998 for Spanish, Rose 2000 and Demuth and Johnson 2003 for French, Ota 1998 for Japanese, Ben-David 2001 and Adam 2002 for Hebrew). While in English and Dutch, foot binarity can be achieved either by a moraic or syllabic analysis, the Hebrew foot is binary only under a syllabic analysis (see §1.2.2).

### 5.2.2. The relation between the children's production and the target words

#### 5.2.2.1. Disyllabic target - disyllabic production

The examples in (37) below present a sample of words produced by the CI children during the minimal word stage for **disyllabic target words** (subscript "1" indicates that the word appeared towards the end of the initial state (36); when the same word appeared in both the initial state and the minimal word stage, subscript "2" was added).

(37) Target: **Disyllabic words** – Production: **Disyllabic words**

| Target | | Children's Productions | Child | |
|---|---|---|---|---|
| Target words with ultimate stress | | | | |
| nafál | 'fell ms.sg.' | apá, papá | A1 | 2;2 |
| paʁpáʁ | 'butterfly' | aá$_{1,2}$, papá | A1 | 2;2 |
| patíʃ | 'hammer' | patíʃ | A1 | 2;4 |
| kivsá | 'sheep' | iá | A1 | 2;4 |
| bakbúk | 'bottle' | babú | A1 | 2;4 |
| ʃalóm | 'hello' | aló | A3 | 2;8 |
| yaldá | 'girl' | tatá | A3 | 2;8 |
| ʃulxán | 'table' | dudá | A6 | 3:10 |
| mitá | 'bed' | titá | A6 | 3;10 |
| tmunót | 'pictures' | tunót | A2 | 2;5 |
| xatúl | 'cat' | xatúl | A2 | 2;5 |
| aʁbé | 'a lot' | bebé, abé | A4 | 2;8 |
| ʃalóʃ | 'three' | tayó, ʃaó | A4 | 2;8 |
| Target words with penultimate stress | | | | |
| íma | 'mother' | ípa | A1 | 2;2 |
| mástik | 'chewing gum' | mái | A1 | 2;2 |
| kóva | 'hat' | pópa | A3 | 2;5 |
| íne | 'here' | íne | A3 | 2.5 |
| dúbi | 'teddy bear' | dúbi, búbi, bibi | A3 | 2;5 |
| máim | 'water' | áim | A3 | 2;5 |
| | | máim | A6 | 3;10 |
| péʁax | 'flower' | péa: | A3 | 2;6 |
| délet | 'door' | déle | A3 | 2;8 |
| óto | 'car' | óto | A6 | 3.1 |
| sába | 'grandfather' | bába | A6 | 3.1 |
| tʁáktoʁ | 'tractor' | táto | A6 | 3;10 |
| pílpel | 'pepper' | pípe | A6 | 3;10 |
| ʃémeʃ | 'sun' | ébeʃ | A6 | 3;10 |
| éfo | 'where' | épo, ébo | A4 | 2;8 |
| álo | 'hello' | áyo$_{1,2}$ | A4 | 2;8 |

Table (38) below presents the percentage of the disyllabic production in the initial and the minimal word stages both for target words with ultimate and penultimate stress.

(38) Syllable preservation in disyllabic target words during the initial and the minimal word stages.

| Target | Children's productions | | | | | |
|---|---|---|---|---|---|---|
| | Preservation of two syllables in the initial stage | | | Preservation of two syllables in the minimal word stage | | |
| | Target | Production | % | Target | Production | % |
| Ultimate stress | 27 (31.4%) | 20 | 74% | 792 (47.7%) | 661 | 83.5% |
| Penultimate stress | 59 (68.6%) | 47 | 80% | 867 (52.3%) | 822 | 94.8% |
| Total disyllabic words | 86 (35%) | 67 | 78% | 1659 (60%) | 1483 | 89% |
| Total number of the whole data | 245 | | | 2753 | | |

**The target parameter**: Although disyllabic words were produced also during the initial stage, the distinction between the initial and the minimal word stage is clear on the target parameter. The table presents an increase in the target tokens of disyllabic words to which the children responded during the minimal word stage (1659/2753= 60%) compared to the initial stage (86/245=35%). These numbers reflect the characteristic of the minimal word stage in which a preference for disyllabic target words is reflected.

**The production parameter**: As can be seen from the table above, during the minimal word stage, children tend to preserve the two syllables in disyllabic target words with ultimate stress (661/792=83.5%), as well as with penultimate stress (822/867=94.8%) to a larger extent than in the initial stage (20/27=74% tokens of produced words with ultimate stress, and 47/59=80% tokens of produced words with penultimate stress). The total numbers show that 1483 out of 1659 disyllabic tokens (89%) are produced during the minimal word stage, compared to only 67 out of 86 disyllabic tokens (78%) produced during the initial stage. Wilcoxon Signed Ranks Test shows a significant difference between the minimal word stage and the initial word stage for disyllabic tokens with penultimate stress (Z=2.201, p=0.028). However, statistical analysis using Wilcoxon Signed Ranks Test failed to show differences between stages for disyllabic tokens with ultimate stress (Z=1.153,

$p > 0.05$). These findings can be attributed to the large standard deviations at this group of words (X=50.53, S.D.= 47.82).

However, it seems that there is a tendency to preserve target words with penultimate stress rather than with ultimate stress. In other words, throughout the minimal word stage, children tend 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 omit syllables, it is usually the weak syllable in words with ultimate stress. This phenomenon, which occurs throughout the following stages, is also reported in the literature (Taelman 2004) and will be discussed later.

#### 5.2.2.2. Trisyllabic target - disyllabic production

The following table presents the children's productions during the minimal word stage for trisyllabic target words with different stress patterns.

(39) Target: **Trisyllabic words** - Production: **Disyllabic words**

| Target | | Children's Productions | Child | |
|---|---|---|---|---|
| Target words with ultimate stress | | | | |
| kubiyót | 'blocks' | biyó | A1 | 2;4 |
| masaít | 'truck' | aí:, maít | A1 | 2;4 |
| daniél | 'proper name' | nié | A2 | 2;1 |
| mitʁiyá | 'umbrella' | miyá | A2 | 2;4 |
| madbiká | 'glues fm.sg.' | itá | A2 | 2;1 |
| agalá | 'cart' | dalá | A2 | 2;5 |
| meluná | 'doghouse' | yuná | A3 | 3;3 |
| igulím | 'circles' | dulím | A3 | 3;3 |
| cipoʁím | 'birds' | polí: | A3 | 3;5 |
| aviʁón | 'airplane' | abó | A6 | 3;6 |
| Target words with penultimate stress | | | | |
| banána | 'banana' | nána | A1 | 2;4 |
| alóni | 'proper name' | óni | A2 | 2;1 |
| enáim | 'eyes' | nái, náim | A2 | 2;1 |
| siyámnu | 'finished ms.pl.' | ánu | A2 | 2;1 |
| lemála | 'above' | mána | A2 | 2;4 |
| ǰiʁáfa | 'giraffe' | yáfa | A2 | 2;4 |
| tapúax | 'apple' | púa, púax | A6 | 3;6 |
| Target words with antepenultimate stress | | | | |
| télefon | 'phone' | téfon | A2 | 2;5 |
| | | éfo | A3 | 3;6 |
| | | éo:, téo: | A5 | 2;6 |
| ótobus | 'bus' | óbuθ, bábuθ, ábuθ, óboθ | A2 | 2;5 |
| | | búbu, óbuθ, tóbus | A3 | 3;3 |
| | | óbus | A1 | 2;5 |
| | | óbu:, ábu, yóbu | A6 | 3;11 |
| ʃókolad | 'chocolate' | kóla, tóla | A4 | 3;3 |
| | | ʃólat | A3 | 3;5 |
| bégale | 'pretzel' | béled | A2 | 2;6 |

The quantitative data below show that during the minimal word stage there is as expected, a significant increase in responses to trisyllabic target words, mostly with disyllabic productions. However, at this stage there is an increase in the target parameter (i.e. trisyllabic target words) but not in the production parameter. In other words, during the initial stage, there were only 5 tokens of trisyllabic target words to which the children responded, which comprised 2% of the tokens (5/245). During the minimal word stage, there was a significant increase in responses to trisyllabic target words, i.e. 321 tokens of trisyllabic target words, which comprise 11.66% (321/2753).

(40) Preservation of syllables for trisyllabic target words in the initial stage and in the minimal word stage

| Trisyllabic target words | Target | | Children's Productions | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total number of trisyllabic of the all data | Trisyllabic targets at each stage | 1σ **Preservation** | | 2σ **Preservation** | | 3σ **Preservation** | |
| Total – Initial stage | 245 | 5 (2%) | 1 | 20% | 2 | 40% | 2 | 40% |
| Total- Minimal stage | 2753 | 321 (11.66%) | 17 | 5% | 179 | 56% | 125 | 39% |

### 5.2.2.3. Quadrisyllabic target - disyllabic production

The following table presents data from children's production during the minimal word stage for quadrisyllabic target words with different stress patterns.

During the initial stage, there were only 2 tokens of quadrisyllabic target words to which the children responded, which comprised 0.8% of the tokens (2/245). During the minimal word stage, however, there was a significant increase in responses to quadrisyllabic target words, i.e. 83 tokens of quadrisyllabic target words, which comprise 3% (83/2753).

(41) Target: **Quadrisyllabic words** – Production: **Disyllabic words**

| Target | | Children's Productions | Child | |
|---|---|---|---|---|
| Target words with ultimate stress | | | | |
| melafefón | 'cucumber' | mefón | A2 | 2;6 |
| | | papó | A1 | 2;5 |
| | | fefón | A3 | 3;7 |
| | | apó, yapó | A6 | 4;1 |
| ipopotám | 'hippopotamus' | titá, topám | A6 | 4;1 |
| agvaniyá | 'tomato' | iá | A6 | 4;3 |
| Target words with penultimate stress | | | | |
| televízya | 'television' | vída | A2 | 2;5 |
| | | íya | A6 | 4;3 |
| miʃkafáim | 'glasses' | pái:, ái:m, máim | A1 | 2;3 |
| naaláim | 'shoes' | yái: | A1 | 2;4 |
| ofanáim | 'bicycle' | pái: | A1 | 2;4 |
| mispaʁáim | 'scissors' | páim, pái | A1 | 2;5 |
| mixnasáim | 'pants' | sái | A3 | 3;3 |
| ofanóa | 'motorcycle' | nóa | A1 | 2;5 |
| avatíax | 'water melon' | tíax | A3 | 3;0 |
| | | ía, íax | A6 | 4;1 |
| taʁnególet | 'hen' | dólet, tólet | A3 | 3;3 |

### 5.2.2.4 Faithfulness to the prosodic properties of the target word

As opposed to the initial stage, during which it seems that the segmental features affect the preference of the syllable preservation in the children's production, during the minimal word stage, the prosodic properties, i.e. the stress patterns and the word edges, are dominant and influence the output forms. These data are shown in table (38) above for **disyllabic target words**. The children produced the two syllables in 83.5% (661/792) target tokens with ultimate stress, and 94.8% (822/867) target tokens with penultimate stress, thus showing a preference to produce target words with penultimate stress rather than words with ultimate stress (see the discussion in §5.2.2.1).

The data for **trisyllabic target words** are shown in table (42) below. For target words with **ultimate stress**, the children produced the final stressed syllable and the penultimate unstressed syllable (deletion of 70% of the antepenultimate syllables as opposed to 29% and 1% of the penultimate and ultimate syllables respectively). For example, child A1 produced *biyó* for the target word *kubiyót* ‘blocks’ (the ultimate stressed syllable and the penultimate unstressed syllable). For target words with **penultimate stress**, the children produced the penultimate stressed syllable and the ultimate unstressed syllable (deletion of 83% of the antepenultimate syllable as opposed to 4.5% and 12.5% of the penultimate and the ultimate syllables respectively). For example, child A2 produced *nána* for *banána* ‘banana’ preserving both the penultimate stressed syllable and the ultimate unstressed syllable. Finally, for target words with **antepenultimate stress**, the children produced the antepenultimate stressed syllable with the ultimate unstressed syllable (deletion of 80% of the penultimate syllables as opposed to 20% and 0% of the antepenultimate and the ultimate syllables respectively). For example, child A3 produced *ʃólat* which are the antepenultimate stressed and ultimate unstressed syllables for the target *ʃókolad* ‘chocolate’.

(42) Syllable **deletion** in trisyllabic target words

| Trisyllabic target words | | Children’s Productions | | | | | |
|---|---|---|---|---|---|---|---|
| | | Syllable **deletion** from $\sigma_3\sigma_2\sigma_1$ | | | | | |
| | | $\sigma_3$ | | $\sigma_2$ | | $\sigma_1$ | |
| Ultimate (wws) – $\sigma_3\sigma_2\acute{\sigma}_1$ | 96 | 68 | 70% | 28 | 29% | 1 | 1% |
| Penultimate (wsw)- $\sigma_3\acute{\sigma}_2\sigma_1$ | 88 | 73 | 83% | 4 | 4.5% | 11 | 12.5% |
| Antepenultimate (sww)- $\acute{\sigma}_3\sigma_2\sigma_1$ | 20 | 4 | 20% | 16 | 80% | -- | |
| Total | 204 | | | | | | |

To summarize, like hearing Hebrew-speaking children (Ben-David 2001, Adam 2002) and children with atypical development (Tubul 2005), the children in the current study selected the last two syllables from the target word, one of which is stressed.

(43) Productions of trisyllabic target words – Comparison among different studies

| | Children’s productions | | |
|---|---|---|---|
| Target | Ben-David (2001) | Tubul (2005) | Current study |
| ǰiʁáfa ‘giraffe’ | fáfa | fáfa | yáfa |
| enáim ‘eyes’ | | nái | nái, náim |
| aviʁón ‘airplane’ | ión | biló | abó |
| agalá ‘cart’ | alá | galá | dalá |
| bégale ‘pretzel’ | éle | | béled |
| télefon ‘phone’ | téfon, téfo | téfo | téfon, éfó |
| ʃókolad ‘chocolate’ | ólat | | kóla, tóla, ʃólat |
| ótobus ‘bus’ | óbus | | óbuθ, bábuθ,<br>ábuθ, yóbu |

When the stressed syllable is the final one (i.e.**ultimate stress**), the children preserved both the ultimate stressed syllable and the unstressed syllable, usually the one adjacent to it (see table 42). However, there were cases in which segmental considerations interfered (see also §5.1.2.2). The words *maít f*or *masaít* ‘truck’ and *miyá* for *mitʁiyá* ‘umbrella’ are two examples of segmental effects, as it seems that the antepenultimate (rather than the penultimate) and the ultimate stressed syllables are selected. However, I assume that due to the absence of the *s* and the *ʁ* in the children’s segmental inventory, they picked the consonant from the first syllable to serve as the onset of the penultimate one (see Gnanadesikan 1995 for similar cases in English). When the target words are with **antepenultimate stress**, the children produced the initial stressed syllable with the ultimate unstressed syllable. However, the numbers in table (42) show 20% (4/20) of antepenultimate syllable deletion (i.e. **the initial stressed syllable**) for target words with antepenultimate stress. Once again, the reason for these numbers is probably attached to segmental effects: in the word *ótobus* ‘bus’ one child produced *tóbus* and the other *yóbu*. Since the initial stressed syllable is onsetless and contains the same vowel *o* as the adjacent syllable, I assume that they preserved the stressed syllable and filled it with an onset - either *t* or *y*. In the target word *ʃókolad* ‘chocolate’, where the child produced *kóla* and *tóla*, it seems like he omited the initial stressed syllable. I believe that once again, the segmental considerations affected his selection: due to the absence of the ʃ in the child's segmental inventory, he picked the onset from the adjacent syllable (*k* in *kóla*, and *t*- because of inconsistent fronting in *tóla*) and they served as an onset of the antepenultimate syllable.

The data for **quadrisyllabic target words** in table (41) above show the same tendencies. The children preserved the stressed and the final syllables of the target words. When the stressed syllable is also the final one, another unstressed syllable is preserved, usually the one adjacent to the stressed syllable. Notice also, that like the hearing children reported in Ben-David (2001), the children do not make any errors with respect to the position of stress.

#### 5.2.2.5. Summary

To conclude, the data presented above show that there is a stage in children's acquisition in which a disyllabic word is the maximal prosodic structure produced. Throughout this subsection, I showed that this restriction holds for various types of target words: disyllabic, trisyllabic and even quadrisyllabic words.

The quantitative data in (38) show progress with respect to the initial state in several aspects:

There is **an increase in the number of responses to disyllabic target words** in the minimal words stage as opposed to the initial state, i.e. 1659 responses to disyllabic words out of 2753 target words in the minimal word stage (60%) compared to 86 responses to disyllabic words out of 245 target words in the initial word state (35%).

There is also **an increase of the number of syllables** in the children's production. While most of the children's productions in the initial stage are monosyllabic (§5.1), there is a significant growth in the number of syllables in the minimal word stage, and most of the words are disyllabic both for disyllabic and trisyllabic target words.

During the minimal word stage we also see a slight increase in responses to

**trisyllabic target words.** As described in §4.2.1.2, in each recording session, the children were shown the entire set of pictures and toys, which also included target words with three and four syllables. However, in the initial stage, the children responded to very few trisyllabic target words. For example: Child A1 and A2 responded to 4 trisyllabic target words but produced only 2 as trisyllabic. At the beginning of the minimal word stage, the children started producing words corresponding to trisyllabic target words. In other words, the response to trisyllabic target words is taking over during the minimal word stage. Since the minimal word stage is characterized by words whose maximal size is disyllabic, as reviewed in §5.2, most of the children's outputs were disyllabic word.

Throughout the minimal word stage, the children started producing trisyllabic words for polysyllabic target words. For example: Child A1 produced *afió*: for *aviʁón* 'airplane', *meʃeʃó* for *melafefón* 'cucumber' (target words with ultimate stress), also *babáma* for *banána* 'banana', *paái:* for *mispaʁáim* 'scissors' (target words with penultimate stress), and also *ótobus* for 'bus', and *ábulas* for *ámbulans* 'ambulance' (target words with antepenultimate stress). The number of these productions increases towards the end of the minimal word stage.

As opposed to the initial stage, where the segments play a role in the selection of the syllable of the target word, in the minimal word stage, the prosodic properties, i.e. the stress patterns and the word edge, are dominant. In most cases, the children selected the last two syllables from the target word, usually the final and the stressed syllables are to be preserved.

## 5.3. The pre-final stage

### 5.3.1. Surface structure of the children's production

During the pre-final stage, the children expanded the number of syllables to three, for both tri- and quadrisyllabic target words.

(44) Target: **Tri- and quadrisyllabic words -** Production: **Trisyllabic words**

| Target | | Children's Productions | Child | |
|---|---|---|---|---|
| Trisyllabic target words | | | | |
| aviʁón | 'airplane' | avió: | A1 | 2;7 |
| ʃeʁutím | 'toilet' | ʃeutí: | A1 | 2;7 |
| taʁnegól | 'rooster' | tanegól | A2 | 2;9 |
| sevivón | 'spinning top' | iibó, tevivó | A4 | 3;5 |
| mitʁiyá | 'umbrella' | mitiyá | A2 | 2;9 |
| mataná | 'present' | ataná | A3 | 3;10 |
| sukaʁyá | 'candy' | kuayá | A3 | 3;10 |
| lemála | 'above' | lemáya | A1 | 2;7 |
| xatúla | 'cat' | xatúya | A1 | 2;7 |
| enáim | 'eyes' | enáim | A2 | 2;9 |
| ǰiʁáfa | 'giraffe' | ʃiáfa | A2 | 2;9 |
| liftóax | 'to open' | liftóax | A3 | 3;10 |
| ʁakével | 'train' | yabébet | A4 | 3;5 |
| ámbuʁgeʁ | 'hamburger' | águge | A3 | 3;10 |
| télefon | 'phone' | téyefo | A1 | 2;7 |
| ámbulans | 'ambulance' | ábulas | A1 | 2;7 |
| | | ádula | A4 | 3;6 |
| ótobus | 'bus' | ótobu | A1 | 2;7 |
| múzika | 'music' | múzika | A2 | 3;0 |
| Quadrisyllabic target words | | | | |
| akoʁdiyón | 'accordion' | kodiyó | A1 | 2;8 |
| melafefón | 'cucumber' | afapón | A2 | 2;11 |
| | 'cucumber' | mafefón | A1 | 2;8 |
| | 'cucumber' | peyapón, mepepón | A4 | 3;5 |
| laavodá | 'to work' | yavodá | A1 | 2;8 |
| ʃarʃeʁaót | 'necklaces' | ʃaʃeʁót | A3 | 4;10 |
| ipopotám | 'hippopotamus' | ipotá | A1 | 2;8 |
| sufganiyá | 'doughnut' | oiyá | A4 | 3;5 |
| leitʁaót | 'bye' | itʁaó | A4 | 3;7 |
| naaláim | 'shoes' | nayái: | A1 | 2;7 |
| mitkaléax | 'takes a shower ms.sg' | kaéax | A1 | 2;7 |
| miʃkafáim | 'glasses' | kafáim | A2 | 2;9 |
| mefaxédet | 'scared fm.sg.' | faxédet | A2 | 2;11 |
| yomulédet | 'birthday' | yulédet | A3 | 3;10 |
| mispaʁáim | 'scissors' | paʁái | A3 | 3;10 |
| taʁnególet | 'hen' | ególe | A6 | 4;7 |

### 5.3.2. The relation between the children’s production and the target words

As stated in §5.2, during the minimal word stage, disyllabic productions take priority, where 56% (179/321) are disyllabic, 5% (17/321) are monosyllabic, and 39% (125/321) are trisyllabic.

The trisyllabic productions, which start growing during the minimal word stage, reach completion in the following, pre-final stage.

During this stage, all three syllables of the trisyllabic target words appeared in the children’s speech, but the quadrisyllabic target words were still incomplete (table 44 above). For quadrisyllabic 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 (e.g. *kaéax* for *mitkaléax* ‘take a shower ms.sg.’, *kafáim* for *miʃkafáim* ‘glasses’, *afapón* for *melafefón* ‘cucumber’, *itʁaó* for *leitʁaót* ‘bye’). This pattern also appeared during the minimal word stage, where they produced the ultimate and stressed syllables for target words with penultimate stress, and final stressed and penultimate unstressed syllables for target words with ultimate stress. This is also reported in other studies of hearing Hebrew-speaking children (Ben-David 2001, Adam 2002, Tubul 2005).

To conclude, 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. However, as mentioned in §5.2.2.4, segmental considerations may interfere. Table (44) above presents a few examples: *nayái*: for *naaláim* ‘shoes’, *mafefón, peyapón, mepepón* for *melafefón* ‘cucumber’ and also *ipotá* for *ipopotám* ‘hippopotamus’. In all these examples, it seems as if 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 hearing children (e.g. *agólet* for *taʁnególet* ‘hen’, *adiyón* for *akoʁdiyón* ‘accordion’). I assume that this inconsistency with regard to syllable preference, 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, i.e. *nayái*: for *naaláim* ‘shoes’ and *yavodá* for *laavodá* ‘to work’. In addition, when two syllables had identical consonants, the children deleted one of the (near) identical syllables (i.e. haplology); e.g. *ipotá* for *ipopotám* ‘hippopotamus’, and *peyapón* for *melafefón* ‘cucumber’. In *mafefón* for *melafefón* ‘cucumber’ and *yulédet* for *yomulédet* ‘birthday’, they preserved the three final syllables and shifted the onset of the first syllable of the word to the adjacent syllable. Finally, in *ʃaʃeʁót* for *ʃarʃeʁaót* ‘necklaces’, there was a deletion of an onsetless pre-final syllable.

The data in table (44) above show the transition from the minimal word stage to the pre-final stage, i.e. from maximally disyllabic forms, the children increased the number of syllables they produced for target words with different kinds of stress patterns.

Adam (2002) reported that during this stage of development, the children in her study increased the number of syllables they produced, but only if the target forms bore penultimate stress. For example: a child in her study produced *akével* for ʁ*akével* ‘train’ and *pij̆áma* for *pij̆áma* ‘pajama’ but *tiyá* for *mit*ʁ*iyá* ‘umbrella’. The numbers in the table (45) below, show the same tendency for the children in the current study, both for each individual child (A5 is an exceptional case) and for all the children as a group.

(45) Preservation of all the syllables in trisyllabic target words with different stress patterns

| Ultimate stress (wws) | | | Non-Ultimate stress (wsw) (sww) | | | Child |
|---|---|---|---|---|---|---|
| Target | Production | | Target | Production | | |
| 47 | 39 | 83% | 42 | 37 | 88% | A1 (2;6-2;9) |
| 47 | 33 | 70% | 38 | 30 | 79% | A2 (2;7-3;0) |
| 181 | 121 | 67% | 198 | 153 | 77% | A3 (3;7-5;0) |
| 69 | 42 | 60% | 60 | 45 | 75% | A4 (3;4-3;11) |
| 93 | 81 | 87% | 97 | 81 | 83% | A5 (2;8-3;4) |
| 72 | 45 | 63% | 103 | 71 | 69% | A6 (4;6-5;6) |
| 509 | 361 | 70% | 538 | 417 | 77% | Total |

As mentioned above, during the pre-final stage, the children preserved the three syllables of the target words. Deletions of syllables, if they occur, are in target words with ultimate stress (30%) more often than in words with non-ultimate stress (23%). Wilcoxon Signed Ranks Test shows a significant difference between trisyllabic target words with ultimate stress to trisyllabic target words with non-ultimate stress (Z=1.992, p=0.046).

### 5.4. The final stage

During the final stage, the children's forms were fully faithful to the target, i.e. their words are prosodically correct in terms of the number of syllable. Note that the development of the syllable structure and the segmental make up of the word have not yet reached the final state.

The examples in (46) below show preservation of four syllables for target words with penultimate stress and ultimate stress.

(46) Target: **quadrisyllabic words -** Production: **quadrisyllabic words**

| Target | | Children's Productions | Child | |
|---|---|---|---|---|
| Target words with ultimate stress | | | | |
| ipopotám | 'hippopotamus' | ipopotám | A1 | 3;4 |
| | | ipopotám, pipopotám | A4 | 4;9 |
| melafefón | 'cucumber' | melafefó | A1 | 3;1 |
| | | melafefón, melafefó | A4 | 4;9 |
| | | lemefefón | A5 | 4;2 |
| leikanés | 'to get in' | leikanés, leikanéθ | A2 | 3;0 |
| xanukiyá | 'Channukah lamp' | xanukiyá | A4 | 4;9 |
| akoʁdiyón | 'accordion' | akodiyón | A4 | 4;9 |
| laavodá | 'to work' | laavodá | A4 | 4;9 |
| leitʁaót | 'bye' | leitaó | A4 | 4;5 |
| bamasáit | 'in the truck' | bamasáit | A4 | 4;3 |
| mexoniyót | 'cars' | mexoniyót | A4 | 4;11 |
| naknikiyá | 'hot dog' | naknikiyá | A4 | 4;11 |
| laxmaniyá | '(bread) roll' | laxpiniyá | A4 | 4;11 |
| Target words with penultimate stress | | | | |
| yomulédet | 'birthday' | yomulédet | A1 | 3;4 |
| plastalína | 'plasticine' | pastanína | A1 | 3;4 |
| mispaʁáim | 'scissors' | mispaʁáim | A1 | 3;3 |
| | | ispaʁái | A4 | 4;6 |
| taʁnególet | 'hen' | taʁnególet | A1 | 3;3 |
| | | tanególet | A5 | 4;2 |
| avatíax | 'watermelon' | avátiax | A1 | 3;1 |
| mixaéla | 'proper name' | mixaéla | A2 | 3;0 |
| meaxóʁa | 'behind' | meaxóa | A2 | 3;1 |
| miʃkafáim | 'glasses' | miʃifáim | A3 | 4;9 |
| televízya | 'television' | televíza | A4 | 4;9 |
| ofanóa | 'motorcycle' | ofanóa | A4 | 4;6 |
| mevaʃélet | 'cooks fm.sg.' | mevaʃélet | A5 | 4;1 |

In 114 out of 152 tokens with penultimate stress patterns, all four syllables were preserved (75%), and in 66 out of 97 tokens with ultimate stress patterns, all four syllables were preserved (68%).

The data in table (46) show correct production of quadrisyllabic target words with regard to the number of syllables in the word. However, as mentioned above, the segmental acquisition has not yet reached its final state. In their study of cochlear implant children, Carter et al. (2002) found that although they had difficulty reproducing the segmental content of nonword patterns, the children were much better in imitating suprasegmental properties. Following these findings, Carter et al. (2002) explained that cochlear implant children are more likely to correctly encoded elements on the suprasegmental tier than the segmental tier, which requires the encoding of much finer phonetic detail. These findings together with these studies of disordered speech populations (Clements and Fee 1994, Tubul 2005) support the assumption that the speech of atypically developing children is characterized by a greater degree of unsynchronized development of different levels of representation.

## 5.5. The development of the prosodic word in the speech of children with HA

This section documents and analyses the development of the prosodic word in the speech of the hearing impaired subjects with HA (group B). As mentioned in §4.1.2, finding children using conventional hearing aids during the one-word stage (and who were not candidates for cochlear implantation) was a very difficult task. Thus, data collection from group B was less homogenous and started at different stages of the phonological development of each child. All the children with hearing aids joined the study shortly after the initial stage of their prosodic development; three children (B1, B2, and B4) started their follow-up during the minimal word stage, and one child (B3) started his follow-up during the pre-final stage. The stages described below follow the stages reported in the literature on the development of the prosodic word in the speech of hearing Hebrew-speaking children (see §2.1.4), and also the development of the implanted children (see §5). The description starts with the minimal word stage (§5.5.1), where the words produced by the children are maximally disyllabic, and the syllables selected from the target word are the stressed and final syllables, or the stressed/final and pre-final syllables (in cases where the final syllable is stressed). In the following pre-final stage (§5.5.2), the children expanded the number of syllables to three, and at the end, in the final stage (§5.5.3), they produced all the syllables in quadrisyllabic target words.

Throughout this section, only the quantitative numbers are presented while most of the data are presented in the appendix. Similarities and differences between the children using hearing aids and those using cochlear implants are discussed.

### 5.5.1. The minimal word stage

As noted above, the initial stage of the development of the prosodic word was missed, thus most of the children started their follow-up during the minimal word stage. However, during the minimal word stage, few monosyllabic word productions occurred for words with both for penultimate and ultimate stress. The following sub-section presents this period among the hearing impaired children using hearing aids.

### 5.5.1.1. Disyllabic target - monosyllabic production

During the minimal word stage, few monosyllabic word productions appeared in the children's productions. I assume, however, that these productions were remnants of the initial stage of the word development and also characteristic of the initial period of the minimal word stage. I will discuss this issue immediately after presenting data in table (47) below. The table contains all the data.

(47) Target: **disyllabic words** – Production: **monosyllabic words**

| Target | | Children's productions | | | | Child | |
|---|---|---|---|---|---|---|---|
| | | Final Syllable | | Non-final syllable | | | |
| | | Stressed | Unstressed | Stressed | Unstressed | | |
| | | Ultimate | | | | | |
| ʃaón | 'watch' | o: | | | | B1 | 1;5 |
| kadúʁ | 'ball' | tu: | | | | B1 | 1;5 |
| migdál | 'tower' | da | | | | B1 | 1;5 |
| kivsá | 'sheep' | ta | | | | B1 | 1;5 |
| liʃón | 'to sleep' | ʃo | | | | B2 | 3;2 |
| liʃtót | 'to drink' | tot | | | | B2 | 3;2 |
| naxáʃ | 'snake' | aʃ | | | | B2 | 3;4 |
| aʁóx | 'long' | o: | | | | B4 | 2;9 |
| axʃáv | 'now' | ʃav | | | | B4 | 2:9 |
| | | Penultimate | | | | | |
| dúbi | 'teddy bear' | | bi | | | B1 | 1;5 |
| íma | 'mother' | | ma | | | B1 | 1;5 |
| álo | 'hello' | | | a, a: | | B2 | 3;4 |
| díyo | 'for a horse' | | yo | | | B4 | 3;0 |

I assume that the monosyllabic productions of target words with penultimate stress are remnants of the initial period of word acquisition. As can be seen from the data above, the children did not produce a target syllable which is non-final and unstressed. That is, their selection of a syllable from the target word is governed mostly by prosodic considerations. However, for target words with penultimate stress, the same segmental effects discussed in §5.1.2.2 for group A appeared for group B. The decision between a final syllable or a stressed syllable is affected by a combination of both the consonants and the vowels of the word. Bilabial segments are preferred (*bi* is preferred to *du* in *dúbi* 'teddy bear', *ma* is preferred to *i* in *íma* 'mammy'). When both syllables have non-labial consonants only the vowels compete: *a* is mostly preferred (*a* and *a:* rather than *lo* in *álo* ‘hello’), and *a* and *o* are preferred to *i* (*yo* rather than *di* for *díyo* ‘for horse’) (see §5.1.2.2 for the above hierarchy).

As noted in §5.1.2.2. the selection of the syllable of the target word in **the cochlear implant children** was consistent with segmental restrictions both for target words with ultimate and penultimate stress. In other words, the children preserved one of the target syllables, which could be the final stressed syllable, the final unstressed syllable, the initial stressed syllable, or the initial unstressed syllable. However, the selection of the syllable of the target word with **the children using hearing aids** was governed mostly by prosodic restrictions for target words with ultimate stress, i.e. producing the final-stressed syllable of the target which was perceptually the most salient syllable in the word (Garret 1998). As for target words with penultimate stress, since the data are insufficient, it is difficult to make broad generalizations: it could be either segmental restrictions (see discussion above and also §5.1.2.2 for segmental considerations), or prosodic restrictions, i.e. producing the word-final syllable (Berman 1977, Faingold 1990, Fikkert 1994). However, since the assessment of the children with the HA began later than that of the children with the CI, there is no evidence of significant differences in these performances in the initial stage.

#### 5.5.1.2. Polysyllabic target - disyllabic production

At this stage of word development, children usually preserved the two rightmost syllables in target words with ultimate and penultimate stress. As for words with antepenultimate stress, which are rather rare, there was a certain degree of variation with respect to the non-final syllable. The data are presented in appendix 1 (table a).

(48) Preservation of syllables for polysyllabic target words in the minimal word stage

| Target | | Production | | | |
|---|---|---|---|---|---|
| Syllable | N | 1 syllable | 2 syllables | 3 Syllables | 4 syllables |
| 2 | 505 | 17 | 488 | | |
| 3 | 116 | 2 | 64 | 50 | |
| 4 | 26 | | 5 | 17 | 4 |
| Total | 647 | 19 | 557 | 67 | 4 |

As can be seen from the table above, during the minimal word stage, most of the children's productions consisted of disyllabic tokens (557/647=86%) (Note the disyllabic targets comprise 78% (505/647) of the polysyllabic words, and even less when monosyllabic targets are counted. There was a beginning of preservation of three syllables of the word (67/647=10.35%). The cases of quadrisyllabic word productions were very few (4/647=0.62%) as well as monosyllabic word productions (19/647=3%)

#### 5.5.1.2.1. Trisyllabic target - disyllabic production

Table (49) presents quantitative data of syllable deletion in tokens of produced words for trisyllabic target words to which the children responded (the data are presented in appendix 1 table b).

(49) Syllable **deletion** in trisyllabic target words

| Trisyllabic target words | | Children's Productions | | | | | |
|---|---|---|---|---|---|---|---|
| | | Syllable **deletion** from ($\sigma_3\sigma_2\sigma_1$) | | | | | |
| | | $\sigma_3$ | | $\sigma_2$ | | $\sigma_1$ | |
| Ultimate (wws) – $\sigma_3\sigma_2\acute{\sigma}_1$ | 34 | 20 | 59% | 13 | 38% | 1 | 3% |
| Penultimate (wsw)- $\sigma_3\acute{\sigma}_2\sigma_1$ | 25 | 22 | 88% | 3 | 12% | 0 | 0% |
| Antepenultimate (sww)- $\acute{\sigma}_3\sigma_2\sigma_1$ | 5 | 4 | 80% | 1 | 20% | 0 | 0% |
| Total | 64 | | | | | | |

As mentioned in §5.2.2.2, during the minimal word stage, the prosodic effect on syllable preservation, i.e. the stress patterns and the word edge, are dominant and influence the output forms. These tendencies are shown for group A as well as for group B. These data are shown clearly in table (49) above.

For target words with **ultimate stress**, the children produced the final stressed syllable and the penultimate unstressed syllable (deletion of 59% of the antepenultimate syllables as opposed to 38% and 3% of the penultimate and ultimate syllables respectively) (e.g. *alé* for *mekaléf* 'peels ms.sg.'). For target words with **penultimate stress**, the children produced the penultimate stressed syllable and the final unstressed syllable (deletion of 88% of the antepenultimate syllable as opposed to 12% and 0% of the penultimate and the ultimate syllables respectively) (e.g. ʃéve for laʃévet 'to sit'). However, it is not clear which syllables were preserved in words with **antepenultimate stress;** for the target word *ʃókolad* 'chocolate', as expected, the children preserved the stressed and the final syllables of the word, i.e. producing *ʃóla*. However, for the target word *télefon* 'phone', the children produced *yáfo, láfo:*, or *yápon*, thus preserving the final and penultimate syllable of the word (according to the onset of the penultimate syllable). This was also the case with the word *bégale* 'pretzel', which was produced as *máne* (according to the vowel of the penultimate syllable). However, since there were only five words of this type, the results are not conclusive.

The above findings are similar to those of **the cochlear implant children** in terms of stress position in the word with ultimate and penultimate stress but are different for words with antepenultimate stress (see §5.2.2.4). In other words, both groups selected the last two syllables from target words with ultimate and penultimate stress, usually the final and the stressed syllables. However, for words with antepenultimate stress, the cochlear implant group usually produced the initial stressed syllable with the ultimate unstressed syllable, while the hearing aid group produced the two unstressed final syllables of the words. I argue, however, that there are cases in which segmental considerations may interfere, and these cases are much more prominent in words with antepenultimate stress. When adjacent syllables have the same vowel, it is quite difficult to decide which syllable is preserved and the assumption relies mostly on the syllable's components (i.e. onset as well as vowel). Moreover, no generalizations should be made since there are insufficient words with antepenultimate stress in the data.

#### 5.5.1.2.2. Quadrisyllabic target - disyllabic production

For quadrisyllabic target words, the children showed the same tendencies as were presented in §5.2.2.3 above for **the cochlear implant group**. For target words with penultimate stress, they preserved the stressed and the final syllables of the target words (e.g. *bída* for *televízya* ‘television’ and also *páim* for *mispaʁáim* ‘scissors’). When the stressed syllable was also the final one, another unstressed syllable was preserved, usually the one adjacent to the stressed syllable (e.g. *epón* and *epó* for *melafefón* ‘cucumber’) (for data see appendix 1 table c).

To summarize the minimal word stage, like hearing Hebrew-speaking children and hearing impaired children using cochlear implant devices, the children with the hearing aids passed through a stage in which a disyllabic word was the maximal prosodic structure produced.

### 5.5.2. The pre-final stage

During the pre-final stage, the children expanded the number of syllables in their words to three. Thus, tri- and quadrisyllabic target words were trisyllabic in the children’s production (appendix 2).

Table (50) below presents quantitative data of syllable preservation in trisyllabic target words of the hearing aid group.

(50) **Preservation** of all the syllables in trisyllabic target words

| Ultimate stress wws | | | Non-Ultimate stress wsw, sww | | | Child |
|---|---|---|---|---|---|---|
| Target | Production | | Target | Production | | |
| 63 | 54 | 85.7% | 68 | 61 | 89.7% | B1 (1;7.3-2:0) |
| 39 | 19 | 48.7% | 33 | 26 | 78.78% | B2 (4:0.17-4;4.22) |
| 70 | 60 | 85.7% | 83 | 64 | 77.1% | B3 (3;5-4;0.13) |
| 23 | 16 | 69.56% | 45 | 37 | 82.2% | B4 (3;3-3;11) |
| 195 | 149 | 76.4% | 229 | 188 | 82.1% | Total |

During this stage the children increased the number of syllables they produced for target words with different kinds of stress patterns. In most cases, all three syllables of the trisyllabic target words appeared in the children's productions (188/229=82.1% and 149/195=76.4% for target words with ultimate and non-ultimate stress respectively). However, the quadrisyllabic target words were still incomplete and generally consisted of three syllables only. These numbers are similar to those of the cochlear implant children (table (45) above)

The children tended to preserve the ultimate, the penultimate, and the antepenultimate syllables of the words, i.e. the last three syllables both for quadrisyllabic target words with **ultimate stress** (e.g. *atetón* for *melafefón* 'cucumber' and *popotám* for *ipopotám* 'hippopotamus'), and for target words with **penultimate stress** (e.g. *babáim* for *mispaʁáim* 'scissor' and *sególe* for *taʁnególet* 'hen'). This is also reported in other studies of Hebrew speaking children (Ben-David 2001, Adam 2002, Tubul 2005) as well as in the cochlear implant children (§5.3.1).

### 5.5.3. The final stage

During the final stage, the children's forms were fully faithful to the target forms and their words were prosodically correct in terms of the number of syllables (see appendix 3). Note that only two children (B1 and B3) had reached this stage by the time the study ended. As stated in §4.1.2, child B2 dropped out of the study after 18 months since she left the city and child B4 dropped out of the study after 14 months since she was implanted.

# CHAPTER 6: ACQUISITION OF THE SYLLABLE

This chapter describes the development of the syllable units. The discussion begins with the acquisition of the onset by the cochlear implant users (§6.1), and the hearing aid users (§6.2), and then proceeds with the acquisition of the coda by the cochlear implant users (§6.3), and the hearing aid users (§6.4).

## 6.1. Acquisition of the onset by the cochlear implant users

The following section describes the onset development in the speech of the hearing impaired subjects with CI. It follows some of the stages reported in the literature on the development of the onset in the speech of hearing Hebrew-speaking children reviewed in §2.2.1. It starts, however, with a stage that is rarely mentioned in the literature, which I define as consonant-free words stage (§6.1.1), a short period characterized by the production of words consisting only of vowels. The following stage is characterized by onset preservation in monosyllabic word production (§6.1.2), where simple onsets are preferred both in monosyllabic CV and CVC target words, and in monosyllabic word productions for disyllabic target words. During the next stage, there is onset preservation in disyllabic word productions (§6.1.3). A broad description of the prosodic development of a simple onset in the word is described (§6.1.3.1, §6.1.3.2 and §6.1.3.3). Segmental effects are described in §6.1.4: I show that stops and nasals are mostly preferred in onset position and are often preserved in the children's productions (§6.1.4.1 and §6.1.4.2). Sub-section §6.1.4.2, also deals with segmental effects on the penultimate onset in disyllabic produced words. I describe both non-assimilatory replacement (§6.1.4.2.1) as well as assimilatory replacement in onset position (§6.1.4.2.2). Onsets in the initial syllable of polysyllabic word productions are the last section of the acquisition of simple onsets (§6.1.4.3). The discussion evaluates the data according to the two familiar parameters: the target parameter and the production parameter.

Table (51) summarizes the order of simple onset development throughout stages. These stages are described in the following sections.

(51) Order of onset development – prosodic development

| Acquisition of the onset | Section |
|---|---|
| V, V:, VV | §6.1.1. Consonant-free words |
| CV(C) | §6.1.2. Simple onset in monosyllabic word productions |
| VCV(C)<br>CVCV | §6.1.3.1 From empty to simple onsets in disyllabic word productions |
| V(C)σσ<br>CV(C)σσ | §6.1.3.2. From empty to simple onsets in polysyllabic word productions |
| CV(C)σσ<br>CV(C)σσσ | §6.1.3.3 Final stage of simple onset development |

C = Consonant     V = Vowel     σ = Syllable

### 6.1.1. Consonant-free words

The initial stage of onset development is characterized by a short period in which the hearing-impaired children produce quite a few words consisting of vowels only. In other words, the children delete the segments of the words, thus leaving them as consonant-free words (this phenomenon has also been reported by several clinicians who work with Hebrew-speaking hearing-impaired children). As shown in (52), this phenomenon appears both in monosyllabic and polysyllabic target words. It should be mentioned, however, that throughout this stage, a few words with VC and CV structures also occurred.

(52) Consonant-free words

| Target: [σ] | | Productions | Child | Target: [σσ(σ)] | | Productions | Child |
|---|---|---|---|---|---|---|---|
| mu | ‘cow sound’ | u | A1 (1;7.11) | myáu | ‘cat sound’ | a:, áu | A1 (1;7.25) |
| tu: | ‘train sound’ | u: | A1 (1;8.16) | paʁpáʁ | ‘butterfly’ | aá | A1 (1;11.15) |
| me | ‘sheep sound’ | e | A1 (1;9.14) | bakbúk | ‘bottle’ | aó | A1 (2;1.12) |
| yad | ‘hand’ | a: | A1 (1;11.15) | sáfta | ‘grandmother’ | áa | A1 (2;1.12) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| xam | ‘hot’ | a: | A1 (1;11.15) | imʁí | ‘proper name’ | ií | A1 (2;1.12) |
| lo | ‘no’ | o | A1 (2;0.6) | adáʁ | ‘proper name’ | aá | A1 (2;1.12) |
| pil | ‘elephant’ | i: | A1 (2;1.12) | aviyá | ‘proper name’ | aá, iá | A1 (2;1.12) |
| tik | ‘bag’ | e | A1 (2;1.12) | kivsá | ‘sheep’ | iá | A1 (2;4.18) |
| li | ‘to me’ | i: | A3 (2;6.26) | álo | ‘hello’ | áo | A2 (1;5.27) |
| mi | ‘who’ | i | A4 (3;1.12) | ʁégel | ‘foot’ | ée | A6 (2;8.19) |
| day | ‘enough’ | a: | A4 (2;11.16) | lisgóʁ | ‘to close’ | o: | A3 (2;6.26) |
| kos | ‘glass’ | o: | A4 (3;3.4) | zéu | ‘that’s it’ | éu | A4 (2;7.13) |
| pax | ‘bin’ | a: | A5 (2;1.8) | bói | ‘come! fm.sg.’ | ói | A4 (2;11.16) |
| dag | ‘fish’ | a | A5 (2;1.22) | báit | ‘home’ | ái | A4 (3;0.11) |
| cav | ‘turtle’ | a | A5 (2;4.0) | kisé | ‘chair’ | eé | A5 (2;1.22) |
| sus | ‘horse’ | u | A5 (2;6.7) | ába | ‘daddy’ | áa | A5 (2;1.8) |
| po | ‘here’ | o: | A6 (2;10.27) | kúmi | ‘get up! fm.sg.’ | úi: | A5 (2;3.3) |
| pe | ‘mouth’ | e | A6 (2;8.19) | | | | |
| ma | ‘what’ | a | A6 (3;4.15) | | | | |

[σ] = Monosyllabic target words
[σσ(σ)] = Polysyllabic target words

The quantitative data below present the ratio of onsetless monosyllabic words produced for monosyllabic and polysyllabic target words during the initial stage of onset acquisition, i.e. the free-consonant words period.

(53)

| Target words | | Produced words | |
|---|---|---|---|
| | | stage I | |
| | | Without onset | |
| With onset | 43 | 25 | 58% |
| Without an onset | 47 | 43 | 91.5% |
| Total | 90 | 68 | 75.5% |

**The target parameter:** During the initial period of onset development 52.2% of the target tokens are onsetless (47/90). As these numbers drop significantly during the following stage (see table 55), they reflect a preference for syllables without an onset during the initial period, given that there are few onsetless words in Hebrew in general and in the current study in particular. In fact, during the initial period of onset development, there were only 14 onsetless target word types to which the children responded (e.g. *od* ‘more’, *en* ‘none’, *oʁ* ‘light’). However, in terms of tokens, the onsetless target words constituted 52.2% (47/90). The preference for onsetless words does not confirm with reports in the literature, where syllables with onsets are the first to be produced (see the discussion in §5.1). However, the findings of my study might be explained as a result of the intervention program designed for the hearing impaired children, whereby VC target words are introduced to the children after V words. Indeed, in Hebrew, there are some basic words, with a VC structure, which clinicians tend to use as targets, encouraging children's production at the beginning of the training program. Such words include *aw* 'dog sound', *op* 'hop', *en* 'none', *od* 'more', *af* 'nose', *an* 'car sound', etc. Gradually, the use of these words decreases, and the use of words such as *kélev* 'dog' (instead of *aw*), *óto* 'car' (instead of *an*) and *kadúʁ* 'ball' (instead of *op*) becomes more common. Since the coda was deleted at this stage, these targets were produced as consonant-free words.

**The production parameter:** During the initial period of onset development most of children's productions were onsetless: in 25 out of the 43 target tokens with an onset (58%), the onset is deleted. Onset insertion in target tokens without an onset is insignificant (i.e. 4/47 = 8.5%) (table (53) above). Moreover, during this period, 51.5% (33/64) of the tokens of the produced words were consonant-free words, but during the following stage (see §6.1.2 below), this number dropped drastically to 22.8% (43/188). There were no consonant-free words in the subsequent stages.

According to Ben-David (2001), consonant-free words did not appear in the speech of hearing Hebrew-speaking children. Ben-David emphasizes that there is no stage in the acquisition where the children produced words without a consonant, and explains it, following Tobin (1997), by the requirement to maintain communicative information. This issue is broadly discussed in §7.3.1.

### 6.1.2. Onset production in monosyllabic words

It is usually claimed that the universally unmarked syllable is CV. It has been shown that CV is the preferred syllable in early development in Hebrew (Ben-David 2001), as well as in English (Ingram 1976, Salidis and Johnson 1997), Dutch (Fikkert 1994, Levelt and Van de Vijver 1998), Portuguese (Fikkert and Freitas 1997, Freitas 1999), and various dialects of Spanish (Macken 1978, Goldstein and Citron 2001). This finding is confirmed by the status of CV syllables in adult language (Kenstowicz 1994). Since every language has CV syllables (and some only have CV syllables) this syllable is considered the most unmarked. As Jakobson (1968) first proposed, children's first productions are characterized by unmarked structures.

Preference for the CV syllable is also found in the speech of the CI children, following the period of consonant-free words (§6.1.1). The table in (54) below presents mono- and disyllabic target words, which were produced as CV (and sometimes CVC) words. In monosyllabic productions of disyllabic target words, the onset is produced whether it is in a stressed or unstressed syllable in the target word.

(54) Onset preservation in monosyllabic words production

| Target: σ | | Production | Child | Target: $\sigma\sigma_s$ | | Production | Child |
|---|---|---|---|---|---|---|---|
| yad | 'hand' | ya | A1 (1;9.21) | bubá | 'doll' | ba | A1 (1;11.15) |
| | | da: | A5 (2;6.7) | balón | 'balloon' | ba:w,<br>ba:m | A1 (2;1.12) |
| kwa | 'frog sound' | wa, ba | A5 (2;5.0) | | | | |
| neʁ | 'candle' | ne | A5 (2;6.7) | nigmáʁ | 'finished' | ma | A1 (2;1.12) |
| pil | 'elephant' | mi | A1 (2;1.12) | ʁocé | 'wants ms.sg.' | ce | A1(2;10.17) |
| day | 'enough' | bay | A1 (2;0.6) | | | | |
| | | da:, da | A2 (1;8.12) | nafál | 'fell down ms.sg.' | pa | A1 (2;2.16) |
| pe | 'mouth' | me | A1 (2;0.6) | | | pam | A2 (2;1.19) |
| | | pe | A3 (2;5.24) | limóʁ | 'proper name' | mo | A1 (2;3.7) |
| bum | 'bang' | bu, ba | A4 (2;8.24) | | | | |
| me | 'sheep sound' | me | A1 (2;0.6) | levád | 'alone' | pa | A1 (2;3.7) |
| | | be | A4 (2;6.16) | kisé | 'chair' | se | A1 (2;4.25) |
| kos | 'glass' | ko: | A5 (2;5.0) | liʃtót | 'to drink' | kok | A1 (2;4.25) |
| cav | 'turtle' | ta | A1 (2;1.12) | | | to | A2(1;11.18) |
| mu | 'cow sound' | mu | A2 (1;5.27) | bakbúk | 'bottle' | ba | A1 (2;4.0) |
| po | 'here' | po | A2 (1;9.12) | paʁá | 'cow' | pa | A1 (2;4.0) |
| ga | 'duck sound' | ga | A6 (2;10.13) | aláx | 'went ms.sg.' | lax | A2 (2;0.11) |
| | | ya | A2 (1;9.12) | tinók | 'baby' | no: | A2 (2;0.11) |
| mic | 'juice' | mi | A5 (2;7.0) | xulcá | 'shirt' | ca | A2 (2;4.11) |
| tu | 'train sound' | tu, bu | A3 (2;3.12) | sakín | 'knife' | ki | A3(2;10.10) |
| | | tu, ku | A6 (2;11.4) | aʁbé | 'a lot' | ba | A3 (2;11.1) |
| bo | 'come!ms.sg | bo | A2 (1;9.0) | naxáʃ | 'snake' | daθ | A3(2;11.23) |
| pax | 'bin' | pa | A2 (1;10.2) | ʃotá | 'drinks | ta | A3 (3;0.26) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | fm.sg.’ | | |
| lo | ‘no’ | yo | A2 (1;11.14) | Target: $\sigma_s\sigma$ | | Production | Child |
| pil | ‘elephant’ | pe | A2 (1;11.18) | íma | ‘mother’ | ma | A1 (1;8.16) |
| | | pi | A3 (2;2.21) | íne | ‘here’ | ne | A2 (1;10.2) |
| | | bi | A5 (2;5.0) | bói | ‘come! fm.sg.’ | bo | A2(1;11.18) |
| xam | ‘hot’ | ba | A3 (2;2.21) | | | be | A3 (2;2.21) |
| tik | ‘bag’ | ti | A3 (2;5.24) | péʁax | ‘flower’ | pe, pex | A2 (1;9.0) |
| dag | ‘fish’ | ba | A3 (2;5.8) | écba | ‘finger’ | ba | A3 (2;2.21) |
| | | da | A4 (2;8.0) | máim | ‘water’ | ma | A4 (2;4.7) |
| | | ta | A5 (2;6.7) | | | ma:, | A6(2;10.13) |
| | | | | | | mam, | |
| | | | | | | me | |
| | | | | báit | ‘home’ | ba | A4 (2;8.24) |
| | | | | dúbi | ‘teddy bear’ | du | A6 (3;2.13) |

$\sigma$ = Monosyllabic target words
$\sigma\sigma_s$ = Disyllabic target words with ultimate stress
$\sigma_s\sigma$ = Disyllabic target words with penultimate stress

Table (55) below presents the quantitative results of onset preservation in monosyllabic word production for monosyllabic and polysyllabic target words during the initial stage of onset acquisition (i.e. the consonant-free words period) as opposed to the second stage of onset acquisition (i.e. onset preservation in monosyllabic word production stage). The words in the targets are with and without onsets.

(55) Onset production in stages I vs. II

| Target | Stage I | | | Stage II | | |
|---|---|---|---|---|---|---|
| | Target | Production with onset | | Target | Production with onset | |
| With an onset | 43 | 18 | 42% | 108 | 82 | 76% |
| Without an onset | 47 | 4 | 8.5% | 70 | 6 | 8.5% |
| Total | 90 | 22 | 24.4% | 178 | 88 | 49.4% |

**The target parameter:** During the second stage of onset development, there is a significant rise in the responses to target words with onsets. While only 47.7% (43/90) of the responses were to target words with onsets during the first stage, in the following stage, the percentage went up to 60.6% (108/178).

**The production parameter:** Table (55) above shows that during the second stage of onset development, as opposed to the first stage, there is also a rise in the production of onsets in monosyllabic CV and CVC target words, and in monosyllabic word productions corresponding to disyllabic target words. Onset preservation is found in the production of 76% (82/108) of the target words with onsets in the second stage, as opposed to the previous stage, in which onset preservation is found in the production of only 42% (18/43) of the target words with onsets. Onset insertion in target words without an onset is as insignificant during the second stage (6/70 = 8.5%) as it is in the first stage (4/47 = 8.5%). The later results conform to studies of typically developed Hebrew-speaking children, who rarely produce words with onset when the target words are onsetless.

### 6.1.3. From empty to simple onsets: Prosodic effects

When the children start producing polysyllabic words, the initial syllable is not always CV. I show that this stage of development is influenced by the stress pattern in disyllabic word productions (§6.1.3.1) as well as in tri- and quadrisyllabic word productions (§6.1.3.2). Final acquisition of simple onset is then described (§6.1.3.3).

#### 6.1.3.1. Onsets in the initial syllable in disyllabic productions

During the second stage, onsets also appear in disyllabic word productions. Since the transition from one stage to the next is gradual, during this stage of onset development, onsets can either be produced or be empty. Fikkert (1994) calls this stage: optional onsets.

Tables (56) and (57) below present examples of disyllabic word productions for polysyllabic target words with ultimate and penultimate stress. The first table (56) contains words in which the onset is deleted in the initial syllable, while the second table (57) contains words in which the onset is preserved. Since, a segmental analysis relating to the sonority aspect is conducted in the following section (§6.1.4.), the words in table (56) are organized according to the sonority of the onset in the penultimate syllables of the target words (i.e. stops, fricatives/sibilants, nasals, and approximants).

(56) **Onsets deletion** in disyllabic words productions

| Target | | Children's Productions | Child |
|---|---|---|---|
| | | Ultimate stress | |
| patíʃ | 'hammer' | atíθ | A1 (2;4.0) |
| todá | 'thanks' | edá | A2 (2.1.9) |
| gumiyá | 'rubber' | iá | A5 (2;4.0) |
| kafé | 'coffee' | apé | A5 (2;6.7) |
| kadúʁ | 'ball' | adú | A2 (1;11.14) |
| kapít | 'teaspoon' | apít | A1 (2;4.0) |
| kisé | 'chair' | iké | A5 (2;6.7) |
| aviyá | 'proper name' | iyá | A1 (2;3.7) |
| cipóʁ | 'bird' | ipó | A1 (2;4.0) |
| sagí | 'proper name' | agí | A1 (2;4.0) |
| ʃalóm | 'hello' | aló: | A3 (2;8.23) |
| ʃelí | 'mine' | ení | A2 (2;1.9) |
| xaméʃ | 'five' | amé | A1 (2;4.18) |
| xayót | 'animals' | ayó | A3 (3;0.26) |
| xaláv | 'milk' | alá | A5 (2;6.7) |
| mitá | 'bed' | itá | A1 (2;4.18) |
| masaít | 'truck' | aí | A1 (2;4.0) |
| nafál | 'fell down ms.sg.' | apá | A1 (2;1.19) |
| naxáʃ | 'snake' | aáʃ | A5 (2;7.0) |
| nadnedá | 'swing' | edá | A4 (3;4.8) |
| limóʁ | 'proper name' | imó | A1 (2;4.18) |
| liʃón | 'to sleep' | iʃón | A2 (2;1.9) |
| lecán | 'clown' | itá | A5 (2;6.7) |
| ʁocé | 'wants ms.sg.' | océ | A3 (2;10.10) |
| | | Penultimate stress | |
| báit | 'home' | ái | A4 (2;10.17) |
| búba | 'doll' | úba | A5 (2;7.0) |
| banána | 'banana' | áda | A2 (1;11.18) |
| dúbi | 'teddy bear' | óbi | A2 (2;1.9) |
| yadáim | 'hands' | áim | A2 (2;4.11) |
| tapúax | 'apple' | éax | A4 (3;4.8) |
| glída | 'ice cream' | ída | A1 (2;4.25) |
| kúmi | 'get up! fm.sg.' | úmi | A5 (2;1.22) |
| kóva | 'hat' | óba | A2 (2;1.9) |
| cífcif | 'bird sound' | ífip | A5 (2;4.0) |
| sába | 'grandfather' | ába | A3 (2;10.10) |
| ʃémeʃ | 'sun' | éme | A5 (2;5.0) |
| máim | 'water' | ái:m | A3 (2;5.8) |

| | | | |
|---|---|---|---|
| miʃkafáim | ‘glasses’ | á:im | A1 (2;4.0) |
| láyla | ‘night’ | áya | A3 (2;8.23) |
| alóni | ‘proper name’ | óni | A2 (2;1.9) |
| ʁéga | ‘just a minute’ | éga | A1 (2;4.18) |
| ʁádyo | ‘radio’ | áko, ádyo, ádo | A4 (2;10.17) |

(57) **Onset preservation** in disyllabic word productions

| Target | | Children’s Productions | Child |
|---|---|---|---|
| | | Ultimate stress | |
| baybáy | ‘bye’ | babá, baybáy | A1 (2;1.12) |
| bakbúk | ‘bottle’ | babú, papú | A1 (2;4.18) |
| bubá | ‘doll’ | bebá, bubá | A2 (1;6.11) |
| aviʁón | ‘airplane’ | bió | A5 (2;11.6) |
| taím | ‘delicious’ | paím | A1 (2;3.7) |
| kapít | ‘teaspoon’ | papí | A1 (2;4.25) |
| patíʃ | ‘hammer’ | patíʃ, papíθ, tatíθ | A1 (2;4.18) |
| paʁpáʁ | ‘butterfly’ | papá | A1 (2;4.0) |
| nafál | ‘fell down ms.sg.’ | papá | A1 (2;1.19) |
| balón | ‘balloon’ | dadó | A2 (2;0.11) |
| kadúʁ | ‘ball’ | dadú, tadó, tadú | A2 (1;11.14) |
| katán | ‘little’ | tatán | A3 (2;11.23) |
| kaxól | ‘blue’ | taxóy | A3 (2;11.23) |
| sagúʁ | ‘closed’ | tanú | A2 (2;1.9) |
| tová | ‘good’ | tová | A2 (1;9.12) |
| todá | ‘thanks’ | todá | A2 (1;11.18) |
| tinók | ‘baby’ | didó, tinó: | A2 (1;11.18) |
| sevivón | ‘spinning top’ | tibóy | A4 (3;5.12) |
| caóv | ‘yellow’ | taó | A3 (2;11.1) |
| mataná | ‘present’ | taná | A4 (3;1.12) |
| yaldá | ‘girl’ | tatá | A3 (2;8.23) |
| aftaá | ‘surprise’ | taá | A4 (3;5.12) |
| simlá | ‘dress’ | sibá | A2 (2;1.9) |
| ʃalóm | ‘hello’ | ʃaó: | A3 (2;6.26) |
| cipóʁ | ‘bird’ | cipó: | A2 (2;1.9) |
| masaít | ‘truck’ | maí | A1 (2;4.25) |
| mitʁiyá | ‘umbrella’ | miyá | A2 (2;4.11) |
| daniél | ‘proper name’ | nié | A2 (2;2.27) |
| ʃaón | ‘clock’ | yaó | A2 (1;9.12) |
| | | Penultimate stress | |
| báit | ‘home’ | bíi, bái | A1 (2;1.12) |
| ambátya | ‘bath’ | bába, báta | A3 (2;11.1) |
| ofanáim | ‘bicycle’ | bái:, pái: | A1 (2;3.7) |

| | | | |
|---|---|---|---|
| zéu | ‘that’s it’ | báu, ðéu | A4 (2;8.0) |
| bói | ‘come! fm.sg.’ | pái | A1 (2;3.7) |
| béten | ‘abdomen’ | péte | A1 (2;4.25) |
| bámba | ‘snack’ | pápa | A1 (2;1.19) |
| | | bába | A2 (1;10.2) |
| kóva | ‘hat’ | pópa | A3 (2;5.24) |
| péʁax | ‘flower’ | pépa | A2 (2;0.11) |
| pípi | ‘penis’ | pípi | A1 (2;1.12) |
| miʃkafáim | ‘glasses’ | pái: | A1 (2;3.7) |
| enáim | ‘eyes’ | páim | A4 (3;4.8) |
| dúbi | ‘teddy bear’ | débi, bíbi | A2 (1;11.18) |
| délet | ‘door’ | dé:le | A3 (2;8.23) |
| dégel | ‘flag’ | dédey | A3 (2;10.10) |
| tíktak | ‘clock sound’ | títa | A2 (1;11.18) |
| géʃem | ‘rain’ | téte | A5 (2;7.0) |
| sáfta | ‘grandmother’ | táta, sáta | A2 (1;11.14) |
| maftéax | ‘key’ | téax | A1 (2;4.18) |
| yéled | ‘child’ | téte | A3 (2;8.23) |
| lemáta | ‘down’ | táta | A4 (2;11.12) |
| ʁakévet | ‘train’ | tébe | A4 (3;4.8) |
| avatíax | ‘watermelon’ | tíax | A3 (3;0.26) |
| ʁádyo | ‘radio’ | táyo | A4 (2;11.16) |
| kóla | ‘cola’ | kóya | A4 (2;10.17) |
| sába | ‘grandfather’ | ʃába | A1 (2;4.25) |
| ʃóko | ‘chocolate milk’ | ʃóʃo | A1 (2;4.25) |
| ʃíʁa | ‘proper name’ | ʃía | A3 (2;10.10) |
| ʃémeʃ | ‘sun’ | ʃéʃe | A3 (2;10.10) |
| máim | ‘water’ | mái, mái:, máim | A1 (2;0.6) |
| mástik | ‘chewing-gum’ | mái | A1 (2;1.12) |
| banána | ‘banana’ | nána | A1 (2;4.0) |
| lemála | ‘above’ | mána | A2 (2;4;11) |
| íma | ‘mother’ | máma | A5 (1;11.20) |
| enáim | ‘eyes’ | nái, náim | A2 (2;1.9) |
| ofanóa | ‘motorcycle’ | nóa | A1 (2;5.23) |
| nóam | ‘proper name’ | nóa | A2 (2.1;9) |
| nóa | ‘proper name’ | yóa | A3 (2;10.10) |
| naaláim | ‘shoes’ | yái: | A1 (2;4.25) |
| ǰiʁáfa | ‘giraffe’ | yáfa | A2 (2;4.11) |
| oznáim | ‘ears’ | yáim | A2 (2;4.11) |

The data in tables (56) and (57) above reflect the characteristics of this stage of onset development: the onset starts appearing in disyllabic word productions while onsetless words are still produced. The later, however, are a residue of the initial period of onset development.

The production of words with and without an onset during the same stage of onset development can be seen in the same subject's productions. For example, child A1 (2;4.18) produced *patíʃ, papíθ,* and *tatíθ* for *patíʃ* 'hammer' (i.e. preserved the onset in the penultimate syllable of disyllabic target word) but during the same session produced *atíθ* for the same target word (i.e. deleted the onset of the same penultimate syllable of a disyllabic target word). Child A2 (1;11.18) produced *débi* and *bíbi* for *dúbi* 'teddy bear' (i.e. preserved the onset in the penultimate syllable of disyllabic target word) but in the same session produced *óbi* for the same target word (i.e. deleted the onset of the same penultimate syllable of the disyllabic target word). The same holds for tri- and quadrisyllabic target words, where child A1 (2;3.7) produced *pái:* for *miʃkafáim* 'glasses' (i.e. preserved the onset in the penultimate syllable of a quadrisyllabic target word) but during the same session produced *á:im* for the same target word (i.e. deleted the onset of the same penultimate syllable of the quadrisyllabic target word). The examples above show that this phenomenon occurs in words with ultimate as well as penultimate stress. However, the quantitative analysis in (58) below shows the preference for word initial onsets in target words with penultimate stress. That is, stressed syllables get their onset before stressless syllables.

(58) Word initial onset preservation in disyllabic target words

| Penultimate stress | | | | Ultimate stress | | | | Child |
|---|---|---|---|---|---|---|---|---|
| Target | | Production | | Target | | Production | | |
| w/o onset | w/ onset | w/ onset | | w/o onset | w/ onset | w/ onset | | |
| 18 | 61 | 51 | 83% | 8 | 61 | 36 | 59% | A1 (1;5.0-2;5.23) |
| 36 | 61 | 49 | 80% | 1 | 50 | 41 | 82% | A2 (1;5.27-2;4.11) |
| 21 | 55 | 49 | 90% | 6 | 48 | 36 | 75% | A3 (2;1.4-3;0.26) |
| 47 | 110 | 74 | 67% | 25 | 94 | 54 | 57% | A4 (2;3.23-3;5.12) |
| 32 | 131 | 89 | 68% | 17 | 129 | 68 | 52% | A5 (1;11.20-2;11.6) |
| 27 | 78 | 61 | 78% | 18 | 74 | 54 | 73% | A6 (2;8.12-3;6.19) |
| 181 | 496 | 373 | 75% | 75 | 456 | 289 | 63% | Total tokens |

Target words with (w/) or without (w/o) an onset means the presence or absence of onset in the target word's syllable corresponding to the initial syllable in the child's production (e.g. *óto* 'car' and *ába* 'daddy' but *dúbi* 'teddy bear' and ʁakévet 'train').

The quantitative data in (58) above compare onset preservation in disyllabic word productions with penultimate stress to that with ultimate stress: Child A1, for example, responded to 18 words without an onset and 61 words with an onset, preserving the onset in 83% (51/61) of the target words with penultimate stress. However, this child responded to 8 words without an onset and 61 words with an onset preserving the onset in 59% (36/61) of the target words with ultimate stress.

**The target parameter:** In my study, there are 302 types of disyllabic target words with ultimate stress but only 143 types of disyllabic target words with penultimate stress. In the stage of onset development, there are 138 types of disyllabic target words with ultimate stress and only 74 types of disyllabic target words with penultimate stress. This reflects the state of stress in Hebrew in general, where forms with ultimate stress are the majority (Bolozky 1978). The numbers in the table above show the same tendency: the children responded to 85.8% (456/531) target tokens with onset with ultimate stress and to 73.3% (496/677) target tokens with onset with penultimate stress.

However, there is a preference for target tokens without an onset with penultimate stress (181/677=26.7%) over target tokens without an onset with ultimate stress (75/531=14%). Note that during the current stage of onset development, 20% (15/74) of the disyllabic types are onsetless words with penultimate stress and 15% (21/138) are disyllabic types with ultimate stress. In other words, the children prefer responding to adult target words lacking an initial onset with penultimate stress (e.g. *îne* 'here', *óxel* 'food') more than to words with ultimate stress (e.g. *adóm* 'red', *exád* 'one').

**The production parameter:** The children tended to preserve the onset of the penultimate syllable in disyllabic word productions with penultimate stress more than in words with ultimate stress. The children produced the onset in 75% (373/496) of the words with penultimate stress, but in only 63% (289/456) of the words with ultimate stress (these numbers only relate to target words with onsets). The effect of the stress pattern on the onset preservation in disyllabic word productions was evident for each individual child, and for the group as a whole. The only exception is the case of child A2 in which no significant difference is found between penultimate and ultimate tokens of produced words (80% and 82% respectively) (table (58) above). Wilcoxon Signed Ranks Test shows a significant difference between onset preservation in penultimate and ultimate stress in disyllabic target words (Z=1.992, p=0.0046).

To summarize, during this stage of onset development, I presented data showing that the onset started appearing in disyllabic word productions. However, during this stage, it can either be produced or can be empty. In the above sub-section, I showed prosodic effects on this stage of onset production: onset preservation or deletion is influenced by the stress pattern of the word. In other words, the children tended to preserve the onset of the stressed syllable of words with penultimate stress, more than of the unstressed syllable of words with ultimate stress. The reason for that is attached by the fact that, stressed syllables are more prominent than unstressed syllables, thus are more stable.

#### 6.1.3.2. Onsets in the initial syllable of tri- and quadrisyllabic productions

The gradual appearance of word initial onsets is also manifested in tri- and quadrisyllabic word productions, where onsets do not always appear in the initial syllable. Table (59) presents trisyllabic and quadrisyllabic word productions without onsets in the initial syllable.

(59) **Onset deletion** in tri- and quadrisyllabic word productions

| Target | | Children’s Productions | Child |
|---|---|---|---|
| | | Ultimate stress | |
| matanᴀ́ | ‘present’ | atatá | A5 (2;6.7) |
| madbiká | ‘glues fm.sg.’ | abitá | A5 (2;11.6) |
| sukaʁyá | ‘candy’ | idiyá | A6 (3;5.21) |
| | | upayé, itiyá | A5 (2;6.7) |
| | | ouyá | A4 (3;3.4) |
| mitʁiyá | ‘umbrella’ | iteá, itiá | A5 (2;6.7) |
| mexonít | ‘car’ | anoní | A5 (2;8.2) |
| nadnedá | ‘swing’ | adedá | A4 (3;3.4) |
| kubiyót | ‘cubes’ | oiyó | A4 (3;4.8) |
| sevivón | ‘spinning top’ | iibó | A4 (3;5.12) |
| xilazón | ‘snail’ | iadó | A4 (3;5.12) |
| melafefón | ‘cucumber’ | eapóːn | A4 (3;4.8) |
| sufganiyá | ‘doughnut’ | oiyá | A4 (3;5.12) |
| | | Penultimate stress | |
| ʁagláim | ‘legs’ | avái | A1 (2;4.18) |
| gaʁbáim | ‘socks’ | abái: | A3 (2;10.10) |
| banána | ‘banana’ | anána | A3 (2;11.23) |
| ʁakévet | ‘train’ | atéve | A5 (2;11.6) |
| xotémet | ‘stamp’ | omélet, obéle | A5 (2;11.6) |
| lemála | ‘above’ | amála | A5 (2;7.0) |
| lemáta | ‘below’ | emáta | A4 (3;1.12) |
| noséa | ‘drives ms.sg.’ | itéa | A4 (3;1.12) |
| tapúax | ‘apple’ | apúa: | A4 (3;3.4) |
| ǰiʁáfa | ‘giraffe’ | iáfa, iába | A4 (3;3.4) |
| televízya | ‘television’ | evíða | A4 (3;3.4) |

Table (60) presents trisyllabic and quadrisyllabic word productions with onsets in the initial syllable of the word produced. The words in the table are organized according to the sonority of the onset in the children’s productions (i.e. stops, fricatives/sibilants, nasals, and approximants).

(60) **Onsets preservation** in tri- and quadrisyllabic word productions

| Target | | Children's Productions | Child |
|---|---|---|---|
| | | Ultimate stress | |
| sevivón | ‘spinning top’ | bibiyó | A5 (2;11.6) |
| melafefón | ‘cucumber’ | peyapón | A4 (3;5.12) |
| daniél | ‘proper name’ | danié | A2 (2;2.27) |

| | | | |
|---|---|---|---|
| sukaʁyá | ‘candy’ | tutayá | A5 (2;11.6) |
| taʁnegól | ‘rooster’ | tayegól | A4 (3;5.12) |
| | | geleó | A5 (2;9.7) |
| sufganiyá | ‘doughnut’ | ganiyá | A4 (3;5.12) |
| madbeká | ‘sticker’ | mebitá | A5 (2;11.6) |
| baloním | ‘balloons’ | manoním | A5 (2;11.6) |
| mitʁiyá | ‘umbrella’ | midiyá | A5 (2;8.2) |
| masaít | ‘truck’ | masaí: | A1 (2;5.23) |
| | | mataím | A5 (2;11.6) |
| matanáá | ‘present’ | nananá | A5 (2;11.6) |
| nadnedá | ‘swing’ | nanedá, ninidá | A5 (2;11.6) |
| | | Penultimate stress | |
| banána | ‘banana’ | babáma, babába | A1 (2;0.6) |
| | | manána | A5 (2;11.6) |
| beyáxad | ‘together’ | beyáħa | A3 (2;11.23) |
| avatíax | ‘watermelon’ | ababía | A5 (2;8.2) |
| mispaʁáim | ‘scissors’ | patái, paħáim | A4 (3;5.12) |
| ʃoméa | ‘listens ms.sg.’ | toméa | A5 (2;11.6) |
| miʃkafáim | ‘glasses’ | tafái: | A4 (3;0.11) |
| mixnasáim | ‘trousers’ | titái: | A3 (2;10.10) |
| caláxat | ‘plate’ | taláa | A5 (2;11.6) |
| ʃamáim | ‘sky’ | ʃamái: | A1 (2;5.23) |
| | | ǰamáim | A3 (2;11.23) |
| maftéax | ‘key’ | mapía | A5 (2;7.0) |
| naaláim | ‘shoes’ | nalái:, nanáim | A2 (2;1.9) |
| | | nayái | A5 (2;7.0) |
| | | lalái: | A4 (2;11.16) |
| televízya | ‘television’ | libíðya, bidíya, tebíya | A5 (2;11.6) |
| yomulédet | ‘birthday’ | yoméde | A5 (2;11.6) |
| ʁakévet | ‘train’ | yabébe | A4 (3;5.12) |
| | | Antepenultimate stress | |
| bégale | ‘pretzel’ | bégae | A4 (2;7.13) |
| télefon | ‘phone’ | téleo | A5 (2;9.7) |
| múzika | ‘music’ | núnuta | A5 (2;8.2) |

Table (61) presents quantitative data of onset preservation in tri- and quadrisyllabic target words with ultimate and penultimate stress. Since words with antepenultimate stress are very rare in Hebrew, they are not included in the table.

(61) word initial onset preservation in tri- and quadrisyllabic target words

| Stress patterns | | Target | | Production | |
|---|---|---|---|---|---|
| | | w/o onset | w/ onset | w/onset | |
| Ultimate stress | (w)wws | 24 | 43 | 22 | 51% |
| Penultimate stress | (w)wsw | 3 | 75 | 53 | 70% |
| Total | 145= | 27 | 118 | 75 | 60% |

w/o onset= Target words without an onset in the initial syllable of the word (*agalá* 'cart')
w/ onset = Target words with an onset in the initial syllable of the word (caláxat 'plate')

The data and the numbers in the tables above show the same tendencies for tri- and quadrisyllabic word productions as were discussed for disyllabic word productions in (§6.1.3.1).

**The target parameter:** In my study, 56% (38/67) of the tri- and quadrisyllabic types of target words bear penultimate stress (i.e. *maxbéʁet* 'notebook', *mixnasáim* 'trousers'), and only 44% (29/67) bear ultimate stress (i.e. *xilazón* 'snail', *melafefón* 'cucumber'). The numbers in the table (61) above show the same tendency: the children responded to 96.1% (75/78) target tokens with onset with penultimate stress but only to 64.2% (43/67) target tokens with onset with ultimate stress.

The findings for target tokens without an onset also reflected the type distribution: 88.8% (24/27) of the tri- and quadrisyllabic target tokens with ultimate stress are onsetless (e.g. *agalá* 'cart', *ugiyá* 'cookie'), while 11.1% (3/27) of the tri- and quadrisyllabic target tokens with penultimate stress are onsetless (e.g. *ambátya* 'bath', *oznáim* 'ears'). The numbers of these types of words (i.e. onsetless words with ultimate and penultimate stress) during the current stage, however, are very similar: 5 types of tri- and quadrisyllabic target words with penultimate stress and 7 types of tri- and quadrisyllabic target words with ultimate stress. In other words, in tri- and quadrisyllabic target tokens, children respond to onsetless target words with ultimate stress more than to words with penultimate and antepenultimate stress. The reason for this might be the different structure of the target words: all the target words with ultimate stress have an initial onsetless open syllable and no medial coda (e.g. *akavîʃ* ‘spider’, *ugiyá* ‘cookie’), while some of the target words with penultimate stress have medial codas (e.g. *ambátya* ‘bath’, *oznáim* ‘ears’). These later words have a more complex syllable structure and thus the children might prefer not to respond to them more than to the others.

**The production parameter:** During this stage, onsets start appearing in tri- and quadrisyllabic target words as well. However, since there is a transitional period between stages, in some cases the onset is often deleted (a residue of the previous stage), and even for the same child, it is inconsistent in the same target word. For example, child A5 produced *upayé* and *itiyá* for *sukaʁyá* ‘candy’ (i.e. deleting the initial onset) as well as *tutayá* (i.e. preserving the initial onset). Similarly, child A4 produced *oiyá* for *sufganiyá* ‘pancake’ and immediately thereafter, he produced *ganiyá.* However, the quantitative data in table (61) show a preference for the preservation of the onset of the initial syllable in tri- and quadrisyllabic word productions with penultimate stress more than in words with ultimate stress, i.e. the children produced 70% (53/75) of the target tokens with onsets in words with penultimate stress, but only 51% (22/43) of the target tokens with onsets in words with ultimate stress. These findings are similar to those of disyllabic words produced: onset preservation (or deletion) is influenced by the stress pattern of the word, i.e. the closer the syllable to the stressed syllable the more likely it is for its onset to be preserved (see also Adam 2002).

### 6.1.3.3. Final acquisition of simple onset

In §6.1.3.2, I presented tri- and quadrisyllabic word productions relating to onset acquisition. In the third stage of onset development (§6.1.3), during which most words are disyllabic productions, onsets in polysyllabic word productions already appear. However, during the next stage, the onset begins to appear in the initial positions of tri- and quadrisyllabic target words to a larger extent.

(62) Onset preservation in tri- and quadrisyllabic word productions: final stage

| Target | Target | | Production | |
|---|---|---|---|---|
| | w/o onset | w/ onset | w/onset | |
| Ultimate stress (w)wws | 152 | 721 | 679 | 94.2% |
| Penultimate stress (w)wsw | 110 | 760 | 700 | 92.1% |
| Antepenultimate sww | 89 | 102 | 96 | 94.1% |
| Total | 351 | 1583 | 1475 | 93.2% |

w/o onset= Target words without an onset in the initial syllable of the word (*agalá* ‘carriage’)
w/ onset = Target words with onset in the initial syllable of the word (calá́xat ‘plate’)

Table (62) above presents data of onset preservation in tri- and quadrisyllabic word productions in this stage of onset development.

A comparison between table (62) and table (61) reveals interesting findings both in the target word and word production aspects:

**The target parameter:** As expected, there is a significant increase in the target tokens to which the children respond as the stages progress. This tendency is equally revealed in all the words, regardless to the position of stress patterns. In the previous stage, there were 96.1% (75/78) target tokens with onset with penultimate stress the children responded to, but only to 64.2% (43/67) target tokens with onset with ultimate stress. In the current stage of onset development, however, the number of tri- and quadrisyllabic target tokens increased significantly both for words with penultimate stress (760/870=87.3%) and words with ultimate stress (721/873=82.6%). Also, as opposed to the previous stage the target tokens with onset in words with antepenultimate stress were increased significantly (102/191= 53.4%) (thus were considered at the total numbers of the penultimate target tokens).

There is no significant difference between target words with and without onsets in words with ultimate stress patterns and those with penultimate stress patterns in both periods: in the previous stage, 46% (67/145) and 54% (78/145) are target tokens with ultimate and penultimate stress respectively. In the current stage, the ratio is similar: 45% (873/1934) and 45% (870/1934) are target tokens with ultimate and penultimate stress patterns respectively, while 9.8% (191/1934) are target tokens with antepenultimate stress.

**The production parameter:** The number of onsets preserved in tri- and quadrisyllabic target words increased significantly in all children regardless of stress patterns. In the previous stage 51% (22/43) of the ultimate stressed tokens of produced words preserve onsets, as opposed to 94.2% (679/721) during the final stage. Also, during the previous stage, 70% (53/75) of the penultimate tokens of produced words preserve onsets, as opposed to 92.1% (700/760) during the final stage. And finally, during the previous stage, there were only 6 antepenultimate tokens of produced words preserving onsets, while during the final stage, 94.1% (96/102) of the token words with antepenultimate stress preserved onsets.

### 6.1.4. From empty to simple onsets: Segmental effects

As mentioned in §6.1.3., when the children started producing polysyllabic words, the initial syllable was not always CV but sometimes also an onsetless syllable i.e. V(C) (V and rarely VC). In §6.1.3.1 I showed that the stress pattern of the target words may influence the preservation of the onset in the initial syllable during the first stage of onset development. In the following sections, I provide evidence for segmental effects, showing that the segmental features of the consonants in the onset position also have a significant influence on the onset preservation in monosyllabic (§6.1.4.1) and polysyllabic word productions (§6.1.4.2 and §6.1.4.3).

#### 6.1.4.1. Onset in monosyllabic productions

As discussed in §1.2.2.3.3, there is a relation between the segment position and its sonority levels, with preference for obstruents in the onset position (Jakobson 1968, Stemberger 1996, Pater 1997, Bernhardt and Stemberger 1998, Kager 1999). Table (63) below presents the type of segments in onset position in monosyllabic word productions of monosyllabic, disyllabic and trisyllabic target words of the implanted children (see data in table (54) above).

(63) Onsets in monosyllabic word productions

| Target | | | Children's production | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Stops | | Fricative | | Nasals | | Liquids | |
| | | | N | % | N | % | N | % | N | % |
| Stops | 199 | 58.4% | 191 | 96% | | | 4 | 2% | 4 | 2% |
| Fricatives | 60 | 17.6% | 42 | 70% | 17 | 28% | | | 1 | 2% |
| Nasals | 56 | 16.4% | 9 | 16% | | | 47 | 84% | | |
| Liquids | 26 | 7.6% | 5 | 19% | | | 3 | 12% | 18 | 69% |
| Total | 341 | 100% | 247 | 72.4% | 17 | | 54 | 1.8% | 23 | |

The quantitative data presented in (63) support the preference for obstruents in the onset position and are similar to those reported in other studies. This tendency is seen in the two quantitative parameters (as was discussed in §5 in the section on prosodic word acquisition and will be discussed in §6.3 in the section on coda acquisition): The target parameter: the ratio of target words that can fit the relevant structure (regardless of whether they were produced with this structure), and the production parameter: the ratio of words produced with the relevant structure. As can be seen from the table above, there is a significant preference for stops in onset position in both parameters.

**The target parameter:** The numbers in the table above show a clear preference for attempted target token with stops in onset position (199/341 = 58.4%), a lower preference for fricatives (60/341 = 17.6%) and nasals (56/341 = 16.5%), and a very low preference for liquids (26/341 = 7.6%). That is, there is a higher rate of attempts to produce target words with stops in onset position than other manners of articulation. This preference matches the proportion of the general data of the current study (relating to all the types of words in the study): during the initial stage of onset development, 53 types of target words are produced, 53% (28/53) were with stops in the onset position (e.g. *day* 'enough', *pil* 'elephant', *bubá* 'doll', *kadúʁ* 'ball'), 18% (10/53) were with nasals (e.g. *máim* 'water', *ma* 'what', *mitá* 'bed', *nigmáʁ* 'finished'), 17% (9/53) were with fricatives (e.g. *xam* 'hot', *sába* 'grandfather', *ʃalóm* ‘hello’), and only 12% (6/53) were with liquids (e.g. *lo* ‘no’, *ʁéga* ‘one moment’, *liʃtót* ‘to drink’).

**The production parameter:** The children tended to preserve stops and nasals in target words with stops (191/199 = 96%) and with nasals (47/56 = 84%) in onset position. However, when the onset of the target words contained fricatives, they were often replaced in the children’s productions by stops (42/60 = 70%). There are fewer liquids, which are usually preserved (18/26 = 69%), but if replaced, they are replaced with either stops (5/26 = 19%) or nasals (3/26 = 12%).

The preference for non-sonorant segment in onset position is already discussed in §1.1.2.2. However, the preference of nasals in onset position does not fit the universal tendency. In other words, although the nasals are more sonorous than the fricatives (for the sonority scale see (9) in §1.1.2.2), they are also preferred in onset position. I assume, however, that the preference for stops, either oral or nasals, plays a dominant role in the segmental preference in onset position. The observation that children start with a stop in onset position was made by Jakobson (1968) and is also reported in the literature. The first contrast to appear is that between a vowel and a consonant, a stop being the prototypical consonant. In this case, the contrast is maximal: complete closure for stops and a wide opening for the vowel. The stop, either oral or nasal, thus, is an optimal syllable onset.

To summarize the above findings, the table above (63) presents a clear preference for oral stops (*p,b,t,d,k*) and nasal stops (*m,n*) in the onset position as opposed to the fricatives and liquids. The same findings are reported in other languages for children with typical development (Fikkert 1994 for Dutch, Freitas 1996 for Portuguese, Barlow and Gierut 1999 for English, Ben-David 2001 for Hebrew, Kappa 2002 for Greek, and Grijzenhout and Joppen (in press) for German) and for those with atypical development (Tubul 2005 for dyspraxic children).

### 6.1.4.2. Initial onset in disyllabic productions

The segmental effects on onset preservation also occurred when the children started to produce disyllabic words. At this stage they use two strategies of replacement: assimilatory and non-assimilatory replacement. Assimilatory replacement (harmony) refers to a process by which a consonant assimilates to a non-adjacent consonant in place or manner of articulation (e.g. *papî* for *kapît* 'teaspoon', *máma* for bámba 'snack').

Non-assimilatory replacement refers to a process by which a consonant is substituted by another consonant irrespective of other consonants in the environment (e.g. *dédey* for *ʁégel* 'leg', *mamá* for *baybáy* 'bye'). Non-assimilatory replacement may be a result of other aspects, such as markedness. However, there are some cases in which it is difficult to decide whether it is a non-assimilatory process or not. Child A1 (2;1.19), for example, produced *papá* for *nafál* 'fell down', a replacement which can be analyzed as stopping plus regressive assimilation, or a non-assimilatory replacement with an unmarked segment. Also, child A3 (2;5.24) produced *pópa* for *kóva* 'hat', which again could be viewed as place assimilation or replacement with the unmarked segment

At the following sub-section (§6.1.4.2.1) I deal with onset replacement according to manner of articulation. The tendency to preserve words with obstruent segments in onset position is seen at this stage as well as the stage mentioned in §6.1.4.1. Thus sonorant segments were generally deleted or replaced with non-sonorant segments. This issue is widely discussed in both child and adult language (Stemberger 1996, Pater 1997, Bernhardt and Stemberger 1998, Kager 1999), and is presented below. The phenomenon of assimilatory replacement is discussed then (§6.1.4.2.2). My discussion will concentrate on place assimilation since it is much more common than manner or voicing assimilation.

### 6.1.4.2.1. Onset replacement

The data in the table (64) below show the onset distribution by manner of articulation in the children's productions. The total numbers at the right column represents the all target tokens with onset, while children's production includes words in which onsets are either preserved or replaced by another manner of articulation. In other words, the numbers in this table include onset productions only, either by preservation or replacement of the onset segment.

(64) Onset preservation: Distribution by manner of articulation in the children's production

| Target words | | Children's production | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Stops | | Fricatives | | Nasals | | Liquids | |
| | Total | Preservation | N | % | N | % | N | % | N | % |
| Stops | 470 | 352 | 338 | 96% | | | 10 | 2.8% | 4 | 1.1% |
| Fricatives | 164 | 99 | 59 | 59% | 38 | 38% | 1 | 1% | 1 | 1% |
| Nasals | 116 | 94 | 9 | 9.5% | | | 76 | 81% | 9 | 9.5% |
| Liquids | 122 | 66 | 18 | 27% | 1 | 1.5% | 5 | 7.5% | 42 | 63% |
| Total | 872 | 611 | 424 | 70% | 39 | 6% | 92 | 15% | 56 | 9% |

The numbers in the table above indicate two main points: first, **target words** with stops in onset position were preferred by the children more than target words with other manners of articulation in onset position, and they responded to them more than to target words with other manners of articulation. Out of 872 target words to which children responded, 53.9% (470/872) were with stops in onset position, while only 18.8% (164/872) were with fricatives, 14% (122/872) were with liquids, and 13.3% (116/872) were with nasals. This tendency reflects the language's preference i.e. out of 364 types of target words in my study with onsets in the penultimate syllable, 34.5% (125/364) were with stops, 30% (109/364) were with fricatives, 21% (77/364) were with nasals, and 14.5% (53/364) were with liquids.

The second aspect concerns **produced words**. The children preserved the onset in penultimate syllables in target words primarily with stops, but also with nasals, more so than target words with fricatives or liquids. The onset is preserved in 72%

(338/470) of the tokens of produced words with stops in onset position, in 65% (76/116) of the tokens of produced words with nasals in onset position, but only in 23% (38/164) of the tokens of produced words with fricatives in the onset position and 34.4% (42/122) with liquids. The onset preservation of stops and nasals was more frequent: 96% (338/ 352) of the stops and 81% (76/94) of the nasals in onset position were produced, while only 38% (38/99) and 63% (42/66) of the fricatives and liquids in onset position were preserved.

If an onset is replaced, it is more likely to be replaced by a stop than by other manners of articulation. Out of 99 target words with fricatives in onset position, 59 (59%) are replaced by stops (e.g. *táta* for *sáfta* ‘grandma’) but only 1 out of 99 (1%) is replaced by a nasal. The same holds for liquids. Out of 66 target words with liquids in onset position, 18 are replaced by stops (27%) (e.g.: *pái* for *mispáʁaim* ‘scissors’), while only 1 out of 66 is replaced by a fricative (1.5%) and 5 out of 66 by nasals (7.5%). The preference of a less sonorous onset is universal and is mentioned in many studies of language acquisition of children speaking Hebrew, as well as studies of other languages. Fikkert (1994) found that plosives are the most frequent onset in the development of onset in Dutch. The same findings are reported in English (Pater 1997), Portuguese (Freitas 1996) and also for Hebrew-speaking children (Ben-David 2001, Tubul 2005).

### 6.1.4.2.2. Assimilatory replacement

Onset assimilation is another strategy, which appears parallel to onset preservation during this stage of acquisition. As stated, consonant assimilation in child language refers to a process by which a consonant assimilate to a nonadjacent consonant in place or manner of articulation. Ingram (1974, 1976) mentions that this process is frequent in the phonological development. It can either be regressive (e.g. *kʌŋ* for ‘tongue’), or progressive (e.g. *kog* for ‘cold’). When both the consonant and the vowel assimilate, the word appears as reduplication (e.g. *titi* for ‘katie’).

In fact, consonant assimilation in child phonology is regressive about two thirds of the time (Vihman 1978), and is exclusively so in the speech of some children. Indeed, regressive complete assimilation is more frequent in my data (see table (65) below), as well as in the data of others (Menn 1975, Vihman 1978, Berg 1992), i.e. the onset production of the penultimate syllable of disyllabic words is influenced by the onset of the ultimate syllable of the word and assimilates accordingly. However, there are few examples of progressive complete assimilation, in which the onset in the ultimate syllable assimilates to the onset of the penultimate syllable of the word. Table (65) below presents these strategies. As mentioned in §6.1.4.2, my discussion will concentrate on place assimilation only.

(65) Assimilatory replacement

| Target | | Children's Productions | Child |
|---|---|---|---|
| | | Regressive assimilation | |
| kapít | 'teaspoon' | papí | A1 (2;4.25) |
| cipóʁ | 'bird' | pipó | A2 (2;2.27) |
| aʁbé | 'a lot' | bebé | A4 (2;8.24) |
| psantéʁ | 'piano' | tatén | A2 (2;11.2) |
| patíʃ | 'hammer' | tatíθ | A1 (2;4.0) |
| kadúʁ | 'ball' | dadú | A2 (1;11.14) |
| | | tadú | A1 (2;5.23) |
| gadól | 'big' | dodó | A4 (3;5.12) |
| | | dadó | A1 (2;5.23) |
| tmuná | 'picture' | nuná | A6 (4;7.22) |
| dúbi | 'teddy bear' | bíbi | A2 (2;1.9) |
| | | búbi | A3 (2;10.10) |
| glída | 'ice cream' | dída | A6 (3;10.8) |
| tʁáktoʁ | 'tractor' | káko | A4 (3;9.17) |
| géʃem | 'rain' | ʃéʃe | A3 (3;3.12) |
| | | Progressive assimilation | |
| patíʃ | 'hammer' | papíθ | A1 (2;4.0) |
| péʁax | 'flower' | pépa | A2 (2;0.11) |
| dúbi | 'teddy bear' | dúdi | A1 (2;5.23) |
| ʃóko | 'chocolate' | ʃóʃo | A1 (2;4.25) |
| ʃémeʃ | 'sun' | ʃéʃe | A3 (2;10.10) |

Ben-David (2001) reported that assimilation appeared during the second stage of onset development with the children in her study: Gefen (1;1) produced *táta* for *sáfta* ‘grandma’, *bába* for *sába* ‘grandfather’, and also *féfe* for *géfen* ‘proper name’. Nadav (1;8) produced *gógo* for *légo* ‘Lego’, *kó*ki for *túki* ‘parrot’, and also *kéke* for *ʃéket* ‘quite’. She emphasized that these productions were not a result of segmental difficulties, as a segment deleted in a certain word might appear in another word, albeit in another prosodic position.

As stated, in terms of features, place assimilation is much more common than manner or voicing assimilation (the latter reported in Matthei 1989). Default features (see § 1.1.1), such as [coronal] plus [-continuant, -sonorant] are the most frequent targets of assimilation, being replaced by nondefault features such as [labial] and [dorsal] (Bernhardt and Stemberger 1988). Stemberger and Stoel–Gammon (1991) report that perhaps half of the hearing English-speaking children show labial or dorsal assimilation at early points in their development. Bernhardt and Stemberger (1988) describe Dylan’s (an English-speaking child) segmental system; they show that [coronal] is the default place, but the system prefers to assimilate [labial] rather than to have [coronal] in the output. Only coronals are targets of labial assimilation, while dorsals are immune.

The data in (65) show preference for regressive assimilation when the first consonant is dorsal, and the second is either labial or coronal (e.g. *paṕi* for *kapît* ‘teaspoon’, *dadó* for *gadól* ‘big’, and also *dadú* for *kadúʁ* ‘ball’, *dîda* for *glîda* ‘ice cream’). No such preference is encountered when the two consonants are labial and coronal, in either order. In such cases assimilation can be either regressive or progressive (e.g. *búbi* (regressive assimilation) and *dúdi* (progressive assimilation) for *dúbi* ‘teddy bear’, as well as *tatîθ* (regressive assimilation) and *papîθ* (progressive assimilation) for *patîʃ* ‘hammer’). Also non-assimilatory replacement suggests that dorsals are the least preferred (e.g. *táti* for *káki* ‘excrement’, *dédey* for *ʁégel* ‘leg’). Thus, it seems as if the children prefer labial and coronal consonants to velars. My findings are consistent with those of Demuth and Johnson (2003), who report that their French-speaking child's early words consisted of labial stops more frequently than velar (and sonorants) consonants in onset position.

Pater (1997) explains that consonant assimilation is a limited form of full reduplication that is so common in babbling and early speech (Jespersen 1922, Goad 1993). He believes that for children at an early stage of development, there is an advantage to gestural repetition at some level of speech production (also Menn 1976, Vihman 1978). He, however, presents a process, which is different from that of my findings: his data display what may be referred to as velar dominant harmony, in that labials and coronals assimilate to velars (e.g. *gɔg* for 'dog', *kIŋk* for 'sink', *gig* for 'big', *gak* for 'box' and also *kek* for 'take'). All these examples, however, are of regressive assimilation. Goad's (1997) findings are very similar to those of Pater's (1977), Bernhardt and Stemberger's (1988) and Pater and Barlow's (2003): coronals acquire a place from a nonadjacent labial or dorsal consonant. For example: /d/ assimilates in place to a final velar – [gʌk] for 'duck', and /t/ assimilates in place to a final labial – [bɔp] for 'stop'. However, there is no assimilation of a labial to a velar (e.g. [bæk] for 'black') or a velar to a labial (e.g. [gʌm] for 'come'). These authors claim that default features either appear in repairs or are the target of a repair. In other words, in these cases, the default feature [coronal] is a target of the repair, thus they typically assimilate in place to labials and velars.

I assume that the hearing impaired children of my study select the labial segments rather than the velars, since they are visibly articulated. Boothroyd (1998) explains that in face to face communication, the visible movements of speech provide valuable sensory evidence that is easily integrated with auditory evidence and serves as a natural complement to it. Thus, speech reading provides much information about the place of articulation of vowels and consonants. Hence, following other studies with hearing children (Stark 1983, Stoel-Gammon 1998), I believe that children prefer the frontal segments and delete the velars which are not visible. This tendency is probably more significant in hearing impaired children, who rely on visual cues to a larger extent than hearing children (Ertmer and Mellon 2001). As for the coronals, their preference might be as a result of their high frequency in the language as well as of markedness reasons.

#### 6.1.4.3. Initial syllable of tri- and quadrisyllabic productions

Productions of trisyllabic words do not provide evidence for segmental effects on onset development. During this stage of the development of the prosodic word, the acquisition of a simple onset is almost complete: Child A1, for example, produces the onset in the initial syllable of tri- and quadrisyllabic productions in 89% of the cases (169 out of 190): 96% of the stops (47/49), 95% of the nasals (58/61), 91% of the fricatives (40/44), and only 66.6% of the liquids (24/36). The few replacements in the fricative group include mostly sibilant replacements by stops (mostly to /t/). The liquids are deleted most often since they include the /l/ and /ʁ/ which are acquired late and rare also after they are acquired, as it is usually the case with novel structures. This tendency is similar with all the six implanted children. These findings are similar to those reported in §6.1.4.1, i.e. the stop, either oral or nasal, thus, is an optimal syllable onset and is the preferred segment in onset position.

### 6.1.5. Complex onsets (word initial clusters)

Cluster acquisition is a challenging task and is one of the longest-lasting processes of speech acquisition in typically developing children. It has gradual developmental stages as were described in §2.2.3 above.

Usually, there are three types of cluster groups according to their position: initial clusters (e.g. *black* in English, *dvaʃ* ‘honey’ in Hebrew), medial clusters (e.g. *donkey* in English, *axbáʁ* ‘mouse’ in Hebrew), and final clusters (e.g. *drink* in English, *tank* ‘tank’ in Hebrew). The ratio among these cluster groups is different among languages. As mentioned in §1.2.2.2, Hebrew has mostly initial and medial clusters. Final clusters are rare and are found in borrowed nouns (e.g. *paʁk* ‘park’, *bank* ‘bank’, *čips* ‘potato chips’), denominative verbs derived from borrowed nouns (e.g. *giʃpénk* ‘approves ms.sg.’ from *guʃpánka* ‘approval’; Bolozky 1978, Bat-El 1994), and in the suffixed verbs (e.g. *axált* 'you ate fm.sg.', *yaʃánt* 'you slept fm.sg.'). Details about the cluster's characteristics in Hebrew have been provided in §1.2.2.2. My discussion will focus on initial (§6.1.5) and medial clusters (§6.3.3) only.

The initial stage of onset acquisition is characterized by words without onsets (§6.1.1). Target words with a complex onset start out in the same manner. The children produce onsetless words, thus as expected, both the first and the second segments of the cluster are deleted (§6.1.5.1). During the following stages, onsets start appearing (§6.1.5.2), however, segmental considerations play a role and may determine which of the two segments in the cluster is preserved. Different clusters with various types of segments are discussed: obstruent-liquid clusters (§6.1.5.2.1), obstruent-nasal clusters (§6.1.5.2.2), and also obstruent-obstruent clusters (§6.1.5.2.3). Coalescence, in which both segments are replaced by another segment that preserves some of their features is infrequent (§6.1.5.3). Two segment production is the final stage of cluster acquisition (§6.1.5.4). This stage is divided into two sub-stages: epenthesis, which is characterized by vowel insertion between the two elements of the cluster (§6.1.5.4.1), and finally appropriate cluster productions (§6.1.5.4.2).

### 6.1.5.1. Onsetless words production

As stated, at the beginning of onset acquisition words are without onsets. Since this issue is discussed broadly in the section dealing with consonant-free words (§6.1.1 above), in the following sub-section, I provide data of target words with complex onsets, showing the same tendency: the onset is deleted in target words with complex onsets (tables (66) below) similarly to what described for target words with simple onsets (§6.1.1 and §6.1.3). The examples below represent all cases of onsetless word productions with complex onsets in the initial syllable of the target words.

(66) Onsetless word productions for monosyllabic and polysyllabic target words

| Monosyllabic target words | | Children's productions | Child |
|---|---|---|---|
| kxi | 'take! fm.sg.' | i: | A1 (2;2.16) |
| | | | A3 (3;0.26) |
| | | i | A2 (2;4.11) |
| tni | 'give! fm.sg.' | i | A4 (2;8.24) |
| | | | A5 (2;4.0) |
| | | i: | A6 (3;2.13) |
| dli | 'bucket' | i | A6 (4;7.22) |
| zvuv | 'fly' | uθ | A5 (2;7.0) |
| kwa | 'frog sound' | aw | A6 (3;2.13) |
| dvaʃ | 'honey' | aʃ | A6 (3;11.12) |
| **Polysyllabic target words** | | **Children's productions** | **Child** |
| glída | 'ice cream' | ía, íba, ída | A5 (2;5.0-2;9.7)) |
| | | ía, ída, íga | A4 (3;0.11-4;3.3) |
| | | íba, ída, | A3 (3;3.12-3;10.19) |
| | | ída | A1 (2;4.25-2;8.29) |
| | | ída | A2 (2;5.15-2;6.20) |
| | | íta, ída | A6 (3;11.12) |
| myáu | 'cat sound' | áu | A2 (1;6.11) |
| tʁáktoʁ | 'tractor' | áto | A4 (3;6.18) |
| | | | A5 (3;4.0) |
| | | áko, áto | A6 (5;1.26) |
| ʃlulít | 'puddle' | uwí | A4 (3;6.18) |
| gviná | 'cheese' | iná | A4 (3;11.7) |
| | | | A5 (2,9.7) |
| | | | A6 (4;4.21) |
| smixá | 'blanket' | ixá | A4 (3;11.7, 4;11.5) |
| ʃtáim | 'two' | áim | A4 (4;0.18) |
| tmuná | 'picture' | umá, uná | A5 (2;6.7, 2;8.2) |
| | | | A6 (4;7.22) |
| kvisá | 'laundry' | itá | A5 (2;7.0) |
| cfaʁdéa | 'frog' | ovéa | A5 (3;8.20) |

The data in the table above show the same selectional restrictions described in the initial stage of onset development (§6.1.1 and §6.1.3). As for the **target parameter** during this stage, children respond to very few target words with complex onsets.

As for the **production parameter,** the tokens of produced words are similar to those reported in §6.1.1 and §6.1.3 above, and include onsetless word productions.

These words contain monosyllabic and disyllabic consonant-free words, i.e. words consisting of vowels only. Codaless monosyllabic target words appear as vowels only (e.g.*i* for *tni* 'give! fm.sg.' and *dli* 'bucket'). The same holds for a few disyllabic words (*îa* for *glîda* 'ice cream', *áu* for *myáu* 'cat sound'). Also, disyllabic words are produced with empty onsets in the initial syllable of the word (see §6.1.3.1). The children produce the nucleus (i.e. the vowel) of the non-final syllable of disyllabic target words and omit the onset (complex onsets in these target words) of the initial syllable (*iná* for *gviná* 'cheese', *îda* for *glîda* 'ice cream' etc.). These findings are similar to those of other studies reported in the literature (Mcleod et al. 2001, Ben-David 2001, Tubul 2005). However, reports of onsetless words for target clusters are rare. Smit (1993), for example, examined word-initial clusters in 1,049 children ages 2 to 9 years. Null onsets for target clusters were characterized as "rare" and were limited to the youngest age group examined (children ages 2 to 3 years). Meline (1997), on the other hand, reported that 9 children with profound hearing loss (between 5 and 12 years of age) produced 19 of 180 (11%) consonant clusters with a null onset.

#### 6.1.5.2. Production of one of the clusters' segments

Following the assimilatory replacement stage (§6.1.4.2.2), during which the simple onset does not correspond to any of the cluster's segments, a consonant related to those in target clusters starts appearing. This correspondence, known as *Cluster Reduction* or *Cluster Simplification*, is observed in the acquisition of other languages, such as Dutch (Beers 1993), Danish (Bloch 1996), Italian (Bortolini and Leonard 1991), Telugu (Chervela 1981), German (Fox an Dodd 1999), Portuguese (Yavas and Lamprecht 1988), and Turkish (Kopkalli, Yavuz and Topbas 1998).

When children reduce complex onsets to singletons, they are usually systematic in terms of which of the cluster's consonants they retain. A common tendency is for the least sonorous member of the adult target cluster to be preserved, regardless of where this segment appears in the target cluster (Fikkert 1994, Gilbers and Den Ouden 1994, Gnanadesikan 1995, Chin 1996, Ohala 1996, 1999, Barlow 1997, Goad and Rose 2000, Goad 2001).

Complex onset reduction and the segment selection are discussed in the following sub-section, using the sonority scale provided in §1.1.2.2. In the following sub-sections, I describe the developmental pattern of different clusters, with reference to the types of segments in the cluster: obstruent-liquid clusters (§6.1.5.2.1), obstruent-nasal clusters (§6.1.5.2.2), and obstruent-obstruent clusters (§6.1.5.2.3). Out of 59 types of target words with clusters, 49% (29/59) are obstruent-obstruent clusters, 34% (20/59) are obstruent-liquid clusters, and (17%) (10/59) are obstruent-nasal clusters.

### 6.1.5.2.1 Obstruent-liquid target clusters

The data in (67) below present target words with initial clusters, containing an obstruent (i.e. stops, fricatives, and affricates) and a liquid (*l,ʁ*), and only one word containing a stop and the glide *w* (i.e. *kwa* ‘frog sound’)

(67) Obstruent - liquid target clusters

| Target | | Children’s productions | Child |
|---|---|---|---|
| pʁaxím | ‘flowers’ | paxím | A2 (2;9.14) |
| | | naxím | A6 (5;1.26) |
| bʁexá | ‘swimming pool’ | bexá | A5 (4;1.5) |
| bʁógez | ‘quarrel’<br>(children’s speech) | bógeð | A1 (2;9.19) |
| bʁúʁya | ‘proper name’ | búʁya, búya | A1 (3;1.18) |
| tʁáktoʁ | ‘tractor’ | táto, táktoʁ | A1 (2;5.23) |
| | | yáto, káko | A4 (3;5.12) |
| | | báto | A5 (3;0.10) |
| | | dádo | A6 (3;7.9) |
| vʁudá | ‘pink fm.sg.’ | vudá | A3 (4;10.27) |
| plastalína | ‘plasticine’ | pastanína | A1 (3;4.10) |
| plásteʁ | ‘plaster’ | páste | A2 (2;11.2) |
| | | másteʁ | A4 (4;6.22) |
| plaxím | ‘slices’ | paí | A5 (3;2.20) |
| dli | ‘bucket’ | di | A3 (4;7.20) |
| | | ki | A4 (4;1.21) |
| | | ni | A6 (5;1.26) |
| klipá | ‘peeling’ | kipá | A5 (3;2.20) |

| | | | |
|---|---|---|---|
| klemantína | ‘clementine’ | kematína | A1 (3;0.5) |
| | | tamanína | A4 (3;9.17) |
| | | temaína | A5 (3;2.20) |
| glída | ‘ice cream’ | gída | A1 (2;9.19) |
| | | lída | A2 (2;7.24) |
| | | dída | A3 (4:0) |
| | | títa | A6 (4;0.16) |
| ʃloʃá | ‘three ms.’ | ʃoʃá | A3 (4;1.9) |
| ʃlulít | ‘puddle’ | ʃuʁík | A3 (4;6.2) |
| | | ʃulít | A5 (3;8.20) |
| kwa | ‘frog sound’ | wa | A1 (2;10.17) |
| myáu | ‘cat sound’ | yáu | A6 (4;0.16) |
| | | máu, yáu | (A2 (2;11.2) |
| | | máu, yáu, wáu | A3 (4:0) |

As can be seen from the data above, targets of obstruent-liquid clusters are produced in most cases as single obstruents. In some cases, the obstruent in the child’s production is identical to that in the target cluster (e.g. *kipá* for *klipá* ‘peeling’, *táto* and *táktoʁ* for *tráktoʁ* ‘tractor’). In others, it is replaced by obstruent with another place of articulation (e.g. *ki* for *dli* ‘bucket’, *dádo* for *tráktoʁ* ‘tractor’) (see also §6.1.4.1 for segmental analysis). That is, of the two segments in the cluster, the liquid, which is the sonorant segment, is omitted and the obstruent is preserved. However, there are very few cases where a nasal is produced instead of both the obstruent - liquid clusters (e.g. *naxîm* for *pʁaxîm* ‘flowers’, *másteʁ* for *plásteʁ* ‘plaster’, and also *ni* for *dli* ‘bucket’). The preference of stops, either oral or nasal, are already discussed in the section of segmental effects on simple onset development (§6.1.4). I will discuss this issue also at the following sub-section, dealing with obstruent-nasal clusters (§6.1.5.2.2).

In 86% (86/100) of the tokens of obstruent-glide/liquid clusters, the obstruent is produced, and in only 14% (14/100) of the tokens is the liquid produced. Since all these words contain stops or fricatives in the initial position of the cluster, these consonants are the ones to be produced.

The preservation of the obstruent rather than the liquid reflects the effect of the sonority sequencing principle (Chin 1996, Gierut 1999, and Ohala 1999). Usually, segments with low sonority values are found in onset positions, and segments with higher sonority values are located towards the end of the syllable (Clements 1990). Typically developing children reduce word initial consonant clusters in a manner that produces a maximal rise in sonority (Ohala 1999, Lleo and Prinz 1996). Thus children tend to preserve the least sonorous of two consonants in a cluster if the cluster is syllable initial. In other words, similarly to the findings in my study, the children omit the second segment of the cluster (the sonorant one) and preserve the initial segment (the non-sonorant one). My findings, thus, are similar to those of other studies with hearing children (Smit 1993, Ohala 1995, 1996, 1998, Gnanadesikan 1995, Barlow 1997, Ben-David 2001, 2006, Kappa 2002, Pater and Barlow 2003, and Tubul 2005), as well as cochlear implant users (Chin & Finnegan 2002), and consistent with acoustic salience and universal preferences. Pater and Barlow (2003) present examples for two American-English-speaking children, who reduced fricative - liquid clusters. Both children always follow the sonority pattern, in other words, they delete the liquid and preserve the fricative segment. I introduce these two children (68) as an example of that universal tendency discussed above and present their data later on while discussing other types of cluster.

(68) *Julia*

| *Type* | *Child Form* | *Adult target* | *Age* |
|---|---|---|---|
| sl | [sip] | ‘sleep’ | 1;8.27 |
|  | [sai:t] | ‘slide’ | 1;11.16 |
| fl | [faʊwə] | ‘flowers’ | 1;11.23 |
| fr | [fɔgi] | ‘froggy’ | 2;0.23 |

*Trevor*

| *Type* | *Child Form* | *Adult target* | *Age* |
|---|---|---|---|
| sl | [sip] | ‘sleep’ | 1;8.26 |
| fl | [fəwə] | ‘flower’ | 1;7.6 |
| fr | [fa:g] | ‘frog’ | 1;10.5 |

I claim, however, that this tendency is also strengthened by segmental development constraints; Since the liquids *l* and *ʁ* are acquired late in Hebrew as well as in other languages (e.g. Smit et al. 1990, Dodd et al. 2003 for English), they are more likely to be deleted while preserving the obstruent. Thus, the children delete both the *l* and the *ʁ* in the clusters and preserve the obstruent (see also Ben-David 2006 for Hebrew-speaking hearing children). I base my claim on Bernhardt and Stemberger's (1988) developmental analysis of the case of clusters consisting of an obstruent and a glide *l* or *ɹ*. They explain that English-speaking children may alternatively use the glides *j* or *w* for *l* and *ɹ* as singletons and cluster elements, during the initial stages of development, while a more drastic type of cluster repair is segment deletion. They give examples of Charles, an English-speaking child with a phonological disorder, who produces *bæk* for 'black' when he is 5:10 years old and *b*$^{ə}$*wæk* when he is older (6:0 years old). In other words, a developmental tendency is presented: during the initial stage, he deletes the *l* of the cluster and preserves the obstruent *b*, and later, he preserves both elements of the cluster while using the glide *w* instead of *l.*

The case of *kwa* 'frog sound', the only word with a stop-*w* cluster is different: in 75% of the cases (25/33 tokens) the stop (i.e. *k*) is deleted and the *w* is preserved. Pater and Barlow (2002) explain that not all children follow the sonority pattern and there are some constraints that might conflict with that of sonority-based onset selection. In the case of velar-initial clusters, the non-preference of the feature [dorsal] is stronger than that of the low sonority preference, thus causing deletion of the velar while preserving the sonorant element of the cluster. For example: *jʌ:* for 'glove', and *jin* for 'clean'. These findings are consistent with those of Chin and Finnegan (2002), who examined consonant cluster productions of cochlear implant users. The children in their study delete the dorsal segment (generally stop) and preserve the most sonorous segment between the two. According to this explanation, since *w* is labio-dorsal segment, the preference for labial segment is higher.

Similar glide preference occurred in the only nasal - glide cluster, in the word *myáu* ‘cat sound’: in 62.5% (10/16) tokens of this word, the glide *y* is preserved while the nasal *m* is deleted. It should be mentioned, however, that there is variability among children and even with the same child: child A6, for example, always deleted the *m* and preserved the *y* (i.e. produces *yáu*), while child A2 produced the *m* three times (i.e. *máu*) and the *y* twice (i.e. *yáu*). A3 produced both *máu, yáu,* as well as *wáu* (i.e. she coalesced the *y* with *m* using the labial feature).

The preference for obstruents, and more specifically, stops in onset position is discussed in detail in (§6.1.4): Since the non-sonorant segments (obstruents) are the preferred segments in onset position, generally initial clusters are reduced to the least sonorous element in the child’s system.

### 6.1.5.2.2. Obstruent-nasal target clusters

The data in (69) below, present target words with initial clusters, containing an obstruent (i.e. stops, fricatives, and affricates) and a nasal (*m,n*).

(69) Obstruent - nasal target clusters

| Target | | Children’s productions | Child |
|---|---|---|---|
| tmuná | ‘picture’ | puná | A1 (3;3.3) |
| | | nuná, tuná | A2 (2;4.11) |
| | | muná | A5 (2;11.6) |
| tmunót | ‘pictures’ | tunót | A2 (2;5.15) |
| tni | ‘give! fm.sg.’ | ni, ti | A2 (2;0.11) |
| kmo | ‘like’ | mo | A3 (4;7.20) |
| smixá | ‘blanket’ | sixá | A1 (2;9.19) |
| | | mixá | A4 (4;7.25) |
| ʃmóne | ‘eight fm.’ | móne | A2 (2;7.24) |
| ʃnícel | ‘schnitzel’ | níʃel | A5 (4;2.24) |

Obstruent-nasal clusters are infrequent: as mentioned above, only 17% (10/59) of the types of target words have obstruent-nasal clusters. As can be seen in table (69) above, in words with obstruent-nasal clusters, the children tend to omit the obstruent and preserve the nasal. In 68.7% (22/32) of the tokens with initial clusters, the nasal is preserved while the obstruent is deleted. This tendency is also reported in other studies of Hebrew-speaking children (Ben-David 2001, Tubul 2005) and in American-English-speaking children (Pater and Barlow 2003). The latter present examples of reduced fricative-nasal clusters of Julia and Trevor (70), the two American-English-speaking children, mentioned in §6.1.5.2.1. Both children deleted the fricative, rather than the nasal, contrary to the sonority pattern.

(70) *Julia*

| *Type* | *Child Form* | *Adult target* | *Age* |
|---|---|---|---|
| sn | [mami + nis] | ‘mommy sneeze’ | 1;9.5 |
| | [nek] | ‘snake’ | 1;11.22 |
| sm | [ʍʌs is mɛʊ] | ‘what (do) I smell? | 2;4.28 |

*Trevor*

| *Type* | *Child Form* | *Adult target* | *Age* |
|---|---|---|---|
| sn | [næ] | ‘snap’ | 1;1.4 |
| | [mæp] | ‘snap’ | 1;8.12 |
| | [no mæn] | ‘snow man’ | 1;11.14 |
| | [ni:z] | ‘sneeze’ | 1;10.5 |

Like Julia and Tervor on the above examples, the children in my study deleted the fricatives *s* and *ʃ* in most cases and preserved the nasals *m* and *n* (e.g. *mixá* for *smixá* ‘blanket’, and *móne* for *ʃmóne* ‘eight’).

Comparison between obstruent-liquid clusters and obstruent-nasal clusters reveals an interesting difference: while in 14% (14/100) of the tokens of obstruent – glide/liquid clusters, the glide/liquid is produced, in 68.7% (22/32) of the tokens of obstruent-nasal clusters, the nasal is produced. In other words, there is a significant preference for the non-sonorant segment (i.e. obstruent) in obstruent – glide/liquid cluster but for the sonorant segment (i.e. nasal) in obstruent-nasal cluster.

I assume, however, that the preference of nasals rather than liquids in a cluster combined with obstruent is based on other reasons: as for the liquids, as is mentioned in §6.1.5.2.1, the liquids *l* and *ʁ* are acquired late in Hebrew as well as in other languages, they are more likely to be deleted while preserving the obstruent. As for the nasals, despite the fact that they are complex sounds (their production required the involvement of three systems: the vocal cords, the uvular and the oral muscles), they are natural and fit our physiology better than oral sounds, thus they start appearing very early in baby's vocalization and are used more frequently in language (Tobin 1997). Moreover, in the case of obstruent-nasal clusters, I assume that, the preference to produce the second segment, i.e. the nasal, rather than the non-sonorant one, is a result of a perceptual parameter. In making my assumption, I rely on Steriade's (2000) explanation in which the position of a segment in the syllable influences its acoustic prominence. Steriade (2000) explains that a consonant before a vowel is acoustically more salient than a consonant before a consonant due to the clear transition from a consonant to a vowel, which is less salient in a consonant–consonant transition. Since the second segment in a two-consonant cluster is adjacent to a vowel, it is more salient than the first consonant, thus it is better perceived and, as a result, produced by the children. I believe that the smaller the sonority gap between the two segments of the cluster is, the greater the influence of the acoustic aspect in the segment selection is. In other words, since the sonority gap between an obstruent and a nasal is smaller than that between an obstruent and a liquid/ or a glide, the preference for the non-sonorant segment, i.e. the obstruent, is lower and acoustic considerations affect the selection of the nasal to a larger extent than the obstruent. The same tendency is reported in the literature (Pater and Barlow 2002, 2003, Goad and Rose 2000).

However, variations in the segment selection are more frequent and mainly occur between [labial] and [coronal]. In other words, as mentioned in §6.1.4.2.2 (relating to assimilatory replacement), the combination of the place feature [coronal] with the place feature [labial] results in bidirectional reduction: either deletion of the obstruent while preserving the nasal or the opposite (see also Pater and Barlow 2002): child A2, for example, produced *tuná* for *tmuná* 'picture (i.e. the obstruent is produced), while child A5 produced *muná* (i.e. the nasal segment is produced). Also, A1 produced *sixá* for *smixá* 'blanket', while A4 produced *mixá*. Finally, A2 produced *ni* but also *ti* for *tni* 'give fm.' In the case of velar-initial clusters, I assume that the non-preference for the feature [dorsal] is stronger than that of the low sonority preference, thus causing deletion of the velar while preserving the sonorant element of the cluster. Since I have only one example in my data (i.e. *mo* for *kmo* 'like'), it is impossible to draw conclusions.

#### 6.1.5.2.3. Obstruent-obstruent target clusters

The data in (71) below present target words with initial clusters, containing two obstruents (i.e. stops, fricatives, and affricates).

(71) Obstruent - obstruent target clusters

| Target | | Children's productions | Child |
|---|---|---|---|
| pkak | 'cork' | ka | A1 (2;4.18) |
| psantéʁ | 'piano' | tatén | A2 (2;11.2) |
| | | saté, pantéʁ | A4 (4;0.18) |
| bgadím | 'clothes' | gadím | A1 (3;1.18) |
| txélet | 'pale blue' | xélet | A3 (4;9.11) |
| dvoʁá | 'bee' | voá | A1 (2;8.29) |
| | | boá | A4 (4;1.21) |
| ktaná | 'little fm.sg.' | taná | A2 (2;9.14) |
| ktaním | 'little ms.pl.' | taním | A3 (3;9.6) |
| kviʃ | 'road' | viʃ | A1 (2;4.18) |
| kxi | 'take! fm.sg.' | ti | A2 (2;1.9) |
| | | xi | A4 (4;6.22) |
| gdolá | 'big fm.sg.' | dolá | A3 (4;3.2) |
| gviná | 'cheese' | vidá | A2 (2;6.20) |
| | | simá, giná | A3 (4;7.20) |
| | | miná | A4 (4;0.18) |
| | | biná, piná | A5 (3;1.14) |
| spagéti | 'spaghetti' | magéti, bagéti | A4 (3;7.28) |
| sfatáim | 'lips' | satáim | A3 (4;3.2) |
| sfatón | 'lipstick' | satón | A3 (4;9.11) |
| zvuv | 'fly' | bu, zuv | A2 (2;5.15) |
| | | vu | A4 (3;11.7) |
| | | tu, dub, wuf | A5 (2;8.2) |
| | | xu | A6 (4;6.11) |
| cfaʁdéa | 'frog' | sadéa, tabía, cadéa | A2 (2;5.15) |
| | | badéa, vaʁdéa, fadéa | A4 (3;6.18) |
| cvaím | 'colors' | vaím | A5 (3;2.20) |
| ʃtáim | 'two fm.' | tái, táim | A2 (2;1.9) |
| ʃvut | 'proper name' | ʃut | A1 (2;6.21) |
| ʃvuʁá | 'broken fm.sg.' | buʁá | A5 (3;8.20) |

In clusters consisting of two obstruents (i.e. stop-stop, stop-fricative, fricative-stop, fricative-fricative, affricate-fricative), usually, the first segment is omitted while the second segment is preserved. For 99 of the tokens with double obstruent clusters, in 81.8% (81/99), the first segment is omitted.

When the cluster consists of two obstruents acoustic considerations are dominant, thus the second segment is the one to be produced since it is adjacent to the vowel, and the sharp transition makes it more salient. All the target words with a fricative-fricative sequence include one of the sibilants *s* or *ʃ* (in the initial position of the cluster) followed by the segments *f* or *v*. In all these cases, however, the children prefered to produce the sibilants *s* or *ʃ*, which are acoustically more salient. However, when the cluster consists of affricate and fricatives there are no any consistent tendency but variation. Since there are very few examples (i.e. *cvaîm* 'colors', *cfaʁdéa* 'frog', *kcat* 'few'), it is difficult to run into conclusions.

Table (72) below summarizes the findings of the current stage of cluster acquisition.

(72) Cluster reduction according to manner and consonant position

| Cluster | | | C1 Production | | C2 Production | |
|---|---|---|---|---|---|---|
| C1 | C2 | | N | % | N | % |
| Obstruent | Glide/Liquid | 100 | 86 | 86% | 14 | 14% |
| Obstruent | Nasal | 32 | 10 | 31.25% | 22 | 68.75% |
| Obstruent | Obstruent | 99 | 18 | 18.2% | 81 | 81.8% |

These findings support Locke's (1983) generalization, based on a cross-linguistic comparison of the position and type of the deleted segment in initial clusters. "If there is a glide or a liquid present, it typically will be the second member, and children will omit it. In most other cases, the first member will be a stop or a fricative, and children will omit the stop or fricative. If both members are stops, fricatives or nasals, the first stop, fricative, or nasal will be omitted." (Locke 1983:71)

### 6.1.5.3. Coalescence

Coalescence occurs when the reduced cluster contains a single new consonant composed of features from the two original consonants. However, there are some cases in which it is difficult to decide whether it is coalescence or a combination of processes. For example: in the word *nuná* for *tmuná* 'picture', it is unclear, whether it is coalescence or assimilation. Such process may include stopping (e.g. *papó* for *melafefón* ‘cucumber’, and *pái* for *miʃkafáim* ‘glasses’), and also selection of the second segment of the cluster plus stopping (e.g. *bu* for *zvuv* ‘fly’, *buʁá* for *ʃvuʁá* ‘broken fm.sg.’, and *biló* for *aviʁón* ‘airplane’) (for more examples see table 71).

The data in the table (73) below present productions exhibiting what could be viewed as coalescence.

(73) Coalescence

| Target | | Children’s productions | Child |
|---|---|---|---|
| cfaʁdéa | ‘frog’ | badéa, pabéa | A5 (3;0.10) |
| kfafót | ‘gloves’ | papót | A4 (4;0.18) |
| gviná | ‘cheese’ | biná, piná | A5 (3;2.0) |
| klemantína | ‘clementine’ | temaína | A5 (3;2.20) |
| dvaʃ | ‘honey’ | baʃ | A5 (2;11.6) |
| | | bab | A4 (3;3.4) |
| tmuná | ‘picture’ | puná | A1 (3;3.3) |
| dvoʁá | ‘bee’ | popá | A1 (2;8.29) |
| kcat | ‘few’ | tat | A3 (3;6.7) |

The phenomenon of coalescence is uncommon and considered a sub-stage of cluster acquisition in which both segments are replaced by another segment that preserves some of the features of both consonants. For example, child A5 (3;2.0) produceds **_b_**_iná_ and **_p_**_iná_ for **_gv_**_iná_ ‘cheese’, preserving the manner of articulation of the first segment of the cluster (i.e. stop) and the place of articulation of the second segment (i.e. labial). Similarly, child A5 (3;2.20) produced **_t_**_emaîna_ for **_kl_**_emantîna_ ‘clementine’, preserving the manner of articulation of the first segment of the cluster (i.e. stop) and the place of articulation of the second segment (i.e. coronal). In all the above examples, as in other studies, the new segment preserves the manner of articulation of the first segment and the place of articulation of the second one (Dyson and Paden 1983, Gnanadesikan 1995, Ben-David 2001, Tubul 2005). In fact, it seems as if the children show a preference for stops in onset position rather than other manners of articulation (liquids, nasals, or fricatives). This tendency is also evident in table (76) below, referring to data from Ben-David (2001) and Tubul’s (2005) studies.

As can be seen from the data above, the children preserve the place feature of the [labial] and [coronal] but not the [dorsal]. For example: **_p_**_apót_ for _kfafót_ ‘gloves’, **_b_**_iná_ and ***p**iná* for *gviná* ‘cheese’, and also ***t**emanîna* for *klemantîna* ‘clementine’. This preference is consistent with my previous findings regarding assimilatory replacement (see §6.1.4.2.2), as well as with Pater and Barlow (2003).

Ben-David (2001) and Tubul (2005) give a few examples of this process in Hebrew-speaking children. They emphasize, as others, that this phenomenon is rare.

(74) Coalescence

| Target | | Ben-David (2001) | Tubul (2005) |
|---|---|---|---|
| cfaʁdéa | ‘frog’ | padéa, badéa | badéa |
| tʁufá | ‘medicine’ | kufá | |
| dʁoʁ | ‘proper name’ | goʁ | |
| cvîka | ‘proper name’ | bîka | |
| tʁax | ‘Crash!’ | kax | |
| klavláv | ‘puppy’ | | taláv |
| kviʃ | ‘road’ | | biʃ |

### 6.1.5.4. Two segments production

During the final stage of cluster acquisition, both segments of the cluster are produced. However, throughout this stage, there are a few examples of another process, which is characterized by a transitional sub-stage: the children produce both segments of the cluster, but insert a vowel between them, thus simplifying the cluster. This sub-stage of epenthesis is discussed in §6.1.5.4.1, followed by appropriate cluster productions in §6.1.5.4.2.

#### 6.1.5.4.1 Epenthesis

Table (75) below presents examples of vowel epenthesis between both segments of a cluster. These few examples represent all the cases of epenthesis in the data from the six implanted children. The words in the table are organized according to a sonority based order of the targets.

(75) Epenthesis

| Target | | Children's productions | Child |
|---|---|---|---|
| bgadím | 'clothes' | b**e**gadím | A1 (2;9.12) |
| kfafót | 'gloves' | k**e**fafót | A2 (2;11.2) |
| kviʃ | 'road' | k**a**víʃ | A2 (3;0.13) |
| gviná | 'cheese' | m**i**niyá | A5 (2;8.2) |
| ʃvi | 'sit down! fm.sg.' | ʃ**e**ví | A5 (3;7.9) |
| zvuv | 'fly' | z**e**vúv | A1 (2;11.14) |
| dli | 'bucket' | g**i**yí | A3 (3;9.6) |
| myáu | 'cat sound' | m**i**yáu | A4 (3;4.8) |

Barton et al. (1980) point out that vowel epenthesis is strong evidence that the child has perceived all components of the cluster. They explain this process by the difficulty a child has when articulating a consonant sequence. In phonological terms, it is the type of syllables which affects the epenthesis. Specifically, CV syllables may be allowed, but CCV may not. Thus, the complex structure of the syllable is simplified and the preferred unmarked CV structure is generated. This way, vowel epenthesis within a cluster replaces a CCV syllable with a CVCV (Smit et al. 1990). In fact, this is the same for all cases of cluster simplification.

The phenomenon of vowel epenthesis between a cluster's segments is infrequent in the current study just as in other studies of cluster development in Hebrew (Ben-David 2001, Tubul 2005) and in English among cochlear implant users (Chin and Finnegan 2002). Ben-David reported five words which displayed epenthesis and Tubul (2005) mentioned only four. Their examples are presented in the table below.

(76) Epenthesis in other studies of Hebrew-speaking children

| Target | | Ben-David (2001) | Tubul (2005) |
|---|---|---|---|
| dli | 'bucket' | d**e**lí | d**i**lí |
| dlukím | 'turned on ms.pl.' | | d**e**lukí |
| kxulím | 'blue ms.pl.' | k**e**xulím | |
| klum | 'nothing' | k**e**lúm | |
| gdolá | 'big fm.sg.' | | g**u**dulá |
| gviná | 'cheese' | g**e**viná | |
| sgurá | 'closed fm.sg.' | | s**e**guá |
| zvuv | 'fly' | z**e**vúv | |

As can be seen in the examples above, three out of the five words which display epenthesis in Ben-David's (2001) study also display epenthesis in the current study (i.e. *dli* 'bucket', *zvuv* 'fly' and *gviná* 'cheese'). Due to the rarely of this phenomenon, I cannot identify a particular type of cluster that shows a greater degree of epenthesis. However, this phenomenon occurred mostly in obstruent-obstruent clusters. As for the quality of the inserted vowels, it can be either an *e*, the epenthetic vowel in Hebrew (e.g. *zevúv* for *zvuv* 'fly', *kefafót* for *kfafót* 'gloves'), or the assimilation of the epenthetic vowel to that of the adjacent syllable of the word (e.g. *miniyá* for *gviná* 'cheese', *gi*yî for *dli* 'bucket'). Only in one word there is an epenthetic *a* (i.e. *k**a**vîʃ* for *kviʃ* 'road'), which might be due to the velar consonant *k* (though *k**e**fafót* for *kfafót* 'gloves'). In many languages, the insertion of a schwa /ə/ between elements of a cluster is by far the most common form of epenthesis and is reported in other studies (Shriberg and Kwiatkowski 1980, Bortolini and Leonard 1991, Dyson and Paden 1983, Smit 1993).

### 6.1.5.4.2. Appropriate cluster's productions

During the final stage of cluster acquisition, both segments are used appropriately. Accurate cluster production occurs in all groups of clusters, i.e. **obstruent-liquid** (e.g. *tʁufá* 'medicine', *zʁiká* 'injection', and also *ʃlulît* 'puddle' and *glîda* 'ice cream'), **obstruent-nasal** (e.g. *kmo* 'like/as', *tmuná* 'picture', *dmaót* 'tears, and also *kniyót* 'shopping'), **obstruent-glide** (e.g. *myáu* 'cat sound', and *kwa* 'frog sound'), and **double-obstruent** (e.g. *kviʃ* 'road', *zvuv* 'fly', *pkak* 'cork', and also *kfafót* 'gloves').

Obsrtruent-approximant clusters (where approximants include liquids and glides), are predicted to be the earliest, based on the sonority hierarchy (Bernhardt and Stemberger 1988). Many studies of English, Dutch, and German show stop - approximant clusters to be earliest clusters acquired (Templin 1957, Ingram 1989a, Fikkert 1994, Beers 1995, Ben-David 2001, Tubul 2005). The findings of my study are similar: at the beginning of this stage, most of the clusters consist of an obstruent and a sonorant segment (either a glide, or a liquid).

To summarized: the development of word initial clusters in the speech of the implanted children is very similar to that of hearing children. Specifically, onsetless words (i.e. deletion of the two elements of the cluster) are rare; single-segment production usually conformed to the acoustic and sonority considerations, and finally two-segment productions.

## 6.2. Acquisition of the onset by hearing aid users

This section describes onset development in the speech of the hearing impaired subjects with HA (group B). It follows some of the stages reported in the literature on the development of the onset in the speech of hearing Hebrew-speaking children reviewed in (§2.2.1), and also some of the stages reported for the CI children of our study (§6.1).

The discussion on onset development begins with the stage characterized by consonant-free words (§6.2.1), i.e. words consisting only of vowels. Then onsets appear in monosyllabic words productions (§6.2.2). It then continues to onset preservation in disyllabic words productions (§6.2.3). Sections 6.2.3.1, 6.2.3.2 and 6.2.3.3 provide a broad description of the prosodic development of a simple onsets, and segmental effects are described in §6.2.4: I show that stops and nasals are preferred in onset position in the children's productions (§6.2.4.1 and §6.2.4.2).

As in the other sections dealing with the hearing aids findings, only the quantitative data are presented, while most of the examples are provided in the appendix. Similarities and differences between the children using hearing aids and cochlear implants are discussed.

As stated, the order of onset acquisition by the hearing aid users is similar to that of the cochlear implant users (see table 51)

### 6.2.1. Consonant-free words

The initial stage of onset development, or word development in general, was characterized in §6.1.1 with consonant-free words, i.e. words without an onset (and of course without coda as well, which appears later on). Only 2 out of the 4 HA children produced such words, since the recording sessions of this group started later. Therefore, the onsetless words, which characterize the initial stage of onset development, were very few in B2 and B4 productions, and were missing in B1 and B3 productions. However, I assume, that this stage also existed in the speech of the

HA children, but we probably missed it. Further studies with earlier follow-up are needed in order to substantiate this claim.

An interesting finding relating to these consonant-free words in the speech of B2 and B4, is the fact that these words appeared throughout all the follow-up sessions, i.e. during the minimal word stage, a few during the pre-final stage, and very few during the final stage. The data of these forms are presented in appendix 4 (table a).

These two children behaved similarly to the dyspraxic children in Tubul's study (2005). In other words, like children with developmental dyspraxia, the HA children produced consonant-free words, which persisted even beyond the minimal word stage. This phenomenon also occurred throughout a very short period in the speech of the CI group, and is not reported in typically developing hearing children.

The existence of consonant-free words in the speech of HA children as well as other groups reported above (CI children of our study, disypraxic children of Tubul's study) strengthens the question raised about the rate of transition between stages relating to different types of groups. Is the transition between stages faster in typically hearing children (and thus sometimes missed), and slower in other groups with speech disorders such as dyspraxia and hearing impairment? Moreover, the last finding raised an additional question: is the transition between stages of the CI children faster than that of the HA children, while the rate of transition between stages of the HA children is slower, and more similar to that of dyspraxic children? I will discuss this issue broadly in §7.3.1.

### 6.2.2. Onset production in monosyllabic words

Parallel to onset appearance in disyllabic words productions, onset preservation in monosyllabic word production also occurred. There is little data and few examples since the recording of the HA children started later than the CI children (see table b in appendix 4).

It has been shown that CV is the preferred syllable in early development in Hebrew as well as in other languages. Preference of the CV syllable is also found in the speech of the CI children, following the period of consonant-free words (§6.1.2).

Since there is less data of the HA children than of the CI children, and since these data were documented relatively late in the children's prosodic development, it is difficult to draw conclusions about this structure.

### 6.2.3. From empty to simple onsets: Prosodic effects

As stated in §6.1.3, when the children start producing polysyllabic words, the initial syllable is not always CV. I will show that this stage of development is influenced by the stress pattern both in disyllabic word productions (§6.2.3.1) and in tri- and quadrisyllabic word productions (§6.2.3.2). In the last section (§6.2.3.3), I deal with the final development of simple onsets.

#### 6.2.3.1. Onsets in the initial syllable of disyllabic productions

During the next stage, onsets appeared in disyllabic words productions. However, since the transition from one stage to the next is gradual, during this stage of onset development, onsets can either be produced or can be empty.

The data of the HA children (table c in appendix 4) and the quantitative data in table (77) below show that at this stage of onset development, most of the word productions preserve onsets in the initial syllable of disyllabic word productions. Moreover, B1 and B3 almost never deleted the onset in the initial position, while B2 and B4 only deleted the onset in a few occasions (recall that B2 and B4 are the children that produced consonant-free words in the earlier stage).

(77) Initial onset preservation in disyllabic words productions

| Penultimate stress | | | Ultimate stress | | | Child |
|---|---|---|---|---|---|---|
| Target | Production | % | Target | Production | % | |
| 15 | 15 | 100 | 21 | 19 | 90 | B1 (1;5.21-1;7.3) |
| 30 | 26 | 86.6 | 40 | 21 | 67 | B2 (3;2.14-3;4.16) |
| 18 | 18 | 100 | 15 | 15 | 100 | B3 (3;5) |
| 12 | 9 | 75 | 19 | 10 | 52 | B4 (2;9.23-3:0) |
| 75 | 68 | 90.66 | 95 | 65 | 68.42 | Total |

**The target parameter**: As mentioned in §6.1.3.1, there are 138 types of disyllabic target words with ultimate stress and only 74 types of disyllabic target words with penultimate stress during the current stage of onset development, thus forms with ultimate stress are the majority. The numbers in the table above show the same tendency, similarly to that discussed for the CI group: the children responded to 56% (95/170) target tokens with onsets with ultimate stress and to 44% (75/170) target tokens with onsets with penultimate stress.

**The production parameter:** The children tend to preserve the onset of the initial syllable in disyllabic word productions with penultimate stress (90.66%) more than in words with ultimate stress (68.42%). The stress pattern's effect on onset preservation in disyllabic word productions is evident with each individual child and all the children as a group.

The above findings reflect the same tendency seen in the CI subjects (§6.1.3.1). That is, there is a clear preference for word initial onsets in words with penultimate stress, i.e. stressed syllables get their onset before unstressed syllables.

In addition, out of 170 disyllabic word productions, only 37 are onsetless in the initial syllable of the word (21.7%). Based on these numbers, I assume that these examples are a residue of this stage of onset development, i.e. the stage in which the onset of a disyllabic word is empty.

### 6.2.3.2. Onsets in the initial syllable of tri- and quadrisyllabic productions

The gradual appearance of word initial onsets is also manifested in tri- and quadrisyllabic word productions. However, in some cases, similarly to disyllabic words, onsets only appear in some of the word productions, while they are deleted in others. Table (d) in appendix (4) presents data of tri- and quadrisyllabic words productions without onsets in the initial syllable.

Table (78) below presents onset preservation in tri- and quadrisyllabic word productions with ultimate and penultimate stress. Since very few words have antepenultimate stress, they are not included.

(78) Initial onset preservation in tri- and quadrisyllabic words productions

| Stress patterns | Target | | Production-polysyllabic | |
|---|---|---|---|---|
| | w/o onset | w/ onset | w/onset | |
| Ultimate stress (w)wws | 22 | 31 | 26 | 84% |
| Penultimate stress (w)wsw | 15 | 87 | 66 | 76% |
| Total 155 | 37 | 118 | 92 | 78% |

w/o onset= Target words without an onset in the initial syllable of the word (*agalá* ‘carriage’)
w/ onset = Target words with an onset in the initial syllable of the word (caláxat ‘plate’)

The numbers in the table above show some of the same tendencies for tri- and quadrisyllabic target tokens as were discussed for disyllabic words in (§6.2.3.1), as well as for the CI children. Again, I will refer to our familiar analysis: the target parameter and the production parameter.

**The target parameter:** As mentioned in §6.1.3.2 for the CI children, in my study, 56% (38/67) of the tri- and quadrisyllabic types of target words bear penultimate stress (i.e. *maxbéʁet* ‘notebook’, *mixnasáim* ‘trousers’), and only 44% (29/67) bear ultimate stress (i.e. *xilazón* ‘snail’, *melafefón* ‘cucumber’). The numbers in table (78) above show the same tendency: the children responded to 85.3% (87/102) target tokens with onsets with penultimate stress but to only 58.5% (31/53) target tokens with onsets with ultimate stress.

The findings for target tokens without an onset also reflected the language preference and are the same as were reported for the CI group:  41.5% (22/53) of the tri- and quadrisyllabic target tokens with ultimate stress are onsetless (e.g. *agalá* ‘cart’, *ugiyá* ‘cookie’), while 14.7% (15/102) of the tri- and quadrisyllabic target tokens with penultimate stress are onsetless (e.g. *ambátya* ‘bath’, *oznáim* ‘ears’). The numbers of these types of words (i.e. onsetless words with ultimate and penultimate stress) during the current stage, however, are very similar: 5 types of tri- and quadrisyllabic target words with penultimate stress and 7 types of tri- and quadrisyllabic target words with ultimate stress. In other words, in tri- and quadrisyllabic target tokens, children responded to onsetless target words with ultimate stress more than to words with penultimate and antepenultimate stress. Accordingly, in tri- and quadrisyllabic target tokens, children react to onsetless target words with ultimate stress more than to words with penultimate and antepenultimate stress. This tendency is evident in both groups (group A and group B). The reason for this is syllable complexity, discussed in §6.1.3.2 above.

**The production parameter:** During this stage the onset is preserved more often than deleted both in words with ultimate and penultimate stress: the onset is preserved in 78% (92/118) of the word productions. The children preserved the onset in 84% (26/31) of the words with ultimate stress and in 76% (66/87) of the words with penultimate stress. There were no cases of epenthesis in words without an onset. These findings are not similar to those of the children in the CI group, who showed a preference for the preservation of the onset of the initial syllable in tri- and quadrisyllabic word productions with penultimate stress more than in words with ultimate stress (table 61). Since there is a tendency to preserve the onset of a syllable closer to the stressed syllable, the results of the HA group are surprising. However, in the HA group, the difference between word productions with ultimate stress (84%) and word productions with penultimate stress (76%) is small and relatively insignificant, as opposed to the CI group (70% of the target tokens with onsets in words with penultimate stress, but only 51% of the target tokens with onsets in words with ultimate stress).

### 6.2.3.3. Final acquisition of simple onset

During the final stage of simple onset acquisition, children preserve the onset of the initial syllable in almost all the tri- and quadrisyllabic target words.

(79) Onset preservation in tri- and quadrisyllabic word productions – Final stage

| Target | Target | | Production | |
|---|---|---|---|---|
| | w/o onset | w/ onset | w/onset | |
| Ultimate stress (w)wws | 52 | 146 | 133 | 91.1% |
| Penultimate stress (w)wsw | 37 | 172 | 154 | 89.5% |
| Antepenultimate sww | 21 | 24 | 24 | 100% |
| Total | 110 | 342 | 311 | 91% |

w/o onset= Target words without an onset in the initial syllable of the word (*agalá* 'carriage')
w/ onset = Target words with onset in the initial syllable of the word (caláxat 'plate')

As discussed above, onset production in tri- and quadrisyllabic words already begins to appear in the previous stage (§6.2.3.2). However, onset production in tri- and quadrisyllabic words gradually increases throughout stages.

**The target parameter:** The number of words produced significantly increases as the stages progress. This tendency is clearly revealed in words with different stress patterns (ultimate, penultimate and antepenultimate). In the previous stage, there were 85.3% (87/102) target tokens with penultimate stress with onsets but only to 58.5% (31/53) target tokens with ultimate stress with onsets. In the current stage of onset development, however, the number of tri- and quadrisyllabic target tokens increased significantly both for words with penultimate stress (172/209=82.3%) and words with ultimate stress (146/198=73.7%). Also, as opposed to the previous stage, the number of target tokens with onsets in words with antepenultimate stress increased significantly (24/45= 53.3%). Since the number of words with antepenultimate stress is small, these were included in the group of words with non-final stress and they are not presented as a separate group.

**The production parameter:** The number of onsets preserved in tri- and quadrisyllabic target words increased significantly for all children and in all words with different types of stress patterns. In the previous stage, 84% (26/31) of the ultimate stressed tokens of produced words preserved onsets, while 91.1% (133/146) of the ultimate tokens of produced words preserved onsets during the final stage. Also, during the previous stage, 76% (66/87) of the penultimate tokens of produced words preserved onsets, while 89.5% (154/172) of the penultimate tokens of produced words preserved onsets during the final stage. And finally, during the previous stage, there were only a few antepenultimate tokens of produced words preserving onsets, while during the final stage, 100% (24/24) of the token words with antepenultimate stress preserved onsets. These findings are similar to those of the CI group (§6.1.3.3) and show that during the final stage of simple onset acquisition, the production of the onset is almost completed without any significant difference among words with different stress patterns (i.e. ultimate, penultimate and antepenultimate).

### 6.2.4. From empty to simple onsets: Segmental effects

As mentioned in §6.2.3, when the children start producing polysyllabic words, the initial syllable is not always CV but sometimes also an onsetless syllable i.e. V(C). In §6.2.3.1, I show that onset preservation is influenced by prosodic effects and that the stress patterns of the target words may influence the preservation of the onset in the initial syllable. In the following sections I provide evidence of segmental effects, showing that the segmental features of the consonants in the onset position also have a significant influence on the onset preservation in monosyllabic (§6.2.4.1) and polysyllabic (§6.2.4.2) word productions.

#### 6.2.4.1 Onsets in monosyllabic productions

Table (80) below, presents the type of segments in onset positions in monosyllabic word productions of monosyllabic, disyllabic, and trisyllabic target words of the HA children.

(80) Onset in monosyllabic words productions

| Target | | | Children's production | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | Stops | | Fricatives | | Nasals | | Liquids | |
| Stops | 24 | 39.3% | 24 | 100% | | | | | | |
| Fricatives | 18 | 29.5% | 7 | 38.8% | 11 | 61.1% | | | | |
| Nasals | 15 | 24.6% | 2 | 13.33% | | | 13 | 86.66% | | |
| Liquids | 4 | 6.5% | | | | | | | 4 | 100% |
| Total | 61 | 100% | 33 | 54.1% | 11 | 18% | 13 | 21.3% | 4 | 6.55% |

The numbers presented in (80) above support the preference of stops in the onset position and are similar to those reported in the development of the cochlear implant sometimes you say CI, sometimes cochlear implant - consistency children as well as hearing children (see §6.1.4.1).

**The target parameter:** The numbers in the table above show a clear preference for target words with stops in onset position (24/61=39.3%), a lesser preference for fricatives (18/61=29.5%) and nasals (15/61=24.6%), and a very low preference for liquids (4/61=6.5%). That is, there is a higher rate of attempts to produce target words with stops in onset position rather than other manners of articulation. As in §6.1.4.1, this preference matches the same proportion of the general data of the current study (relating to all types of words in the study) and is similar to the CI group (58.4% for stops, 17.6% for fricatives, 16.4% for nasals and 7.6% for liquids) (see table 63).

**The production parameter:** The children tend to preserve the same manner of articulation as the target word, but as expected, with greater success in stops (100%) and nasals (86.66%) than in fricatives (61.1%). The liquids consist of 4 words only, thus their production is 100%. In addition, when the onset of the target words is not preserved, it is always replaced by stops (9/9=100% replacement of nasals and fricatives with stops). These findings are similar to those of the CI group and strengthen my previous explanation (§6.1.4.1) according to which the stop, either oral or nasal, is an optimal syllable onset and is the mostly preferred onset by the children in both groups.

### 6.2.4.2. Initial onset in polysyllabic productions

The segmental effect on onset preservation also occurred when the children started producing polysyllabic words. In §6.1.4.2, I discussed the two strategies of replacement: assimilatory and non-assimilatory replacement. The following sections deal with onset replacement (§6.2.4.2.1) and assimilatory replacement (§6.2.4.2.2) in the HA group.

#### 6.2.4.2.1. Onset replacement

The data in table (81) below show the onset distribution by manner of articulation in the children's productions. The table presents data of onset preservation, and it includes words in which the onset is either preserved or replaced by another manner of articulation for polysyllabic target words. In other words, the numbers in this table include onset production only, either preservation or replacement.

(81) Onset preservation - distribution by manner of articulation in the children's production in polysyllabic productions

| Target words | | Children's production | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Stops | | Fricatives | | Nasals | | Liquids | |
| | | N | % | N | % | N | % | N | % |
| Stops | 176 (56%) | 168 | 95.5% | 3 | 1.7% | 3 | 1.7% | 2 | 1.1% |
| Fricatives | 58 (18%) | 24 | 41.4% | 33 | 56.9% | 1 | 1.7% | | |
| Nasals | 53 (17%) | 9 | 17% | 1 | 1.9% | 42 | 79.2% | 1 | 1.9% |
| Liquids | 29 (9%) | 10 | 34.5% | | | 2 | 6.9% | 17 | 58.6% |
| Total | 316 | 211 | 66.7% | 37 | 11.7% | 48 | 15.2% | 20 | 6.3% |

Table (81) shows the same tendencies both for the target words and for the word productions for the HA children as is reported for the CI children: first, **target words** with stops in onset position are preferred by the children and they respond to them more than to target words with other manners of articulation. The children responded to 56% (176/316) of the token target words with stops in the initial position (53.9% in the CI group). Only 18% (58/316) are with fricatives (18.8% in the CI group), 17% (53/316) are with nasals (13.3% in the CI group), and 9% (29/316) are with liquids

(14% in the CI group). As stated before, the numbers are very similar to those of group A, and reflect the language's preference; out of 364 types of the target words in our study with onsets in the penultimate syllable – 125 (34.5%) are with stops, 109 (30%) are with fricatives, 77 (21%) are with nasals, and 53 (14.5%) are with liquids.

Although the children's productions reflect the types of manner's ratio, the percentage of the stop productions (66.7%) is more than that of the targets (56%), while it is smaller at the other manner of articulations (fricatives: 11.7% as opposed to 18%; nasals: 15.2% as opposed to 17%; liquids 6.3% as opposed to 9%).

The second aspect concerns **word productions**. The children preserved the onset in the initial syllables of target words in all manner of articulation (more than 50% for all manners of articulation are preserved). However, stops and nasals are preserved to a larger extent (95.5% and 79.2% respectively) than fricatives and liquids (56.9% and 58.6% respectively).

Also, as stated for the CI children, if an onset is replaced, it is more likely to be replaced by a stop rather than any other manner of articulation. Out of 58 target words with fricatives in onset position, 24 are replaced by stops (41.4% as opposed to 59% in group A) (e.g. *tatú* for *xatúl* 'cat') but only 1 (1.7%) is replaced by a nasal and none by a liquid. Out of 53 targets words with nasals in onset position, 9 are replaced by stops (17%) but only 1 (1.9%) is replaced by a fricative and none by a liquid. And finally, out of 29 target words with liquids in onset position, 10 are replaced by stops (34.5%) but only 2 (6.9%) are replaced by nasals and none by fricatives. The preference for low-sonority onsets is universal and is broadly discussed in §6.1.4.2.1.

#### 6.2.4.2.2. Assimilatory replacement

As stated in §6.1.4.2.2, onset assimilation is another strategy, which appears parallel to onset preservation during this stage of acquisition. Recall that in some cases, it seems as if more than one process is involved. For example: *déde* for *gézeʁ* 'carrot' and *tité* for *kisé* 'chair' (stopping plus regressive place assimilation), and *kúki* for *gúfi* 'Goofy' (progressive place assimilation plus devoicing). The discussion for the CI group (§6.1.4.2.2) concentrates on place assimilation only, however, the data in table (82), although limited, show both place and manner effects.

(82) Assimilatory replacement

| Target | | Children’s Productions | Child |
|---|---|---|---|
| | | Regressive assimilation | |
| ʃémeʃ | ‘sun’ | méme | B1 (1;5.21) |
| cipóʁ | ‘bird’ | pipó | B1 (1;7.3) |
| naméʁ | ‘tiger’ | mamé | B1 (1;9.13) |
| agvaniyá | ‘tomato’ | yayá | B1 (1;7.3) |
| laxtóx | ‘to cut’ | tató | B2 (3;4.16) |
| sáfta | ‘grandma’ | táta | B2 (3;4.16) |
| dúbi | ‘teddy bear’ | bóbi | B2 (3;4.16) |
| | | búbi | B3 (3;5) |
| yaldá | ‘girl’ | dadá | B2 (3;5.22) |
| simlá | ‘dress’ | lalá | B2 (3;6.20) |
| davár | ‘thing’ | vavá | B3 (3;6.5) |
| katán | ‘little ms.sg.’ | tatá | B3 (3;6.5) |
| kivsá | ‘sheep’ | sisá | B1 (1;9.13) |
| | | Progressive assimilation | |
| gézeʁ | ‘carrot’ | gége | B1 (1;8.7) |
| tinók | ‘baby’ | titó | B2 (3;4.16) |
| baʁváz | ‘duck’ | babá | B2 (3;4.16) |
| patíʃ | ‘hammer’ | papí | B2 (3;5.22) |
| píta | ‘pita’ | pípa | B3 (3;5) |
| káxa | ‘like this’ | káka | B3 (3;6.5) |

As stated, our data in table (82) above are very limited, thus it is quite difficult to run into generalizations, even though it seems as if stops are preferred to other manners of articulation (e.g. *tató* for *laxtóx* ‘to cut’, *táta* for *sáfta* ‘grandma’, *gége* for *gézeʁ* ‘carrot’ and *káka* for *káxa* ‘like this’). As for places of articulation, however, labials are preferred to coronals, thus leading to either regressive assimilation (e.g. *búbi* for *dúbi* ‘teddy bear’, *mamé* for *naméʁ* ‘tiger’) or progressive assimilation (e.g. *pípa* for *píta* ‘pita’, *papí* for *patíʃ* ‘hammer’), and coronals are preferred to dorsals (e.g. *tatá* for *katán* ‘little’ and *sisá* for *kivsá* ‘sheep’).

These findings, however, are partially similar to those reported for the CI children regarding place preference, i.e. labials and coronals are much more preferable than dorsals. But, while in the CI group, combinations of labial and coronal created either regressive or progressive assimilation, the HA group shows a clear preference for labials rather than coronals. Since there is very limited data for the HA group, one should be more careful with the conclusions.

### 6.2.5. Complex onsets (word initial clusters)

As described in §6.1.1, the initial stage of acquisition is characterized with a period of consonant-free words, which are, of course, onsetless. Thus, as reported above, children in group A started out with onsetless words, deleting both the first and the second segments of the cluster (see §6.1.5.1). However, after a short time, onsets started appearing (§6.1.5.2). The findings of the HA group are quite different for methodological reasons: since data are limited and the recording sessions started later than the cochlear implant group, the initial documented stage of complex onset acquisition starts with production of one of the segments of the clusters. However, child B2 showed a great degree of inconsistency: She simplified word throughout all stages. She preserved the cluster in *dli* ‘bucket’ (4;7.23), and *dvoá* for *dvoʁá* ‘bee’ (4;7.23), deleted one consonant in *taná* for *ktaná* ‘little fm.sg.’ (4;8.26), and *tuná* for *tmuná* ‘picture’ (4;8.26), but  did not preserve any of the cluster consonants in *iná* for *gviná* ‘cheese’ (4;7.23) and *ída* for *glída* ‘ice cream’ (4;7.23). Careful observation of her data shows that B2 tended to delete the onset of the initial syllable of the words, throughout all stages, even when onset acquisition had already occurred. For example, during the final recording session (4;8.26), she produced *dúbi* but also *úbi* for *dúbi* ‘teddy bear’, *táta* for *sáfta* ‘grandma’ and *dadá* for *yaldá* ‘girl’, but also, *atî* for *patîʃ* ‘hammer’, *isé* for *kisé* ‘chair’, and *um* for *xum* ‘brown’. In other words, until the end of the follow-up, this child deleted the onset of the initial syllable of the word whether it was simple or complex.

For all children as a group (group B), different clusters with various types of segments are discussed, as was the case for group A: Obstruent-liquid clusters (§6.2.5.1.1), obstruent-nasal clusters (§6.2.5.1.2), and also obstruent-obstruent clusters

(§6.2.5.1.3). The infrequent phenomenon of coalescence, in which both segments are replaced by another segment that preserves some of the features of each segment, is discussed in §6.2.5.2. Two-segment production is the final stage of cluster acquisition (§6.2.5.3). This stage is divided into two sub-stages: epenthesis which is characterized by vowel insertion between the two elements of the cluster (§6.2.5.3.1), and finally appropriate cluster productions (§6.2.5.3.2).

### 6.2.5.1. Production of one of the clusters' segments

Following the consonant harmony stage, in which none of the cluster's segments surfaced, in most cases, there is one consonant corresponding to the target cluster. As stated above, this correspondence is known as *Cluster Reduction* or *Cluster Simplification*.

When children reduce complex onsets to singletons, they are usually systematic in terms of which consonant from the cluster they retain. As mentioned before, a common tendency is for the less sonorous member of the adult target cluster to be preserved (Fikkert 1994, Gilbers and Den Ouden 1994, Chin 1996, Ohala 1996, 1999, Barlow 1997, Gnanadesikan 1995, Goad 2001). Complex onset reduction and the segment selection are discussed in the following sub-section, using the sonority scale described in §1.1.2.2.

#### 6.2.5.1.1. Obstruent-liquid target clusters

The data in table (a) in appendix (5) present target words with initial clusters containing an obstruent (i.e. stops, fricatives, and affricates) and a liquid (l,ʁ), and only one word containing a stop and the glide *w* (i.e. *kwa* 'frog sound').

In obstruent-liquid clusters, most words are produced with a single obstruent in the onset. In some cases, the obstruent in the child's production is identical to that of the target word (e.g. *paxîm* for *pʁaxîm* 'flowers'). In others, it is replaced by an onset with another place of articulation (e.g. *gi* for *dli* 'bucket'). That is, the liquid, which is a sonorant, is deleted and the obstruent, which is a non-sonorant segment, is preserved.

In 48% (26/54) the tokens of obstruent-glide/liquid clusters, the first consonant (i.e. the obstruent) is produced, and in 15% (8/54) it is replaced by another obstruent. In other words, in 63% (34/54) tokens an obstruent is produced. In 33% (18/54) tokens the liquid is produced, and in 2 cases the liquid is replaced by another liquid. In other words, out of 54 tokens, the liquid is produced in 20 productions (37%).

The preservation of the obstruent rather than the liquid is also reported in group A (§6.1.5.2.1).

The case of *kwa* 'frog sound', the only word with a stop plus the glide *w* is very similar for both groups: in all cases for group B (19/19=100%) the stop (i.e. *k*) is deleted and the *w* is preserved (recall 75% for group A). For the combination of the nasal and glide cluster of the word *myáu* 'cat sound': in 2 out of 2 tokens of this word (100%), the glide *y* is preserved while the nasal *m* is deleted (recall 62.5% for group A).

To summarize, since, the non-sonorant segments (obstruents) are preferred in onset position, target initial clusters are usually reduced to the least sonorous element, at the stage where the children's grammar does not allow a complex onset.

#### 6.2.5.1.2. Obstruent-nasal target clusters

As was reported for the CI group, in words with clusters consisting of an obstruent and a nasal, which are rather infrequent, the children tended to omit the obstruent and preserve the nasal (table (b) in appendix 5). In 66.66% (12/18) tokens of words with initial clusters, the nasal is preserved while the obstruent is deleted. This tendency is also reported for group A (68.7% nasal preservation and obstruent deletion). (For physiological and acoustic explanations, see discussion in §6.1.5.2.2).

#### 6.2.5.1.3. Obstruent-obstruent target clusters

In clusters consisting of two obstruents (i.e. stop-fricative, stop-stop, fricative-stop, fricative-fricative, affricate-fricative) usually the first segment is omitted while the second is preserved (table (c) appendix 5). For example: in the word *gviná* 'cheese' the child produced *viná* (i.e. deleted the first segment *g* and preserved the second segment *v*), and in the word *kxi* 'take fm.sg.' the child produced *xi* (i.e. deleted the first segment *k* and preserved the second segment *x*). For 55 tokens with obstruent clusters, in 36 words, the first segment is deleted (65.45%), while in 19 words, the second segment is deleted (34.54%) (see also table (83) below). The production of the second segment of a cluster, without any relation to its sonority level, is discussed broadly in §6.1.5.3.3 (in the section dealing with the CI children) and is anchored by Steriade's (2000) explanation.

Table (83) below summarizes the findings of the current stage of cluster acquisition for the HA children.

(83) Cluster reduction according to manner and consonant position

| Cluster | | | C1 Production | | C2 Production | |
|---|---|---|---|---|---|---|
| C1 | C2 | | N | % | N | % |
| Obstruent | Glide/Liquid | 54 | 34 | 63% | 20 | 37% |
| Obstruent | Nasal | 18 | 6 | 33.3% | 12 | 66.66% |
| Obstruent | Obstruent | 55 | 19 | 34.5% | 36 | 65.45% |

To summarize the above table (83): In obstruent–liquid clusters, the obstruent (C1) tends to be preserved while the liquid (C2) is deleted, both for sonority (§6.1.5.1.1) and developmental considerations (§6.1.5.1.2). In obstruent–nasal and obstruent–obstruent clusters, the second segment (C2) tends to be preserved due to perceptual considerations, i.e. the smaller the sonority gap between the two segments of the cluster is, the greater the influence of the acoustic aspect in the segment selection is (see the discussion in §6.1.5.1.2).

### 6.2.5.2. Coalescence

Coalescence occurs when the reduced cluster contains a new consonant composed of features from the two original consonants. However, as mentioned in §6.1.5.1.2, there are some cases in which it is difficult to decide whether the process seen is coalescence or a combination of processes, thus all the examples of the HA group are uncertain. For example: child B1 (2;7.15) produced ***t****anté* for ***ps***antéʁ 'piano', child B2 (4;1.23) produced ***p****apót and* ***p****apó*θ for ***kf****afót* 'gloves', and child B3 (3;9) produced ***b****iná* for ***gv****iná* 'cheese', thus preserving the manner of articulation of the first segment of the cluster (i.e. stop) and the place of articulation of the second segment (i.e. either coronal or labial). These three examples, however, can be analyzed as a combination of processes, i.e. deletion of the first segment plus stopping.

As discussed in §6.2.4.2.2, regarding assimilatory replacement, stops are preferred to other manners of articulation and labials and coronals are preferred to dorsals. Thus, it is not surprising to find a new consonant composed of unmarked features from the two original consonants. In other words, the children selected the most unmarked manner of articulation, i.e. stop, with the most unmarked place of articulation, i.e. labial or coronal, thus they are influenced by markedness considerations in their selections.

### 6.2.5.3. Two segments productions

During the final stage of cluster acquisition, the two segments of the cluster are produced. However, throughout this stage, there are very few examples of epenthesis which serves as a transitional sub-stage: the children inserted a vowel between the two segments of the cluster, thus producing a CV syllable (§6.2.5.3.1). Appropriate cluster production is described immediately after (§6.2.5.3.2).

#### 6.2.5.3.1. Epenthesis

Table (84) below presents examples of vowel insertion between the two segments of the cluster. These few examples represent all cases of epenthesis with the HA children.

(84) Epenthesis

| Target | | Children’s productions | Child |
|---|---|---|---|
| ʃxoʁím | ‘black ms.pl.’ | ʃ**a**xoʁím | B1 (2;2.7) |
| syáx | ‘foal’ | s**i**yá, s**i**yáx | B1 (2;2.7) |
| tʁufá | ‘medicine’ | **te**ʁufá | B1 (2;3.10) |
| tmuná | ‘picture’ | **te**muná | B3 (3;10.5) |
| gviná | ‘cheese’ | **ge**viná | B3 (3;10.5) |

The phenomenon of vowel epenthesis between a cluster’s segments is as infrequent in the HA group as in the CI group (see §6.1.5.4.1). In the above examples, however, children insert the vowel *e* (3 times), the vowel *i* (before the glide *y*), and the vowel *a* (before the fricative *x*). In the first example, however, the *a* might be due to paradigm uniformity, given the singular form *ʃaxoʁ* ‘black ms.sg’.

I will try to provide some generalizations regarding the type of the epenthetic vowel expected between the segment’s clusters, relying on all the data of the Hebrew-speaking children (based on the current study’s data for both groups as well as that of Ben-David 2001 and Tubul 2005); As stated in §6.1.5.4.1, the standard epenthetic vowel in Hebrew is *e* and it is usually inserted between the two segments of the cluster. Indeed, in most cases the children inserted *e* between the cluster’s segments. The vowel *i* is generally inserted before the glide *y* (e.g. *siyá*, *siyáx* for *syáx* ‘foal’, *giyî* for *dli* ‘bucket’) or as an assimilated vowel of the adjacent syllable of the word (e.g. *miniyá* for *gviná* ‘cheese’). The vowel *a* might be inserted near velar segments (e.g. *kavîʃ* for *kviʃ* ‘road’, and *ʃaxoʁím* for *ʃxorîm* ‘black ms.sg.’). Recall that all these generalizations are based on very few examples.

#### 6.2.5.3.2. Appropriate cluster productions

During the final stage of cluster acquisition, both segments are used appropriately. Accurate cluster production occurs in all groups of clusters, i.e. **obstruent-liquid** (e.g. *tʁáktoʁ* ‘tractor’, *dli* ‘bucket’, *glída* ‘ice cream’), **obstruent-nasal** (e.g. *tmuná* ‘picture’), and **obstruent-obstruent** (e.g. *cfaʁdéa* ‘frog’, *ʃtáim* ‘two’, *spagéti* ‘spaghetti’).

### 6.3. Acquisition of the coda by the cochlear implant users

This section describes the development of the coda in the speech of the hearing impaired subjects with CI (group A). It follows the stages reported in the literature on the development of the coda in the speech of hearing Hebrew-speaking children reviewed in §2.2.2, starting with the initial stage (§6.3.1), where most syllables are codaless, regardless of their position in the word and its size (i.e. monosyllabic and polysyllabic target words). Throughout this section, the special phenomenon of vowel lengthening is also mentioned. It then continues to coda preservation in final position (§6.3.2), both in monosyllabic target words and in the final syllable of polysyllabic words, regardless of their stress patterns, i.e. codas appear in the final syllable, whether stressed or unstressed. The segmental acquisition order in coda position is then discussed. In the final section (§6.3.3), word medial coda acquisition is described. Here, the coda is preserved in all the syllables of polysyllabic target words.

#### 6.3.1. Codaless words

During the early stages of acquisition, children produce words without codas, regardless of their target language. This is also true for the children of the present study. As shown in (85) below, target words with up to three syllables were produced without a coda, regardless of whether the coda was final or medial and whether it was in a stressed or unstressed syllable.

(85) Codaless children’s productions for different types of target words

| Target | | Children’s Productions | Child |
|---|---|---|---|
| Monosyllabic words | | | |
| yad | ‘hand’ | ya | A1 (1;9) |
| xam | ‘hot’' | a | A1 (1;9) |
| | | ba | A3 (2:2) |
| day | ‘enough’ | da | A2 (1;9) |
| pax | ‘bin’ | pa | A2 (1;10) |
| dag | ‘fish’ | da | A4 (2;8) |
| | | wa, a | A5 (2;2.13) |
| cav | ‘turtle’ | ta, a | A5 (2;4) |

| | | | |
|---|---|---|---|
| kos | ‘glass’ | ko | A4 (3;1) |
| op | ‘hop’ | o | A1 (1:5) |
| en | ‘none’ | e: | A1 (1;9) |
| od | ‘more’ | o: | A2 (1;9) |
| eʃ | ‘fire’ | e: | A4 (3;1) |
| Disyllabic words with penultimate stress | | | |
| máim | ‘water’ | i, mái | A1 (1;9) |
| mástik | ‘chewing-gum’ | mái | A1 (2:1) |
| bámba | ‘snack’ | bába | A2 (1;10) |
| péʁax | ‘flower’ | pépa | A2 (2;0.11) |
| | | péba: | A5 (2;3) |
| écba | ‘finger’ | éba:, bába: | A3 (2;1) |
| tíktak | ‘clock sound’ | títa | A3 (2;2) |
| ʁádyo | ‘radio’ | áko | A4 (2;10) |
| ʃtáim | ‘two fm.sg.’ | tái: | A4 (2;10) |
| enáim | ‘eyes’ | nái, enái: | A2 (1;9) |
| tapúax | ‘apple’ | púa | A2 (2;4.11) |
| ótobus | ‘bus’ | bóbu | A3 (2;5) |
| Disyllabic words with ultimate stress | | | |
| balón | ‘balloon’ | baó, baló | A1 (2;0.6) |
| | | bo: | A5 (2;5.0) |
| liʃtót | ‘to drink’ | to | A2 (1;11) |
| yoʃév | ‘sits ms.sg.’ | oʃé | A6 (3;1.16) |
| baybáy | ‘bye’ | babá | A1 (2;0.6) |
| | | mamá | A5 (1;11) |
| ʃaón | ‘watch’ | yaó: | A2 (1;9) |
| bakbúk | ‘bottle’ | babú | A3 (2;5) |
| | | babú, abú | A4 (2;10) |
| masáit | ‘truck’ | ái, mái | A1 (2;4) |
| aviʁón | ‘airplane’ | ayó | A1 (2;4) |
| | | avió | A4 (3;0.11) |
| ugiyót | ‘cookies’ | udiyó | A5 (2;6.7) |

It is well known that codas are universally marked (Kenstowicz 1994). Thus, the preferred syllable during the early stages of development is codaless, as reported in studies on the acquisition of languages such as English (Ingram 1976, Salidis and Johnson 1997), Dutch (Fikkert 1994, Levelt and Van de Vijver 1998), Portuguese (Fikkert and Freitas 1997, Freitas 1999), various dialects of Spanish (Macken 1978, Goldstein and Citron 2001), Greek (Kappa 2002), and Hebrew (Ben-David 2001).

The absence of codas during this stage is explained by prosodic markedness. Since language development proceeds from the unmarked to the marked, and since a syllable without a coda is less marked than a syllable with a coda (see §2.2), children are expected to first produce syllables without a coda.

This prosodic markedness is perceptually grounded: since a segment following the vowel of a syllable (i.e. coda) is less prominent acoustically than a segment preceding a vowel (i.e. onset) (Steriade 2000), the coda is more likely to be deleted during the initial stages of acquisition.

The absence of codas during this stage is not due to the nature of the segments, as a segment missing from a coda can be produced when in onset position. For example, child A1 did not preserve the *d* in the coda position of the target word *yad* ‘hand’ (i.e. produced *ya*) but produced it in the onset position in the target word *dag* ‘fish’ (i.e. produced *da*). Similarly, child A2 deleted the segment *p* in coda position in the target word *op* ‘hop’ (i.e. produced *o:*), but produced *po* ‘here’ and *pe* for *pil* ‘elephant’ during the same period. Even stronger evidence was provided by words where the onset and the coda of the produced syllable were identical. For example, child A2 produced *to* for *liʃtót* ‘to drink’ i.e. preserving *t* in onset position while simultaneously deleting it in coda position. This evidence reveals that during this stage of development, coda omission occurred in most syllables, regardless of whether the segment in the coda had been acquired. The same is reported in Abraham (1989) with regard to English-speaking hearing impaired children using hearing aid devices.

However, while the coda segment does not appear in the children’s productions, there is evidence from vowel lengthening that the coda position is often preserved.

Related to this stage of coda development is the appearance of long vowels in the final position of the word, instead of the coda. This phenomenon occurs both in monosyllabic and polysyllabic word productions. The claim that the coda position is preserved is supported by the fact that there were no long vowels in words without a coda (though there are words with a coda in which a long vowel does not appear in the children’s production).

(86) Long vowels

| Target | Children | | Target | Children | |
|---|---|---|---|---|---|
| Monosyllabic Productions | | | Polysyllabic Productions | | |
| pil | i: | ‘elephant’ | balón | baó: | ‘balloon’ |
| xam | a: | ‘hot’ | tinók | ió: | ‘baby’ |
| yad | a: | ‘hand’ | masaít | aí: | ‘truck’ |
| ec | e: | ‘tree’ | miʃkafáim | pái: | ‘glasses’ |
| en | a: | ‘none’ | ʃaón | yaó: | ‘watch’ |
| af | a: | ‘nose’ | máim | mái: | ‘water’ |
| cav | ta: | ‘turtle’ | báit | bái: | ‘home’ |
| aw | a: | ‘dog sound’ | bakbúk | obú: | ‘bottle’ |
| oʁ | o: | ‘light’ | kapít | kapí: | ‘spoon’ |
| od | o: | ‘more’ | nafál | naá: | ‘fell down ms.sg.’ |
| an | a: | ‘car sound’ | ofanáim | anái: | ‘bike’ |
| tinók | no: | ‘baby’ | enáim | enái: | ‘eyes’ |
| limóʁ | mo: | ‘proper name’ | mispaʁáim | mispaʁái: | ‘scissors’ |
| bakbúk | ba: | ‘bottle’ | masaiyót | masaiyó: | ‘trucks’ |

Hebrew does not have phonemic long vowels, and there are also no reports of long vowels in the speech of hearing Hebrew-speaking children. Therefore, the appearance of long vowels in the speech of the implanted children may be surprising.

I discuss this issue in §7.3.2.

### 6.3.2. Word-final coda

At a later stage, the children started producing word-final codas in both monosyllabic and polysyllabic word productions. Table (87) below presents data of coda preservation. During this stage, most productions are maximally disyllabic.

(87) Word final coda preservation

| Target | | Children’s Productions | Child |
|---|---|---|---|
| | | Monosyllabic target words | |
| dag | ‘fish’ | dad, dat | A1 (2;4.25) |
| od | ‘more’ | od, ot | A1 (2;4.25) |
| ec | ‘tree’ | et | A4 (3;3.4) |
| sus | ‘horse’ | suθ , uθ | A2 (2;4.11) |
| af | ‘nose’ | af | A2 (2;4.11) |
| xam | ‘hot’ | am | A4 (3;3.4) |
| am | ‘eating sound’ | am | A2 (2;4.11) |

|  |  |  |  |
|---|---|---|---|
| en | ‘none’ | en | A1 (2;4.25) |
| an | ‘car sound’ | an | A1 (2;4.25) |
| pil | ‘elephant’ | pil | A2 (2;4.11) |
| day | ‘enough’ | bay | A1 (2;4.25) |
| aw | ‘dog sound’ | aw | A4 (3;3.4) |
| Target words with ultimate stress |  |  |  |
| naxáʃ | ‘snake’ | aáʃ, taíʃ | A5 (2;7.0) |
| ʁevitál | ‘proper name’ | itáy | A5 (2.7.0) |
| cipóʁ | ‘bird’ | ipóy | A5 (2;7.0) |
| baʁváz | ‘duck’ | baláy | A5 (2;7.0) |
|  |  | dadáy | A4 (3;1.2) |
| gadól | ‘big’ | dadól | A5 (3;0.10) |
| katán | ‘little’ | tatán | A5 (3;0.10) |
| ʃulxán | ‘table’ | an | A1 (2;4.18) |
| taím | ‘delicious’ | paím | A1 (2;4.18) |
| patíʃ | ‘hammer’ | tatíθ, atíθ, papíθ, patíʃ | A1 (2;4) |
| liʃtót | ‘to drink’ | kok | A1 (2;4) |
| kapít | ‘teaspoon’ | apít | A1 (2;4) |
| nafál | ‘fell down ms.sg.’ | nafál | A2 (2;5.15) |
| liʃón | ‘to sleep’ | iʃón | A2 (2;5.15) |
| adóm | ‘red’ | adóm | A2 (2;5.15) |
| ʃulxán | ‘table’ | uxán | A2 (2;5.15) |
| misxák | ‘game’ | misát | A2 (2;5.15) |
| limóʁ | ‘proper name’ | mimón | A2 (2;5.15) |
| kaxól | ‘blue’ | aól | A4 (3;1.2) |
| melafefón | ‘cucumber’ | peyapón | A4 (3;1.2) |
| taʁnegól | ‘rooster’ | tayegól | A4 (3;1.2) |
| Target words with non-ultimate stress |  |  |  |
| enáim | ‘eyes’ | ináim | A5 (3;0.10) |
|  |  | páin | A4 (3;1.2) |
| géʃem | ‘rain’ | gétem | A5 (3;0.10) |
|  |  | yétem | A4 (3;1.2) |
| ʃamáim | ‘sky’ | ʃamáim | A5 (3;0.10) |
| máim | ‘water’ | máim | A5 (3;0.10) |
| léxem | ‘bread’ | léem | A5 (3;0.10) |
|  |  | léxem | A2 (2;5.15) |
| ʃémeʃ | ‘sun’ | ʃémeʃ | A5 (3;0.10) |
| ótobus | ‘bus’ | óbus, us | A1 (2;5.23) |
|  |  | óbuθ, bábuθ | A2 (2;5.15) |
| miʃkáfaim | ‘glasses’ | páim | A1 (2;5.23) |
|  |  | ʃafáim | A2 (2;5.15) |
| mispaʁáim | ‘scissors’ | páim | A1 (2;5.23) |

| | | | |
|---|---|---|---|
| maftéax | ‘key’ | téax | A1 (2;5.23) |
| télefon | ‘phone’ | téfon | A2 (2;5.15) |
| ʃétel | ‘implant’ | ʃétel | A2 (2;5.15) |
| naaláim | ‘shoes’ | naadáim | A2 (2;5.15) |
| | | yayáim | A4 (3;1.2) |
| kélev | ‘dog’ | télev | A2 (2;5.15) |
| xáim | ‘proper name’ | áim | A4 (3;1.2) |

In the following subsections (§6.3.2.1 and §6.3.2.2), I consider the prosodic and segmental effects of the preservation of word-final codas.

### 6.3.2.1. Word-final coda: Prosodic effects

The data in table (87) above show the beginning of coda preservation in word-final position. This phenomenon appears in target words of different lengths (i.e. monosyllabic and polysyllabic target words).

Table (88) below presents the ratio between ultimate and non-ultimate stress of all types of target words in the study, while table (89) presents quantitative data of word-final codas during the initial stage (codaless words) and during the second stage of coda development (word-final coda).

(88) The ratio between ultimate and non-ultimate stress in all types of target words in the study

| Stress | Disyllabic | Trisyllabic | Quadrisyllabic | Total | |
|---|---|---|---|---|---|
| Ultimate | 302 | 77 | 9 | 388 | 63% |
| Non-ultimate | 143 | 66 | 20 | 229 | 37% |
| Total | 445 | 143 | 29 | 617 | 100% |

(89) Preservation of word-final coda

| Target word’s stress pattern | Initial stage (codaless words) | | | Second stage (Word-final coda) | | |
|---|---|---|---|---|---|---|
| | Target | Production | % | Target | Production | % |
| Ultimate | 110 | 10 | 9% | 639 | 242 | 37.8% |
| Non-ultimate | 85 | 9 | 10.6% | 518 | 194 | 37.4% |
| Total | 195 | 19 | 9.7% | 1157 | 436 | 37.7% |

A comparison between the initial stage (codaless words) and the second stage of coda development (word-final coda) shows an increase in both parameters discussed earlier.

**The target parameter**: During the second stage of coda development, the number of tokens of target words with final codas to which the children responded increases both in words with ultimate stress (639 in the second stage as opposed to 110 in the initial stage of coda development) and in words with non-ultimate stress (518 in the second stage as opposed to 85 in the initial stage of coda development). However, the ratio within each stress group of words (i.e. ultimate and non-ultimate stress pattern) does not change: words with ultimate stress are about 55% of all target words (110/195 in the initial stage, and 639/1157 in the second stage of coda development), while words with non-ultimate stress are about 45% of all target words (85/195 in the initial stage, and 518/1157 in the second stage of coda development).

It should be noted that the smaller number of productions of target words with non-ultimate stress does not imply the children's preference for ultimate stress. As shown in table (88), the database consists of more words with ultimate stress (63%) than with non-ultimate stress (37%). This seems to reflect the state of affairs in the language, although there are no quantitative studies available.

**The production parameter:** In the second stage of coda development, coda preservation occurred in 37.8% (242/639) of the produced words with ultimate stress, as opposed to the initial stage, in which coda preservation occurred in only 9% (10/110) of the produced words with ultimate stress. Similarly, in the second stage of coda development, coda preservation occurred in 37.4% (194/518) of the produced words with non-ultimate stress, as opposed to the initial stage, in which coda preservation occurred in only 9.7% (9/85) of the produced words with non-ultimate stress. Although there is an increase in coda preservation, once again the ratio of coda preservation within each stress group of the words produced has not changed: in the initial stage, 52% (10/19) of the token words with ultimate stress are produced with a coda, and in the second stage of coda development, 55% (242/436) of the token words with ultimate stress are produced with a coda.

The numbers in table (89) above show that stress does not play a role in coda preservation in the final syllable of the word. That is, a coda appears to the same extent in stressed or unstressed syllables: out of 639 target tokens with ultimate stress, the coda is preserved in 242 (37.8%), and out of 518 target tokens with non-ultimate stress, the coda is preserved in 194 (37.4%). It can be seen, however, that during this stage of coda development, there is still a lot more coda deletion than coda preservation. Out of 1157 target tokens with word-final codas, the coda is preserved in only 37.7% (436/1157). That is, the coda in final position is developed gradually. Table (90) below shows the gradual development in the coda preservation of two children (A1 and A5) throughout three meetings.

(90) Gradual development of coda preservation in two children

| | Target words with ultimate stress | | | Target words with non-ultimate stress | | | Child |
|---|---|---|---|---|---|---|---|
| Period | Total | Coda Preservation | | Total | Coda Preservation | | |
| 14th meeting | 24 | 3 | 12.5% | 18 | 0 | 0% | A5 (2;8.2) |
| 15th meeting | 20 | 2 | 10% | 15 | 4 | 26.6% | A5 (2;9.7) |
| 16th meeting | 50 | 20 | 40% | 43 | 17 | 39.5% | A5 (3;0.10) |
| Total | 94 | 25 | 26.6% | 76 | 21 | 27.6% | |
| 18th meeting | 13 | 2 | 15.4% | 10 | 1 | 10% | A1 (2;4.25) |
| 19th meeting | 21 | 4 | 19% | 26 | 8 | 30.8% | A1 (2;5.23) |
| 20th meeting | 30 | 10 | 33.3% | 30 | 15 | 50% | A1 (2;6.21) |
| Total | 64 | 16 | 25% | 66 | 24 | 36% | |

Child A1 preserved the coda in final position in 15.4% (2/13) of the target tokens with ultimate stress and in 10% (1/10) of the target tokens with non-ultimate stress during the 18th meeting. In the 19th meeting, there is an increase both in the number of the target tokens (21 target tokens with ultimate stress and 26 with non-ultimate stress) and in the number of the produced tokens with final codas in ultimate (4/21=19%), and non-ultimate (8/26=30.8%) stress productions. Finally, in the 20th meeting, there were 30 target tokens with ultimate stress and 30 target tokens with non-ultimate stress. This time, the child preserved the final coda in 33.3% (10/30) of the token words with ultimate stress and in 50% (15/30) of the token words with non-ultimate stress. In other words, there is a gradual increase in the number of both target tokens and produced tokens with final coda preservation in subsequent meetings.

Coda preservation during the second stage is significantly greater in word-final position than in medial position. This preference is reflected in table (91) below.

(91) Coda production in final and medial position during the second stage of coda development

| | Final coda preservation | | | Medial coda preservation | | |
|---|---|---|---|---|---|---|
| Stress patterns | Target | Production | % | Target | Production | % |
| Ultimate | 639 | 242 | 37.8% | 171 | 14 | 8.1% |
| Non-ultimate | 518 | 194 | 37.4% | 137 | 13 | 9.5% |
| Total | 1157 | 436 | 37.7% | 308 | 27 | 8.8% |

In 37.7% (436/1157) of the target tokens, the final coda is preserved, while in only 8.8% (27/308) of the target tokens, the medial coda is preserved. The ratio of preservation of medial codas in tokens with ultimate (8.1%) and non-ultimate stress (9.5%) is similar to that of final codas in tokens with ultimate (37.8%) and non-ultimate stress (37.4%), thus strengthening my claim that there is no stress effect during this stage of coda development. I will give a few examples to show the preference for preserving codas in final position as opposed to codas in medial position with the same child: child A2 (2;5.15), for example, produced *uxán* for *ʃulxán* 'table' and *yadá* for *yaldá* 'girl', but *gadól* 'big ms.sg.' (i.e. preserving the *l* in final position but deleting it in medial position). Similarly, child A5 (3;0.10) produced *máim* 'water', but *labátya* for *ambátya* 'bath', (i.e. preserving the *m* in final position but deleting the same segment in medial position). Child A4 (3;5.12) produced *babáy* for *baybay* 'bye'(i.e. in the same word, the same segment *y* is deleted in medial position but is preserved as a coda in final position).

It is well documented that the position of syllables towards the ends of words is important in language development. Snow (1988) explains that final syllables are longer in duration than non-final syllables and are thus more salient. That is, because the final syllable, whether stressed or unstressed, is a prominent syllable of a word, segmental units (i.e. coda in final position) have a higher probability of being preserved by the children as opposed to the units in non-final syllables (i.e. coda in medial position). Schwartz and Goffman (1995) examined the influence of syllable stress and syllable position on segmental productions. In contrast to other reports in which segmental omissions were influenced mostly by stress patterns (Ben-David 2001, Zamuner and Gerken 1998), their findings support my claim: segment omissions were affected mainly by their syllable position in the word rather than the syllable stress pattern, that is, consonant omission occurred in word non-final position more than in word-final position and did not appear to be influenced by stress. The authors assume that the lengthening of final vowels may have made ultimate syllable consonants more resistant to omission.

Stress, however, is indirectly relevant to the prominence of the final syllables in Hebrew, which renders the final coda more accessible. As reported in Becker (2003), high tones appear on the final syllables of words, whether stressed or preceded by a stressed syllable. Since almost all Hebrew words have ultimate or penultimate stress, most final syllables in Hebrew have high tones and are thus prominent.

#### 6.3.2.2. Word-final coda: Segmental effects

Word-final codas appear in the children's speech gradually, subject to the manner features of the segments. Tables (92) and (93) present coda consonant inventories across children. Coda consonants are categorized according to four manner classes: liquids, nasals, fricatives and stops. Only those consonants which were produced at least twice in a meeting are listed (Dinnsen et al. 1990, Dyson 1988, Serry and Blamey 1999, Serry et al. 1997, Stoel-Gammon 1987). However, in the following meeting, these segments are listed after a single production, if they appear in the child's corpus again. Accuracy is not taken into consideration, i.e. the segments in the table reflect the children's production of either the precise coda of the target word or its substitution by another segment. For example: child A4 (3;4.8) produced *tut* for *sus* 'horse', substituting the target coda *s* with *t*, thus the replaced segment *t* is listed in the table and the target is in parentheses: *t (s)*. Note that the segment *θ* does not exist in the Hebrew phoneme inventory (§1.2.1), but, it is a common substitute for the sibilants (*s,ʃ,c*) in Hebrew speaking children, and therefore, it appears in the table. In each period, each new segment is marked in bold.

(92) Coda consonant inventories in each child

| Period | Child | Coda inventories | | | |
|---|---|---|---|---|---|
| | | Liquids & Glides | Nasals | Fricatives | Stops |
| 1 | A1 (2;3.7) | **w** | **m,n** | | |
| | A2 (2;2.27) | **y,l** | **n** | | |
| | A3 (2;10.10) | **y (l)** | | **ʃ,θ(t)** | |
| | A4 (3;1.12) | **y,l** | | | |
| | A5 (2;7.0) | **y** | | **ʃ** | |
| | A6 (3;1.16) | **y,w** | **m** | | |
| 2 | A1 (2;4) | w | m,n | **θ(s,ʃ)** | t(d,s,c,x),k,p |
| | A2 (2;4.11) | y,l | n,**m** | **ʃ,f,θ(s)** | |
| | A3 (2;11.1) | y | **m** | ʃ,θ(ʃ),**x** | |
| | A4 (3;3.4) | y,l,**w** | | | t (d,c) |
| | A5 (2;9.7) | y | **m** | ʃ | b(t) |
| | A6 (3;4.15) | y,w | m | **θ(s)** | |
| 3 | A1 (2;4.18) | w | m,n | θ(c),ʃ | t,k,p |
| | A2 (2;5.15) | l | n(ʁ),m | ʃ,θ(s),f,**v,x** | **t(k),d** |
| | A3 (3;0.26) | y | m,**n** | ʃ,θ(t),x | |
| | A4 (3;4.8) | y,(l),l,w | **m,n** | **x** | t (s,c) |
| | A5 (2;11.6) | y,**l** | m | ʃ,**f** | b |
| | A6 (3;5.21) | y,w | m | θ(s**),ʃ** | |
| 4 | A1 (2;4.25) | w | m,n | ʃ(s),θ(c) | t(g),k,p,**d(g)** |
| | A2 (2;6.20) | l | n,m | ʃ,θ(s),f,v,x,**s** | t,d |
| | A3 (3;3.12) | **l** | m,n | ʃ,θ(s),x, **s** | t,**d,p** |
| | A4 (3;6.18) | l,w | m,n | x | t,**d** |
| | A5 (3;0.10) | y,l | m,**n** | ʃ,f (s,v) | b,**t,p** |
| | A6 (3;6.19) | w,y | m | ʃ,θ(s),**x** | **t** |

Table (93) summarizes the above table, with reference to the number of children that acquired each segment.

(93) Summary of the above table

| Period | Liquids | | | Nasals | | Fricatives | | | | | | Stops | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | y | w | l | m | n | f | v | ʃ | θ | s | x | p | t | k | b | d |
| 1 | **5** | 2 | 2 | 2 | 2 | | | 2 | 1 | | | | | | | |
| 2 | 5 | **3** | 2 | **5** | 2 | 1 | | **3** | **4** | | 1 | 1 | 2 | 1 | 1 | |
| 3 | 4 | 3 | **3** | 6 | **4** | 2 | 1 | 5 | 4 | | **3** | 1 | **3** | 1 | 1 | 1 |
| 4 | 2 | 3 | 4 | 6 | 5 | 2 | 1 | 5 | 4 | 2 | 4 | **3** | 6 | 1 | 1 | **4** |

**Lateral liquid**: Throughout the periods, the number of children producing *y* in final coda decreases (5 in period 1, 2 in period 4) while the number of children producing *l* increases (2 in period 1, 4 in period 4). This tendency is actually normal since the acquisition of *l* is relatively late in Hebrew (Lavie 1978, Ben-David 2001) and the glide *y* is a common replacement for *l* in the speech of Hebrew-speaking children during the earlier stages of acquisition (e.g. *náa***y** for *náa***l** 'shoe', *gamá***y** for *gamá***l** 'camel'). Thus, those numbers represent a developmental tendency.

**Nasals**: Throughout the periods, the number of children producing the nasals *m* and *n* gradually increased and during period 4, all 6 children produced *m* in final coda position, and almost all the children (5) produced *n* in final coda position.

**Fricatives**: Throughout the periods, fricatives are very few and infrequent in final coda position. Moreover, only 2 children produce *s* during the final period, while 4 children produce *θ* during this period, replacing *s* and *c*. Lavie (1978) and Ben-David (2001) reported in their studies of Hebrew consonant acquisition, that sibilant consonants are the last consonants to be acquired in the speech of hearing Hebrew-speaking children. Interdentals (i.e. *θ* or *s̪*) are a common substitute for sibilants among Hebrew-speaking children (Ben-David 2001). Thus, the infrequent productions of the *s* alongside the frequent production of *θ* reflect typical developmental tendencies as well. The production of the sibilant *ʃ* is thus surprising since it already appears in period 1 (2 children) and gradually increases up to period 4, where 5 children produce it in final coda position. As mentioned in §3.3.2, the perception of the sibilants by the implanted children is very good, since these segments have a large amount of high-frequency energy. Moreover, the perception of the sibilant *ʃ* by the implanted children is good in particular, since it has a wide spectrum of frequencies and it might stimulate more areas in the cochlea (Ladefoged 1991).

**Stops**: Throughout the four periods, there is an increase in the production of the coronals *t* (6 children in period 4) and *d* (4 children in period 4) as opposed to the velars *k* (1 child in period 4) and *g* (none). In other words, there is a preference for the coronal place of articulation rather than the dorsal place of articulation (see also §6.1.4.2.2). As mentioned in §1.2.2.2, the stops *p* and *b* are rare in coda position in Hebrew and appear mostly in loanwords (e.g. *ǰip* 'jeep', *pab* 'pub').

Tables (92) and (93) indicate that during this stage of coda development, i.e. word-final coda, the segmental features have a prominent influence on whether children preserve the coda in word-final position. As discussed in §1.1.2.2, there is a strong relation between the segment position in a syllable and its sonority level. The sonority level of segments is determined according to the sonority scale repeated below.

(94) Sonority scale

glides> liquids> nasals> voiced fricatives > voiceless fricatives> voiced stops> voiceless stops

Table (95) summarizes the above findings, with respect to final coda acquisition across periods.

(95)

| Period | Segments | |
|---|---|---|
| 1 | Glides | /y/, /w/ |
| 2 | Nasal | /m/ |
| | Voiceless fricative | /θ/ |
| | Sibilant | /ʃ/ |
| 3 | Nasal | /n/ |
| | Liquid | /l/ |
| | Voiceless fricative | /x/ |
| | Voiceless stop | /t/ |
| 4 | Voiced stop | /d/ |
| | Voiceless stop | /p/ |

At the beginning of coda production, the children tend to preserve codas with high sonority and delete non-sonorant segments in coda position. The first codas to be preserved (period 1) are the glides /y/ and /w/. The next group to be produced (period 2) is the labial nasal /m/, the sibilant /ʃ/ (which behaves as a voiceless fricative in adult languages), and the voiceless fricative /θ/ (which stands for most of the sibilants in Hebrew). The next group to be produced (period 3) is the liquid /l/, the coronal nasal /n/, the obstruents, which include the voiceless fricative /x/, and the voiceless stop /t/. During period 4, the voiced stop /d/ and the voiceless stop /p/ are produced. The obstruents; dorsal stops /k,g/, voiced stop /b/, and fricatives /f,v,s,z/ rarely appeared in word-final coda position. Also, the segment /ʁ/ is almost the last one to appear. It is well documented that /ʁ/ is acquired late in many languages as is the case in Hebrew (Sander 1972, Dinnsen et al. 1990, Chin and Pisoni 2000 for English, Ben-David 2001 for Hebrew).

As stated above, it is well documented that there is a relation between the types of segments and their appearance in coda position. However, there is a difference among studies as well as languages, thus some of the findings are similar to mine, but others are not in complete agreement with those of the current study:

Stoel-Gammon's (1985) longitudinal study of English-speaking children reported that voiceless stops and the nasal /n/ predominated in most of her subjects' inventories with /t/ being the first coda consonant in the speech of more than half of the children. Likewise, Bernhardt and Stemberger (1998) had the same order of coda acquisition, i.e. voiceless stops and nasals followed by fricatives and voiced stops. The above findings are not similar to mine, in that my Hebrew-speaking children produced fricatives before stops. However, as with my findings, they reported that sonorants were produced before obstruents. On the basis of these studies, the pattern in English is not consistent with Fikkert's (1994) observation that obstruents as a class are produced before sonorants. However, as with my findings, she reported that her Dutch-speaking children produced fricatives before stops.

A comparison between my findings and those of others dealing with Hebrew-speaking children reveals similar tendencies: liquids, fricatives and nasals are produced before stops. These finding are reported for typically (Ben-David 2001) and atypically (Tubul 2005) developmental Hebrew-speaking children and are consistent with the hearing-impaired children (see table 95).

I assume, however, that the differences among the studies may indicate language-specific trends. For example, the early acquisition of *m* in word-final coda position in the current study might be due to its high frequency in this position, given that *–im* is the unmarked plural suffix in Hebrew nouns.

Moreover, my findings are consistent with acoustic salience which might be another explanation for early acquisition on the basis of speech perception of the hearing impaired children of my study. It is well known that sonorant consonants have acoustic characteristics, such as formant structure and low frequency energy, similar to vowels, making them acoustically and perceptually more salient than stops or fricatives. In my study, therefore, the acoustic features of the sonorant segments might be the reason for better preservation of the sonorant segments rather than the non-sonorant segments in coda position. The children of my study are hearing impaired and they rely on the acoustic cues of the syllable's components more than hearing children do. Since a segment in final position is more vulnerable to deletion than a segment in initial position, its acoustic characteristics might influence its preservation by the CI children.

### 6.3.3. Word-medial coda

As mentioned in §6.3.2.1, during the second stage of coda development, i.e. word-final codas, medial codas are frequently deleted. Out of 1177 polysyllabic tokens with medial codas, the medial coda is deleted in 983 tokens (83.5%), while in only 194 tokens, the medial coda is preserved (16.5%). This ratio changes significantly during the following stage (§6.3.3.1).

There are three cases in which coda deletion occurs: first, when the segment in coda position has not yet been acquired, i.e. does not exist in the child's inventory. This includes *ʁ* and *l* which are acquired relatively late in Hebrew (§1.2). Second, when the segment in onset position of the following syllable has not yet been acquired, thus the children take the segment of the medial coda in the target word and produce it as an onset. Third, when the segment in coda position does exist in the child's inventory but despite this, it is not produced. Tables (96), (97) and (98) below present data of these three cases.

(96) Medial-coda deletion - non-acquired segment

| Target | | Children's production | Child |
|---|---|---|---|
| aʁ.bé | 'a lot' | a.bé (ʁ) | A1 (2;4.0) |
| baʁ.váz | 'duck' | ba.báz (ʁ) | A1 (2;8.29) |
| aʁ.yé | 'lion' | a.yé (ʁ) | A2 (2;5.15) |
| áʁ.ba | 'four fm.sg.' | á.ba (ʁ) | A2 (2;11.2) |
| miʁ.yám | 'proper name' | mi.yám (ʁ) | A5 (3;1.14) |
| ʃul.xán | 'table' | ʃu.xán (l) | A1 (2;6.21) |
| yal.dá | 'girl' | ya.dá (l) | A2 (2;6.20) |
| xul.cá | 'shirt' | xu.cá (l) | A1 (2;8.15) |

(97) Medial-coda deletion – coda in onset position

| Target | | Children's production | Child |
|---|---|---|---|
| im.ʁí | 'proper name' | i.**m**í (ʁ) | A1 (2;5.23) |
| ʃíf.ʁa | 'proper name' | ʃí.**f**a (ʁ) | A1 (2;5.23) |
| mík.ʁo | 'microwave oven' | mí.**k**o (ʁ) | A1 (3;1.18) |
| pit.ʁi.yá | 'mushroom' | pi.**t**i.yá (ʁ) | A1 (2;10.17) |
| mit.ʁi.yá | 'umbrella' | mi.**t**i.yá (ʁ) | A2 (2;6.20) |
| zéb.ʁa | 'zebra' | zé.**b**a (ʁ) | A2 (2;11.2) |
| mas.ʁék | 'comb' | ma.**s**a.ék (ʁ) | A2 (2;11.2) |
| ef.ʁá.im | 'proper name' | e.**f**á.im (ʁ) | A2 (2;9.14) |
| le.it.ʁa.ót | 'see you' | le.i.**t**a.ót (ʁ) | A2 (2;9.14) |
| sim.lá | 'dress' | ti.**m**á (l) | A6 (3;5.19) |
| ox.lím | 'eat ms.pl.' | o.**x**ím (l) | A6 (4;10.7) |
| mag.le.ʃá | 'playground slide' | ma.**g**e.ʃá (l) | A1 (2;10.17) |

(98) Medial-coda deletion - acquired segment

| Target | | Children's production | Child |
|---|---|---|---|
| sáf.ta | 'grandma' | sá.ta (f) | A2 (2;7.24) |
| bám.ba | 'snack' | bá.ba (m) | A2 (1;10.2) |
| bay.báy | 'bye' | ba.báy (y) | A4 (3;1.12) |
| mas.pîk | 'enough' | ma.pîk (s) | A2 (2;7.24) |
| kiv.sá | 'sheep' | ki.tá (v) | A5 (2;8.2) |
| bak.búk | 'bottle' | ba.búk (k) | A1 (2;8.15) |

The distribution of these three cases is presented in table (99) below.

(99) Medial-coda deletion

| Medial coda | Total | Coda-not acquired | | Coda-acquired | | Onset-not acquired | |
|---|---|---|---|---|---|---|---|
| Coda deletion | 983 | 273 | 27.7% | 600 | 61% | 110 | 11.3% |
| Total | 1177 | | | | | | |

As can be seen in table (99) above, during the stage of word-final coda, in 27.7% (273/983) of the produced words, the medial coda is deleted since it has not yet been acquired by the children. In these cases, the children preserve the onset in the following syllable, leaving the medial coda position empty.

In 11.3% (110/983) of the produced words the onset is deleted while the preceding segment, in coda position in the target word, fills the onset position. In other words, since the segment in the onset position has not yet been acquired (usually the liquids *ʁ* and *l*), the coda takes its role, replacing it in onset position. For example: *zé**b**.ʁa* 'zebra' becomes *zé.**b**a, mî**k**.ʁo* 'micro' becomes *mî.**k**o*, and also *ma**d**.lîk* 'light' becomes *ma.**d**îk*. Only in very few cases is the onset deleted even though it exists in the children's inventory, resulting in segment movement from medial coda position to onset position. For example: *mi.sát* for *mis.xák* 'a play', *tá.ko* or *á.ko* for t*ʁák.toʁ* 'tractor', *ma.sé* for *mas.méʁ* 'nail', and also *sá.fa* for *sáf.ta* 'grandma'. Goad (1998) argues that codas are initially syllabified as onsets of empty headed syllables. She bases her claim on phonetic properties: in the child's data, there is a pause between the vowel and a post nuclear consonant. She suggests that the pause is present because it corresponds to a syllable boundary. In other word, the consonant is not incorporated into the syllable of the preceding vowel, but instead, is the onset of its own syllable.

Goad's (1998) arguments are based on the data of six English-speaking children and a Portuguese-speaking child (discussed in Fikkert and Freitas 1997).

During this stage (i.e. word-final coda), in most cases (600/983 = 61%), however, children delete the medial coda even though they have it in their inventory. Steriade (2000) explains that a segment following the vowel of a syllable (i.e. medial coda) has less acoustical prominence then a segment preceding a vowel (i.e. onset). Indeed, in most cases (61%), children omit the medial coda and preserve the onset of the following syllable. Ohala (1998), in contrast, shows in his study with English-speaking children that the deletion of segments is not affected by their position but rather by their sonority. In other words, the least sonorous segment in various positions (either the medial coda or the onset of the following syllable) is the one to be preserved.

Although in this stage of coda development, in most cases, the medial coda is deleted, in 16.5% (194/1177) of the tokens, it is preserved. These numbers bear evidence for a gradual progress in comparison to the previous stage. Table (100) below presents the types of segments to be preserved in word medial codas during this stage of coda development.

(100) Preservation of word medial-coda – segmental analysis

| Child | Liquids | | | Nasals | | Fricatives | | | | | | Stops | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | y | w | l | m | n | f | v | ʃ | θ | s | x | p | t | k | b | d | g | Total |
| A1 (2;8.8-2;11.1) | 8 | 4 | | 3 | | 4 | | 7 | 7 | 2 | 2 | | 1 | 1 | | | 1 | 40 |
| A2 (2;6.20-3;1.6) | 3 | | 1 | 3 | | 2 | | 7 | 4 | 1 | | 1 | 1 | 1 | 1 | | | 25 |
| A3(3;7.11-4;4.14) | 6 | 6 | 1 | 3 | 1 | 4 | 2 | 6 | 7 | 1 | 1 | | 1 | 1 | | 1 | 7 | 48 |
| A4 (3;6.18-4;5.3) | 3 | 4 | 1 | 1 | 1 | 2 | 2 | | 4 | 0 | 4 | | 2 | 4 | 1 | 1 | 1 | 31 |
| A5 (3;0.10-3;9.23) | 2 | 7 | 1 | 6 | 1 | 7 | | 4 | 1 | 0 | | | 1 | 2 | 2 | | 2 | 36 |
| A6 (3;11.12-5;6.9) | | | | | | 2 | 1 | 3 | 5 | 1 | 1 | | | 1 | | | | 14 |
| Total | 22 | 21 | 4 | 16 | 3 | 21 | 5 | 27 | 28 | 5 | 8 | 1 | 6 | 10 | 4 | 2 | 11 | 194 |

A comparison between the order of final coda (table 95) and medial coda acquisition (table 100) reveals partial similarities: as reported for the final coda, when medial codas start appearing, the glides /*y,w*/ are initially produced, as well as the nasal /*m*/, the sibilants /*ʃ*/ and the voiceless fricatives /*θ*/. Moreover, the liquid /*l*/, the nasal */n/* and the voiced and voiceless stops */t,d,p,b/* as well as the fricatives */x,v,s,z/* are infrequent. As stated, these findings are consistent with other studies with Hebrew-speaking children (Ben-David 2001, Tubul 2005). The dorsal stops */k,g/* rarely appear in word final position (see §6.3.2.2, also this is consistent with finding of Ben David's latest study). In fact, our findings show that in medial positions, dorsals are more frequent than coronals and labials. The fact is also consistent also with the results of the HA group (see §6.4.3). This finding might have some connection to the distribution of the segments in the language, i.e. since more words in spoken Hebrew end with coronals and labials (due to affixation) than with dorsals, it is more likely to find a dorsal in word medial position than in word final position (p.c. Cohen Evan). Of course this is only an assumption and further empirical data are necessary to validate it.

### 6.3.3.1. Word-medial coda in the penultimate syllable of the words

During the third stage of coda development, there is a gradual progress in coda production in the medial position of the penultimate syllable of the words regardless of their stress pattern. The medial coda is produced in the penultimate syllables only, while the preceding syllables in trisyllabic words are still codaless. Table (101) below presents examples of coda preservation in polysyllabic target words in the penultimate syllable of the words.

(101) Coda preservation in polysyllabic target words in the penultimate syllable of the words

| Target | | Children's Productions | | Child |
|---|---|---|---|---|
| baybáy | 'bye' | baybáy | y | A1 (2;7.17) |
| abáyta | 'home' | abáyta | y | A1 (2;10.17) |
| baʁváz | 'duck' | bawbáw | w (ʁ) | A5 (3;7.9) |
| paʁpáʁ | 'butterfly' | pawpáw | w (ʁ) | A1 (2;7.17) |
| | | paʁpáʁ | ʁ | A4 (4;0.18) |
| sukaʁyá | 'candy' | sukaʁyá | ʁ | A5 (4;1.5) |
| pílpel | 'pepper' | pílpel | l | A5 (3;7.9) |
| bakbúk | 'bottle' | bambá, bambám | m(k) | A1 (2;7.17) |
| kumkúm | 'kettle' | kumkúm | m | A2 (3;0.13) |

| | | | | |
|---|---|---|---|---|
| kivsá | ‘sheep’ | tivsá | v | A5 (3;7.9) |
| zébʁa | ‘zebra’ | zébʁa | z | A4 (4;0.18) |
| mástik | ‘chewing-gum’ | mástik | s | A1 (2;8.8) |
| misxák | ‘play’ | misxák | s | A5 (3;7.9) |
| li∫tót | ‘to drink’ | li∫tót | ∫ | A1 (2;8.8) |
| | | li∫tót, o∫tót, i∫tót | ∫ | A2 (2;7.24) |
| ni∫páx | ‘was spilled ms.sg.’ | ni∫páx | ∫ | A2 (2;9.14) |
| itgalá∫ti | ‘I slid’ | igalá∫ti | ∫ | A3 (5;0.16) |
| sáfta | ‘grandma’ | sáfta | f | A1 (2;8.8) |
| | | táfta | f | A5 (3;7.9) |
| | | sáθta | θ | A3 (4;0) |
| pásta | ‘pasta’ | páθta | θ (s) | A3 (3;9.6) |
| tiftáx | ‘open! ms.sg.’ | iftáx | f | A2 (2;7.24) |
| bifním | ‘inside’ | bifním | f | A5 (3;7.9) |
| oxlím | ‘eat ms.pl.’ | oxlím | x | A3 (4;0) |
| íxsa | ‘yuck’ | íxsa | x | A4 (4;0.18) |
| meluxláx | ‘dirty’ | meluxláx | x | A4 (4;3.3) |
| medabʁím | ‘speaking’ | midabʁím | b | A5 (3;5.19) |
| televízya | ‘television’ | tevídya | d (z) | A4 (3;7.28) |
| nigmáʁ | ‘was finished ms.sg.’ | nigmáʁ | g | A3 (3;10.19) |
| ambátya | ‘bath’ | abátya | t | A2 (3;0.13) |
| mikxól | ‘paintbrush’ | mikxól | k | A4 (4;0.18) |

Out of 422 polysyllabic tokens with medial codas, the medial coda is preserved in 312 tokens (74%).

During the same stage of coda development, however, codas in the antepenultimate syllable position in tri- and quadrisyllabic target words are deleted. Table (102) below shows this tendency.

(102) Coda deletion in the antepenultimate syllable of the words.

| Tri- and quadrisyllabic target words | | Children’s Productions | | Child |
|---|---|---|---|---|
| ámbuʁgeʁ | ‘hamburger’ | águge | m | A3 (3;10.19) |
| ambátya | ‘bath’ | abátya | m | A1 (2;11.14) |
| | | | | A4 (4;1.21) |
| ámbulans | ‘ambulance’ | ábulans | m | A1 (2;11.14) |
| | | ábulas | m | A2 (2;11.2) |
| | | ábuaθ | m | A5 (3;7.9) |
| sandalím | ‘sandals’ | tadalím | n | A5 (3;7.9) |
| aftaá | ‘surprise’ | ataá | f | A5 (3;7.9) |
| nadnedá | ‘swing’ | nanidá | d | A5 (3;7.9) |

| | | | | |
|---|---|---|---|---|
| agvaniyá | ‘tomato’ | avaniyá | g | A2 (2;11.2) |
| magleʃá | ‘playground slide’ | maiʃá | g | A5 (3;7.9) |
| yitkaʁéʁ | ‘will get cold’ | yikaʁé | t | A1 (2;10.17) |
| makʃivá | ‘listens fm.sg.’ | maʃivá | k | A5 (3;7.9) |

Table (103) below shows the gradual process of coda preservation in the penultimate position of polysyllabic target words as opposed to coda preservation in the antepenultimate syllable position of the words of three children.

(103) Medial coda preservation

| | Penultimate syllable | | | Antepenultimate syllable | | | Child |
|---|---|---|---|---|---|---|---|
| Period | Total | Coda Preservation | | Total | Coda Preservation | | |
| 27th meeting | 10 | 4 | 40% | 4 | 1 | 25% | A1 (2;10.17) |
| 28th meeting | 12 | 9 | 75% | 2 | 1 | 50% | A1 (2;11.1) |
| 29th meeting | 15 | 13 | 86.6% | 7 | 1 | 14.3% | A1 (2;11;14) |
| 21st meeting | 8 | 1 | 12.5% | 2 | 0 | 0% | A4 (3;11.7) |
| 22nd meeting | 11 | 4 | 36.3% | 5 | 0 | 0% | A4 (4;0.18) |
| 23rd meeting | 20 | 11 | 55% | 5 | 2 | 40% | A4 (4;1.21) |
| 22nd meeting | 24 | 7 | 29.1% | 11 | 1 | 9% | A5 (3;7.9) |
| 23rd meeting | 25 | 9 | 36% | 11 | 2 | 18% | A5 (3;8.20) |
| 24th meeting | 33 | 11 | 33.3% | 7 | 1 | 14.2% | A5 (3;9.23) |
| Total | 158 | 69 | 43.6% | 54 | 9 | 16.6% | |

The data in both tables (102) and (103) above show a clear preference for coda preservation in penultimate position (43.6%) as opposed to coda preservation in antepenultimate position (16.6%). During this stage of coda development, when a segment appears in a coda in penultimate position in the target words, it is either preserved by the children or replaced by another segment according to the segmental stages of coda acquisition. For example, child A2 produced the penultimate coda *m* in the word *kumkúm* ‘kettle’ while at the same time deleted the *m* in the antepenultimate syllable position in the target word *ámbulans* ‘ambulance’ and produced *ábulas*. Also, child A5 produced the segment *f* of the target word *bifnîm* ‘inside’ (coda in the penultimate syllable) but deleted the same segment *f* of the target word *aftaá* ‘surprise’ (coda in the antepenultimate position) thus produced *ataá*. These examples give clear evidence that the production of a non-final coda during this stage of acquisition is on the basis of prosodic rather than segmental considerations. Both children A2 and A5 in the examples above had the specific segment in their inventory, but they selected where to produce it according to its position in the prosodic word. This stage of coda development is also reported in Hebrew speaking children (Ben-David 2001) as well as in English (Smith 1973).

### 6.3.3.2. Word medial-coda - final stage

During the final stage, the coda is preserved in all the syllables including tri- and quadrisyllabic target words. The data in table (104) present this stage of coda development:

(104) Coda preservation in polysyllabic target words

| Target | | Children's production | Child |
|---|---|---|---|
| | | Trisyllabic Target words | |
| iʃtolél | 'went wild ms.sg.' | iʃtolél | A1 (3;0.5) |
| pílpelim | 'peppers' | pílpelim | A1 (3;0.5) |
| maxbéʁet | 'notebook' | maxbéʁet | A1 (3;0.5) |
| itpocéc | 'exploded ms.sg.' | itpocéc | A1 (3;0.5) |
| mistovév | 'turns around ms.sg' | mistovév | A1 (3;0.5) |
| liftóax | 'to open' | liftóax | A4 (4;1.21) |
| miglaʃá | 'playground slide' | magyeʃá | A1 (3;1.2) |
| miʃtaʁá | 'police' | miʃtaʁá | A1 (3;1.2) |
| ámbulans | 'ambulance' | ámbulas | A1 (3;1.2) |
| | | ámbulan | A5 (3;11.5) |
| mivʁéʃet | 'brush' | mivʁéʃe | A4 (4;1.21) |
| liʃmóa | 'to listen' | liʃmóa | A4 (4;3.3) |
| misxakím | 'plays' | misxakím | A4 (4;3.3) |
| baʁvazím | 'ducks' | baʁvaθím | A4 (4;5.3) |
| pitʁiyá | 'mushroom' | itʁiyá | A4 (4;6.22) |
| | | pitʁiyá | A5 (4;2.24) |
| nigmeʁá | 'was finished fm.sg.' | igmeʁá | A4 (4;6.22) |
| cfaʁdéa | 'frog' | vaʁdéa | A4 (4;6.22) |
| | | cfaʁdéax | A5 (4;2.24) |
| nadnedá | 'swing' | nadnedá | A4 (4;6.22) |
| liʃmóa | 'to hear' | liʃmóa | A5 (4;1.5) |
| madlikím | 'light ms.pl.' | madlikím | A5 (4;1.5) |
| mitʁiyá | 'umbrella' | mitʁiyá | A5 (4;2.24) |

| | | | |
|---|---|---|---|
| kéngeʁu | ‘kangaroo’ | kényo | A5 (4;2.24) |
| mitʁaxéc | ‘takes a shower ms.sg.’ | mitʁaxéc | A5 (4;2.24) |
| Quadrisyllabic target words | | | |
| mispaʁáim | ‘scissors’ | mispaʁáim | A1 (3;1.2) |
| | | mispáim | A2 (2;11.2) |
| | | miθpaʁái, ispaʁái | A4 (4;1.21) |
| taʁnególet | ‘hen’ | taʁnególe | A1 (3;1.2) |
| | | kaʁnególet | A4 (4;7.25) |
| agvaniyá | ‘tomato’ | agvaniya | A1 (3;1.2) |
| | | | A5 (3;11.5) |
| plastalína | ‘plasticine’ | pastanína | A1 (3;4.10) |
| mixnasáim | ‘trousers’ | mixnasáim | A4 (4;9.10) |
| miʃkafáim | ‘glasses’ | miʃkavái | A4 (4;6.22) |
| | | miʃkafáim | A5 (4;2.24) |

### 6.4. Acquisition of the coda by the hearing aid users

The following section describes the development of the coda in the speech of the hearing impaired subjects with HA (group B). It follows some of the stages reported above for the cochlear implant users (§6.3), starting with the initial stage (§6.4.1), where most syllables are open, i.e. without a consonant in the coda position in both monosyllabic and polysyllabic target words. It then continues to coda preservation in final position (§6.4.2) in monosyllabic target words and in the final syllable of polysyllabic words in either stressed or unstressed syllables. The segmental aspects of development are then discussed (§6.4.2.2). In the following stage (§6.4.3), medial codas in the penultimate syllable of polysyllabic target words are produced, while medial codas in the antepenultimate syllable of tri- and quadrisyllabic target words are not yet produced. The final stage, is coda preservation in non-final position, i.e. codas are preserved in all the syllables of tri – and quadrisyllabic target words.

As noted in the above sections dealing with the HA group findings, only the quantitative numbers are presented while most of the data are presented in the appendix (6). Similarities and differences between the children using HA and CI are discussed.

#### 6.4.1. Codaless words

During the early stages of acquisition, children produce words without codas, regardless of their target language. As mentioned in §6.3, a codaless syllable is the universally unmarked structure (Kenstowicz 1994). The occurrence of this stage is based on phonetic as well as prosodic explanations (Steriade 2000). This is true for hearing children as well as for the CI children of the current study (§6.3.1), and is also true for the group of children using HA. As shown in table (a) in appendix (6), target words with up to three syllables, were produced without a coda, regardless of whether the coda was final or medial. In addition, the position of stress did not seem to play a role.

However, while deletion of codas was a prominent stage in the CI group, it occurred parallel to final coda preservation in the HA group. In other words, 'codaless words' was a long and extended stage within the CI group, but was a very short one within the HA group and occurred simultaneously with the following stage, i.e. 'word-final coda'. I assume, however, that since the recording sessions of the children using HA started later compared to that of the CI users, the data were remnants of the initial period of coda acquisition, i.e. codaless words occurred alongside the appearance of word-final codas.

Another finding related to this stage of coda development is the appearance of long vowels in the final position of the word, instead of a coda. This phenomenon appeared in both monosyllabic and polysyllabic word productions (see table (b) in appendix 6). As for the CI children, there were no words with a long vowel in the final stage of coda development.

As argued in §6.3.1 with respect to CI children, the long vowels in the children's speech corresponded to target vowels in a very specific environment: in a syllable with a coda. In other words, all CV: syllables corresponded to CVC in target words (CV: → CVC). The data of the HA group as well as the CI group is discussed in the discussion section (§7.3.2).

### 6.4.2. Word-final coda

During the following stage, the children started producing word-final codas in both monosyllabic and polysyllabic word productions. Tables (c) and (d) in appendix (6) present data of final coda preservation in monosyllabic and polysyllabic target words respectively. During this stage, most productions were maximally disyllabic.

In the following sections, I discuss data of the HA subjects with reference to the prosodic and segmental aspects of coda development.

### 6.4.2.1. Word-final coda: Prosodic effects

The data in tables (c) and (d) in appendix (6) show the beginning of coda preservation in word-final position. This stage occurred alongside the previous stage, i.e. codaless words. Comparison between the initial stage (codaless words) and the second stage of coda development (word-final coda) is presented in table (105) below and is analyzed according to the two parameters discussed.

(105) Word-final coda – HA group

| Stress pattern | Initial stage (Codaless words) | | | Second stage (Word-final coda) | | |
|---|---|---|---|---|---|---|
| | Target | Production | % | Target | Production | % |
| Ultimate stress | 575 | 143 | 24.87% | 585 | 328 | 56% |
| Penultimate stress | 393 | 72 | 18.32% | 383 | 174 | 45% |
| Total | 968 | 215 | 22.2% | 968 | 502 | 51.86% |

**The target parameter**: The numbers of produced words corresponding to target words with codas in both the second stage and the initial stage of coda acquisition is the same (i.e. 968 target words with codas in both the initial and the second stage of coda development). A comparison between stages according to stress patterns shows the same tendency: during the initial stage (codaless words) - 59.4% (575/968) as opposed to the second stage (word-final codas) - 60% (585/968) target words were with ultimate stress. Also, during the initial stage – 40.6% (393/968) as opposed to the second stage – 40% (383/968) target words were with penultimate stress. In other words, there is no difference between the number of target words with codas to which the children responded in both stages. The target parameter does not support, in this case, the distinction between these two stages.

Table (106) presents a comparison between the two groups of children in the two stages discussed. The data of the CI group are taken from §6.3.2.1.

(106) Word-final coda - Comparison between the two groups

| Stress pattern | Initial stage (Codaless words) | | | | Second stage (Word-final coda) | | | |
|---|---|---|---|---|---|---|---|---|
| | HA | | CI | | HA | | CI | |
| | Target | % | Target | % | Target | % | Target | % |
| Final stress | 575 | 60% | 110 | 56.4% | 585 | 60% | 639 | 55% |
| Non-final stress | 393 | 40% | 85 | 43.6% | 383 | 40% | 518 | 45% |
| Total | 968 | 100% | 195 | 100% | 968 | 100% | 1157 | 100% |

As shown in (106) above, relating to the target parameter, the results of the CI group were different compared to those of the HA group: during the second stage of coda development, the number of tokens of target words with final codas to which the CI children responded increased both in words with ultimate stress (639 in the second stage as opposed to 110 in the initial stage of coda development) and in words with non-ultimate stress (518 in the second stage as opposed to 85 in the initial stage of coda development). However, as shown in (107), the relation between words with ultimate and penultimate stress during both stages in both groups and in comparison to the total types of target words in the current study are similar (table 107 below

(107) The ratio between words with ultimate and penultimate stress among stages, groups and language distribution

| Stress pattern | Types of target words of the current study | | Initial stage | | Second stage | |
|---|---|---|---|---|---|---|
| | Total | % | HA | CI | HA | CI |
| Ultimate stress | 388 | 63% | 60% | 56.4% | 60% | 55% |
| Penultimate stress | 229 | 37% | 40% | 43.6% | 40% | 45% |
| Total | 617 | 100% | | | | |

**The production parameter:** In the second stage of coda development, coda preservation occurred in 56% (328/585) of the tokens of the produced words with ultimate stress (compared to 37.8% in the CI group), as opposed to the initial stage, in which coda preservation occurred in only 24.87% (143/575) of the tokens of produced words with ultimate stress (compared to 9% in the CI group). In addition, in the second stage of coda development, coda preservation occurred in 45% (174/383) tokens with penultimate stress (compared to 37.8% in the CI group), as opposed to the initial stage, in which coda preservation occurred in only 18.32% (72/393) of the tokens with penultimate stress (compared to 9.7% in the CI group). Although there was an increase in coda preservation between stages in both stress patterns, coda preservation in words with ultimate stress (60%) was greater than in words with penultimate stress (40%). For the CI group, however, no difference was found (during the initial stage - 9% and 10.6% for words with ultimate and penultimate stress respectively, and during the second stage – 37.8% and 37.4% for words with ultimate and penultimate stress respectively). It can be seen, however, that during this stage of coda development, there was still considerable coda deletion: out of 968 target words with word-final codas, the coda was preserved in only 502 words (51.86%). That is, the coda in final position develops gradually.

Table (108) below shows the gradual development in the coda preservation of two children (B1 and B2) throughout three meetings.

(108) Coda preservation in target words with ultimate and non-ultimate stress

| | Target words with ultimate stress | | | Target words with non-ultimate stress | | | Child |
|---|---|---|---|---|---|---|---|
| Period | Total | Coda Preservation | | Total | Coda Preservation | | |
| 1st meeting | 20 | 2 | 10% | 16 | 2 | 12.5% | B1 (1;5.21) |
| 2nd meeting | 12 | 3 | 25% | 4 | 1 | 25% | B1 (1;7.3) |
| 3rd meeting | 41 | 26 | 63.4% | 13 | 7 | 53.8% | B1 (1;8.7) |
| Total | 73 | 31 | | 33 | 10 | | |
| 8th meeting | 24 | 6 | 25% | 15 | 3 | 20 | B2 (3;11.13) |
| 9th meeting | 36 | 10 | 27.7% | 15 | 4 | 26.6% | B2 (4;0.17) |
| 10th meeting | 80 | 40 | 50% | 20 | 10 | 50% | B2 (4;1.23) |
| Total | 140 | 56 | | 50 | 17 | | |

Both children show a significant increase in coda preservation in the last meeting presented in (108).

#### 6.4.2.2. Word-final coda: Segmental effects

It seems that the segmental features of the final coda also influenced the children's preference to preserve it (see discussion in §6.3.2.2). Tables (109) and (110) present coda consonant inventories across children. As in the case of the CI group (§6.3.2.2), coda consonants are categorized according to four manner classes: liquids, nasals, fricatives and stops. As stated before, only those consonants which were produced at least twice in a meeting are listed (Dinnsen et al. 1990, Dyson 1988, Serry and Blamey 1999, Serry et al.1997, Stoel-Gammon 1987). However, in the following meeting, these segments are listed after a single production, if they appear in the child's corpus again. Accuracy is not taken into consideration, i.e. the segments in the table reflect children's production of either the precise coda of the target word or substitution by another segment along this period. For example, child B1 (1;5.21) produced *at* for *af* 'nose', thus replacing the target coda *f* with *t.* The replacing segment *t* is listed in the table and the target is in parentheses, i.e. *t (f)*.

Also, as stated in §1.2.1, the segment *θ* does not exist in the Hebrew phoneme inventory. However, it is a common substitute for the sibilants (*s,ʃ,c,z*) in Hebrew speaking children, and therefore, it appears in the table. This is also true for the segment ð which appears in the table below.

(109) Coda consonants inventories in each child

| Period | Child | Coda inventories | | | |
|---|---|---|---|---|---|
| | | Liquids & Glides | Nasals | Fricatives | Stops |
| 1 | B1 (1;5.21) | | **n** | **θ(c,t,s,ʃ),x** | |
| | B2 (3;2.14) | | **m** | **θ(ʃ,s),ʃ, f** | |
| | B3 (3;5) | **l** | | **ʁ,x** | |
| | B4 (2;9.23) | | **m** | | |
| 2 | B1 (1;8.7) | | n,**m** | θ(f,s,z**),**x**,ʃ,v** | |
| | B2 (3;5.22) | **l** | m | θ(ʁ,l,g),ʃ,f,**v** | |
| | B3 (3 ;6.5) | l | **m,n** | ʁ,x,**f** | |
| | B4 (2;10.28) | | m | **ʃ** | **p** |
| 3 | B1 (1 ;9.13) | **l,y(l)** | m,n | x, v, ʃ,θ | **t,d,k** |
| | B2 (3;8.8) | l,**y(ʁ,g)** | m,**n** | θ,ʃ,v,f,**ð** | **p** |
| | B3 (3 ;7.17) | l | m,n | ʁ,x,f**,ʃ,v** | |
| | B4 (3 ;2.13) | **l,y** | m | ʃ,**f** | p |
| 4 | B1 (1.10.17) | l,y(l), | m,n | x, v, ʃ,θ,**ʁ** | t,d,k |
| | B2 (3;11.13) | l,y(n,s, ʁ) | m,n | θ,ð,ʃ,v,f,**x,** | p,**t,b,d** |
| | B3 (4 ;0.13) | l | m,n | ʁ,ʃ,v,x,f | **t,k,d,p** |
| | B4 (3 ;5.22) | l,y | m,**n** | ʃ,f,**v** | p,**t,d** |

(110) Consonants inventory across children

| Period | Liquids | | | Nasals | | Fricatives | | | | | | | | Stops | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | y | w | l | m | n | f | v | ʃ | θ | ð | s | x | ʁ | p | t | k | b | d |
| 1 | | | 1 | **2** | 1 | 1 | | 1 | **2** | | | **2** | 1 | | | | | |
| 2 | | | **2** | 4 | **2** | **2** | **2** | **3** | 2 | | | 2 | 1 | 1 | | | | |
| 3 | **3** | | 4 | 4 | 3 | 3 | 3 | 4 | 2 | 1 | | 2 | 1 | **2** | 1 | 1 | | 1 |
| 4 | 3 | | 4 | 4 | 4 | 3 | 4 | 4 | 2 | 1 | | 3 | **2** | 3 | **4** | **2** | 1 | **4** |

Once again, the tables indicate that during this stage of development the segmental features have a prominent influence on whether children preserve the coda in final position, showing a strong relation between the segment position in a syllable and its sonority level (see §1.1.2.2 for the sonority scale).

In period 1 of coda development, the children produced the nasal /*m*/ and some fricatives */θ,x/*. Significantly, there are no stops produced in this period. In period 2, there was an increase in the types of fricatives produced /*f,v*/, the sibilant /*ʃ*/, the nasal /*n*/ and the liquid /*l*/. The number of children producing both the sonorants and the fricatives also increased. During this period, there was one stop, /*p*/, produced by one child, i.e. the stops started to emerge. All sonorants and fricatives, with the exception of /*s*/ were produced during period 3, where all stops, with the exception of /*b*/ were also produced by at least one child. The only two consonants that do not appear in coda position in period 4 are /*s*/ (which is substituted by *θ* ), and /*w*/ (recall from §6.1.5.2.1 that /*w*/ is rare in Hebrew, thus its absence is not surprising).

Table (111) summarizes the above findings, with respect to final coda acquisition across periods in the HA group in comparison to CI group

(111) final-coda acquisition across periods

| Period | HA Group | | CI Group | |
|---|---|---|---|---|
| 1 | Nasal | /m/ | Glide | /y/, /w/ |
| | Voiceless fricative | /θ,x/ | | |
| 2 | Liquid | /l/ | | |
| | Nasal | /n/ | Nasal | /m/ |
| | Sibilant | /ʃ/ | Sibilant | /ʃ/ |
| | Voiceless fricative | /f,v/ | Voiceless fricative | /θ/ |
| 3 | Glide | /y/ | Nasal | /n/ |
| | Voiceless stop | /p/ | Liquid | /l/ |
| | | | Voiceless fricative | /x/ |
| | | | Voiceless stop | /t/ |
| 4 | Voiced stops | /d/ | Voiced stop | /d/ |
| | Voiceless stop | /t,k/ | Voiceless stop | /p/ |
| | Liquid | /ʁ/ | | |

Comparison between the two groups reveals differences with respect to the period in which each segment was produced, but similarities with respect to the order of acquisition: At the beginning of final-coda acquisition, both groups produced the nasal /*m*/ (before /*n*/ ), as well as some fricatives and the sibilant /*ʃ*/. The number of children producing both the sonorants and the fricatives gradually increased in both groups. However, stops were the last to be produced, while the dorsal stop /*g*/ was not produced at all during data collection.

### 6.4.3. Medial coda

Coda production during the second stage was significantly greater in final position than in medial position. This preference is reflected in table (112) below.

(112) Final vs. medial coda production during the second stage of coda development

| | Word-final coda | | | Word medial coda | | |
|---|---|---|---|---|---|---|
| Stress patterns | Target | Production | % | Target | Production | % |
| Ultimate stress | 585 | 328 | 56% | 150 | 32 | 21.3% |
| Non-ultimate stress | 383 | 174 | 45% | 85 | 28 | 32.9% |
| Total | 968 | 502 | 51.86% | 235 | 60 | 25.5% |

In 51.86% (502/968) of the target tokens, the final coda was preserved, while in only 25.5% (60/235) of the target tokens, the medial coda was preserved. Child B1 (1;10.17), for example, did not produce the *x* in medial coda position, thus provided *adá* for *a**x**ʃáv* 'now', but he did produce it in final coda position in *aʁó**x*** 'long'. The same goes for *l*, which was not produced in *ya**l**dá* 'girl' for which he provided *yadá*, but was produced in *xatú**l*** 'cat'. Similarly, child B3 (4;4.19) correctly produced *kéle**v*** 'dog', but for *ki**v**sá* 'sheep' he provided *kitá*.

During the following stage of coda development, there was gradual progress in coda production in the non-final syllable of polysyllabic target words, regardless of their stress patterns. During this period, codas in antepenultimate syllables of tri- and quadrisyllabic target words were not yet produced. The data of coda preservation in polysyllabic target words in the non-final syllable of the words is presented in table (e) in appendix (6).

As mentioned above, during the second stage of coda development (i.e. word-final coda), medial codas were frequently deleted. Out of 235 polysyllabic tokens with medial codas, the medial coda was deleted in 175 (74.5%), while in only 60, the medial coda was produced (25.5%). The ratio between these numbers changed significantly during the following stage, i.e. medial coda production. Out of 112 polysyllabic tokens with medial codas, the medial coda was deleted in 45 (40%), while the medial coda was preserved in 67 (60%). During the same stage of coda development, however, codas in antepenultimate syllables of tri- and quadrisyllabic target words were deleted. Table (f) in appendix (6) shows this tendency. Child B1, for example, correctly produced *paʁpáʁ* 'butterfly' (preserving the ʁ in medial and final coda position, but at the same age producing *kabólet* for *kaʁbólet* 'crest' and *taegól* for *taʁnegól* 'rooster' (deleting the ʁ in the coda of the antepenultimate syllable).

**Segmental analysis**: The stages of coda production in non-final position in relation to the segment's features are presented in table (113) below.

(113) Medial coda production in relation to the segment's features

| Child | Liquids | | | Nasals | | Fricatives | | | | | | Stops | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | y | w | l | m | n | f | ʃ | θ | s | x | ʁ | p | t | k | b | d | g | Total |
| B1 (2;1-2;6.2) | | | 1 | | 1 | 1 | 4 | 2 | 2 | 3 | 9 | 1 | 2 | 4 | 3 | 1 | 4 | 38 |
| B3 (4;8.6) | 1 | | 1 | 3 | 1 | | 3 | | | 5 | 9 | | 1 | 2 | | 1 | 3 | 29 |
| Total | 1 | | 2 | 3 | 2 | 1 | 7 | 2 | 2 | 8 | 18 | 1 | 3 | 6 | 3 | 2 | 7 | 67 |

A comparison between medial coda (113) and final coda production (100) reveals no similarities regarding the order of the segments produced. While, the nasal /*m*/, as well as some fricatives and the sibilant /*ʃ*/ were mostly preferred in word-final coda position and stops, mainly dorsals, were the last to be produced, in medial coda position, the dorsals, both fricatives and stops, were very prominent in the children's productions. Recall, that the case of the dorsals also appeared in the CI group, a fact which leads me to believe that this is no coincidence (see hypothesis in section §6.3.3).

Finally, the coda was produced in all the syllables of tri- and quadrisyllabic target words. For example: B1 (2;11.7) produced *á**m**bulan* for *á**m**bulans* 'ambulance', *mi**t**ʁiyá* for 'umbrella', *á**m**bungeʁ* for *á**m**buʁgeʁ* 'hamburger', and also *ta**ʁ**nególet* for ‘hen’ and *mi**s**paʁáim* for ‘scissors’. B3 (4;8.6) produced *ma**x**ʃefá* for ‘witch’, *ké**n**guʁu* for ‘kangaroo’, and also *mi**ʃ**kafáim* for ‘glasses’.

# PART IV DISCUSSION AND CLINICAL IMPLICATIONS

## CHAPTER 7: SUMMARY AND CONCLUSIONS

This dissertation presented a study of the prosodic development of Hebrew-speaking hearing impaired children, evaluating the effect of auditory deprivation on the acquisition of the prosodic elements of the word. Currently, this is the only available study that analyzed the speech development of hearing impaired Hebrew-speaking children in terms of syllabic structure, i.e. number of syllables and syllable structure introduced in §5 and §6.

The first goal of this study was to document and analyze the speech development of two types of hearing impaired Hebrew-speaking children, cochlear implant users (CI) and hearing aid users (HA). This served as the basis for the second goal, which was to detect the effects of auditory deprivation on the speech development of hearing impaired children. This goal was achieved by comparing the speech development of two types of the hearing impaired children with that of hearing children speaking Hebrew (Ben-David 2001, Adam 2002) and other languages (Fikkert 1994 for Dutch, Demuth and Fee 1995 for English, Garret 1998, Demuth 2001 for Spanish, Demuth 2003 for French, Ota 1998, 1999 for Japanese, Demuth 1994 for Sesotho).

Transitions in the development of particular structures and the distinction among stages in general were evaluated on the basis of two quantitative parameters: the target parameter and the production parameter. *The target parameter* evaluated the increase of target words that fit the structure characterizing a certain stage (regardless of whether they were produced with this structure). *The production parameter* evaluated the increase of words produced with the structure characterizing this certain stage. The following discussion summarizes the main issues discussed in the dissertation, and draws theoretical and clinical conclusions regarding the analyzed data.

Section §7.1 provides a general comparison among the performances of CI children, that of hearing children and that of HA children. The similar tendencies are pointed out, accompanied by clinical implications.

Section §7.2 discusses the relation between the rate of acquisition and variability within subjects. Two background variables of the implanted subjects are discussed: age of identification and intervention of the hearing loss, i.e. age of hearing aid fitting (§7.2.1) and age of implantation (§7.2.2).

The last section (§7.3) deals with two phenomena, which do not appear in the speech of Hebrew-speaking hearing children, consonant-free words (§7.3.1) and long vowels (§7.3.2).

## 7.1. Comparison between hearing impaired and hearing children

The current study compared the developmental stages of the prosodic acquisition of Hebrew-speaking hearing impaired children with those of hearing children as well as other languages.

My study reveals that, with respect to the development of the prosodic word and the development of the syllable, i.e. onset and coda, the acquisition paths of the implanted children are very similar to those of Hebrew-speaking hearing children as well as to those of hearing impaired children using hearing aids. Also, the comparison between my findings to those of typically developed children speaking different languages reveals the same tendencies in the prosodic aspects as well as in the segmental aspects.

With regard to the prosodic word development, I found monosyllabic words in the initial stage, whose syllable was selected from the target word regardless of prosodic considerations (§5.1). The minimal word stage, where words are maximally disyllabic, was the following one as expected (§5.2). The following gradual increase in the number of syllables in the word up to the pre-final (§5.3) and final stages (§5.4) was also apparent.

With regard to the syllable structure development, it followed most of the stages reported in the literature on the development of the onset (§6.1) and the coda (§6.3) in the speech of hearing children. *Onset development*, however, started with a stage rarely documented, which I called as 'consonant-free word stage' (§6.1.1), a short period characterized by the production of words consisting only of vowels. *The coda development* started as expected, without a coda (§6.3.1), but a missing coda was often compensated for with a long vowel. These two phenomena are broadly discussed in §7.3.1 and §7.3.2 below.

The findings of the study may have important implications for clinical use. The analysis of the data suggests trends in the order of the prosodic development similar to those of hearing children. Fee (1997) suggests that prosodic stages provide a model for assessment and treatment of children with delayed phonological development, and I believe that this is also true for assessment and treatment of hearing impaired children. In the evaluation procedure, the clinician should determine the prosodic stage at which the child's speech is, and lead him/her gradually through the subsequent stages.

## 7.2. Rate of development and variability among children

All children started producing their first words immediately after implantation or throughout the first months after (§4.2). A1 and A2 produced their first words within the normal range of acquisition (1;5), while A3, A4, A5 and A6 produced their first words much later (2;1, 2;3, 1;11, 2;8 respectively). The individual profiles of the cochlear implant children according to the stages of the prosodic word development are presented in (114) below.

(114) The development of the prosodic word - Profiles of the CI children

| Stage | A1 | T | A2 | T | A3 | T | A4 | T | A5 | T | A6 | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age of implantation | 1;2.10 | | 1;0.0 | | 1;9.6 | | 2;0.7 | | 1;9.11 | | 2;5.13 | |
| Age of HA fitting | 0;5.0 | | 0;6.0 | | 1;3.0 | | 0;10.0 | | 0;3.0 | | 1;8.0 | |
| The initial stage | 1;5-2;1 | 8 | 1;5-1;9 | 4 | 2;1-2;5 | 4 | 2;3-2;7 | 4 | 1;11-2;1 | 2 | 2;8-3;1 | 5 |
| Minimal word stage | 2;1-2;6 | 5 | 1;9-2;7 | 10 | 2;5-3;7 | 14 | 2;7-3;3 | 8 | 2;1-2;8 | 7 | 3;1-4;4 | 15 |
| Pre final stage | 2;6-2;9 | 3 | 2;7-2;11 | 4 | 3;7-4;10 | 15 | 3;3-3;11 | 8 | 2;8-3;4 | 8 | 4;4-5;6 | 14 |
| Final stage | 2;9- | | 2;11- | | 4;10- | | 3;11- | | 3;4- | | Hasn't finished | ??? |
| Total | 1;5-2;9 | 16 | 1;5-2;11 | 18 | 2;1-4;10 | 33 | 2;3-3;11 | 20 | 1;11-3;4 | 17 | 2;8- | 34 |

T= the time (in months) between stage n and stage n+1

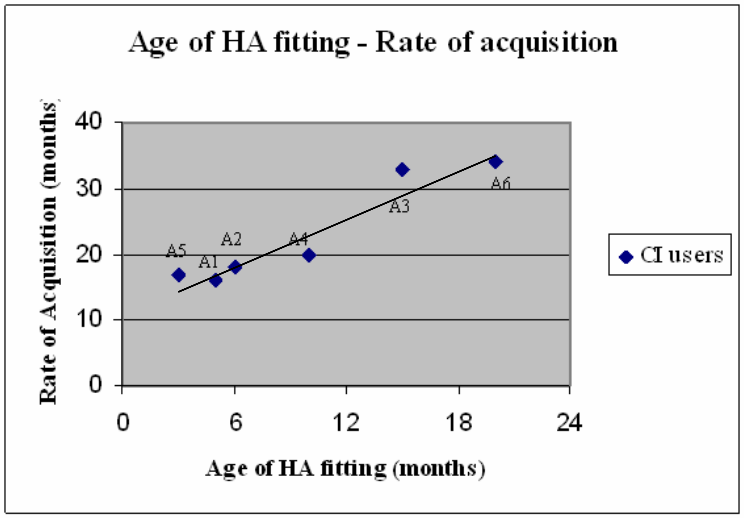
The hearing aid group is not included in this discussion since their follow-up started much later (see appendix 7). In other words, none of the hearing aid users were recorded at the initial stage of the prosodic development but only much later (§4.1.2).

In the following sub-sections, I discussed the relation between the rate of word acquisition and two variables that may have an influence on it: age of identification and intervention of hearing loss (§7.2.1) and age of implantation (§7.2.2).

### 7.2.1. The relation between rate of development and age of intervention

Figure (115) below shows the relation between the age of hearing aid fitting of the CI users and the rate of development, i.e. the time it took each child to reach the final stage of prosodic word acquisition (the time between the initial and the final stage).

(115) The relation between the age of hearing aid fitting and rate of development



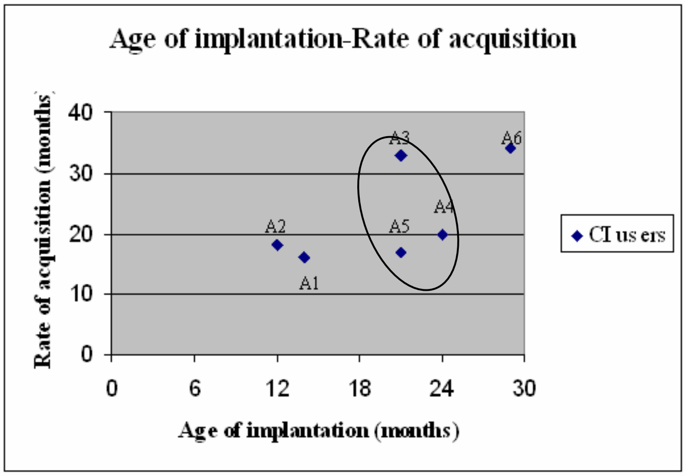
As can be seen from the figure above, the earlier the age of hearing aid fitting is, the shorter the rate of word development is.

Yoshinaga-Itano (2002) mentions that children with early-identified hearing loss (within the first six months of life) have demonstrated language development within the low average range of development in the first four to five years of life. Their language development is significantly better than children identified later (Yoshinaga-Itano et al. 1998, Stevens 2002). In fact, early–identified children have better speech intelligibility (Apuzzo and Yoshinaga-Itano 1995, Yoshinaga-Itano et al. 2000), better language development and vocabulary knowledge (Yoshinaga-Itano et al. 2000), and also better social-emotional development (Yoshinaga-Itano 2002).

### 7.2.2. The relation between rate of development and age of implantation

It seems that age of implantation plays only a partial role in the rate of development. Figure (116) below presents the relation between the age of implantation and the rate of prosodic word development, i.e. the time it took each child to reach the final stage of word acquisition (the time between the initial and the final stage).

(116) The relation between age of implantation and rate of development



As can be seen from the figure above, A1 and A2 demonstrate that, the earlier the age of implantation is, the shorter the rate of word development is. As for children A3, A4 and A5 (the points within the ellipse), there is a variability within subjects. Child A3 was implanted when she was 1;9.6 years old and it took her 33 months to reach the final stage. However, child A5 was implanted when she was 1;9.11 years old (approximately the same age as A3) but it took her only 17 months till the final stage of word acquisition, and child A4 was implanted when he was 2;0.7 years old (after A3) and it took him only 20 months till the final stage of word acquisition. In other words, the rate of acquisition of these two children (A4 and A5) is better than that of A3, and is much more similar to that of A1 and A2, who were implanted earlier.

Interaction between age of hearing aid fitting and age of implantation shows an interesting relation. Table (117) below presents the age of HA fitting and the age of implantation of each child as well as their age at the final stage of the prosodic word development.

(117) Interaction between age of hearing aid fitting and age of implantation

| Child | Age of HA fitting | Age of implantation | Age at the final stage |
|---|---|---|---|
| A1 | 0;5.0 | 1;2.10 | 2;9 |
| A2 | 0;6.0 | 1;0.0 | 2;11 |
| A3 | 1;3.0 | 1;9.6 | 4;10 |
| A5 | 0;3.0 | 1;9.11 | 3;4 |
| A4 | 0;10.0 | 2;0.7 | 3;11 |
| A6 | 1;8.0 | 2;5.13 | Hasn’t finished |

Children A3 and A5 were implanted almost at the same age (with a difference of 5 days only), but child A5 reached to the final stage of the prosodic word development much before child A3. The age of HA fitting, however, shows that child A5 got her HA device much earlier than child A3. Moreover, child A4 was implanted later than child A3 but he had reached the final stage before her. This might also be due to his earlier HA fitting.

Child A1 and A2 show the same relation: although child A2 was implanted before child A1 (2 months and 10 days difference), child A1 had reached to the final stage of the prosodic word development before child A2. Once again the age of HA fitting might be the reason for that, i.e. child A1 received his hearing aid earlier than child A2. As for child A6, both his age of HA fitting and age of implantation were very late and he hadn’t reached to the final stage of the prosodic word development till the end of the study.

To conclude, age of implantation has only a partial effect on word development, however, the age of hearing aid fitting is much more crucial, i.e. an early age of implantation might results with a late acquisition with the presence of lately age of hearing aid fitting. However, since my study includes only 6 subjects it is difficult to run into broad generalization. Following the findings reported in the literature, I assume that other factors might be involved. Pisoni (2003-2004) emphasizes the fact that despite the success of cochlear implants in many deaf children, large individual differences have been reported on a wide range of speech and language outcome measures. This finding is observed in all research centers around the world. Some children do extremely well with their cochlear implants while others derive only minimal benefits after receiving their implants. Many demographic variables have been identified in the literature as potentially affecting the development of spoken language in children who use cochlear implants. These include, among others, the age of onset of deafness (Fryauf-Bertschy et al. 1992), the age of implantation (Kirk et al. 2002a, 2002b), the duration of device use (Blamey et al. 2001b), the communication mode (Chin and Kaiser 2002, Kirk et al. 2002b), as well as fundamental differences in rapid phonological coding and verbal rehearsal processes used in working memory (Cleary et al. 2002, Pisoni 2003-2004).

Moreover, a comparison between the early implanted children, A1 and A2, and the hearing children of Ben-David's (2001) study reflects an interesting finding:

(118) From initial stage to final stage: Implanted vs. hearing children

| | Child | Initial stage | Reached final state | Time (months) |
|---|---|---|---|---|
| Hearing | Carmel | 1;1 | 2;1 | 12 |
| | Maayan | 1;3 | 3;0 | 21 |
| **Implanted** | **A1** | **1;5** | **2;9** | **16** |
| | **A2** | **1;5** | **2;11** | **18** |

As for the age–stage correspondence, the implanted children A1 and A2 had a slightly later start than that of Carmel and Maayan, but they certainly caught up towards the end of the development. As shown in (118) above, the implanted children reached the final stage at almost the same age (and even a little earlier) as the slowest hearing child in Ben-David's (2001) study. Moreover, it took them only 16 and 18 months respectively to progress from the onset of the initial stage to the final stage, much less than it took for the slowest hearing child (21 months). The cochlear implant child of Ertmer and Mellon's (2001) exhibits similar findings in relation to rate of development. Hannah's transition from one stage to another (in the latest stages of productions) was more rapid than that seen in hearing infants. They suggest that Hannah's rate of development bears evidence to the fact that children who receive an implant at a young age may not need as much vocal practice at each stage as younger, typically developing infants and toddlers appear to require.

As mentioned in §3.4 recent studies suggest that an early age of implantation has an important influence on the speech development of hearing impaired children (Kirk and Hill-Brown 1985, Tobey et al. 1991, Tye-Murray et al. 1995, Kirk et al. 2002b). More specifically, children who receive a cochlear implant before 18 months of age are found to have normal or even accelerated language development growth patterns than children who receive a cochlear implant at an older age (Osberger 1993, Waltzman and Cohen 1998, Novak et al. 2000, Hammes et al. 2002, Govaerts et al. 2002). The advantage of an early age of implantation is realized in speech perception (Yaremko 1993, Waltzman and Cohen 1998), as well as in speech production (Tye-Murray et al. 1995, McCaffrey et al. 1999, Ertmer and Mellon 2001, Ertmer 2001a).

The findings in this study have a partially support in the literature's claim that an early age of implantation has a dominant effect on speech and language development, i.e. the later the implantation is, the slower the rate of acquisition is.

The findings of the current study reveal that age of hearing aid fitting plays a crucial role in word acquisition. Since there is a large variably among subjects, I assume that other variables may play a role in children's speech acquisition. Such variables may include objective factors (e.g. electrode location at the cochlea) as well as subjective factors (e.g. child's cognitive abilities, his/her self motivation, parental involvement, the amount of rehabilitation a child receives). Pisoni (2003-2004) claims that understanding the reasons for the variability in outcomes and the large individual differences following cochlear implantation is one of the most important problems in the field today.

## 7.3. Special phonological phenomena

The following sub-sections discussed the two phenomena characterizing the speech of the hearing impaired children of my study: consonant-free words (§7.3.1) and long vowels (§7.3.2).

### 7.3.1. Consonant-free words

As stated in §6.1.1, during the initial stage of the prosodic word development, shortly after implantation, the cochlear implant children produced quite a few words consisting only of vowels. In other words, the children deleted the onset of monosyllabic productions, thus leaving them as consonant-free words (given that the coda is not get produced at this stage). This phenomenon appeared both in monosyllabic and polysyllabic target words and gradually decreased throughout subsequent stages. Below are a few examples of monosyllabic and polysyllabic target words (for more examples see (52) in §6.1.1).

(119)

| *Monosyllabic* | | | *Polysyllabic* | | |
|---|---|---|---|---|---|
| Target | | Production | Target | | Production |
| lo | ‘no’ | o | paʁpáʁ | ‘butterfly’ | aá |
| mi | ‘who’ | i | imʁí | ‘proper name’ | ií |
| dag | ‘fish’ | a | aviyá | ‘proper name’ | aá, iá |
| en | ‘none’ | e | ʁégel | ‘foot’ | ée |
| op | ‘hop’ | o | álo | ‘hello’ | áo |

The preference for consonant-free words during the initial period of onset development within all the implanted children is not consistent with reports in the literature, where syllables with onsets, i.e. CV, are the first to be produced (see discussion in §5.1.2). Moreover, the hearing Hebrew-speaking children in Ben-David’s (2001) study never produced consonant-free words (with the exception of *o* for *oʁ* ‘light’), even in the stage of codaless words, where VC target words were produced as VC and these were the only words with codas at this stage. Ben-David explains her findings relying on Tobin’s (1997) approach of the requirement to maintain communicative information. That is since the consonants carry the essential communicative information of speech, a word without at least one consonant cannot convey even the minimal contrast required. This issue is also discussed in Bonatti et al. (2005), where experiments with French-speaking adults dealing with the role of consonants and vowels in continuous speech processing were conducted. The results of their study suggest that consonants play a significant role in word identification.

The participants of the study were able to break a continuous speech stream into its component words when relying on consonants, but they were apparently unable to do so when relying on vowels. The authors suggest that the vowel-consonant asymmetry depends on the different roles of vowels and consonants in language; consonants serve mainly to individuate words, whereas vowels tend to carry grammatical information.

These assumptions, thus, strengthen the question with regard to my findings: Are these consonant-free words to be considered as a deviant state in the speech of the hearing impaired children of the current study? If the answer is negative, another question might be raised: what is the role of this period in the developmental process of these children?

Studies of consonant-free words are limited, and, to the best of my knowledge, there is no explanation at hand for the issue. Some studies suggest that consonant-free words may appear in normal development (Bernhardt and Stemberger 1998 and Vihman and Velleman 2000 for English, Freitas 1996, Costa and Freitas 1998 for Portuguese), but others claim that they appear only in disordered development (Menyuk 1980 for English, Grijzenhout and Joppen 1999 for Germany, Tubul 2005 for Hebrew).

Following Adi-Bensaid and Bat-El (2004), I assume that consonant-free words are residues of the babbling stage (this has been suggested by Phiyona Margaliyot p.c.). Consonant-free syllables (as well as CV syllables) appear during the babbling stage (Stoel-Gammon and Otomo 1986, Paul and Quigley 1994), and may also persist during the transition phase from babbling to speech (Oller et al. 1978, Stoel-Gammon 1985). Dore et al. (1976) identify a stage which they call Phonetically Consistent Forms (PCF), which appears to be an intermediate stage between prelinguistic babbling and words. They assume that the child may develop a lot of PCFs before producing the first words, and these forms function as words for the child. The authors describe four varieties of PCFs, one of which includes single or repeated vowels. PCFs are found in all children regardless of their target language. Following

Dore et al. (1976), I assume that PCFs serve as a link between babbling and adultlike words in that they are more limited and consistent than babbling but not as structured as adult speech. Ferguson (1978:281) names them "babbling-like sounds used meaningfully".

As noted, consonant-free words in hearing Hebrew-speaking children are not reported in Ben-David's (2001) and Adam's (2002) studies. It is possible, however, that these studies missed this short period in children's productions, thus documenting only the subsequent stage of onset development. As a matter of fact, a study currently being conducted by Adam and Bat-El reveals that typically developed children produce consonant-free words (e.g. *eeé* for *lecayéʁ* 'to paint', *éo* for *éfo* 'where', *o* and *oː* for *od* 'more', *o* for *lo* 'no'). The recording of the children in this study began during the canonical babbling stage (around 8 months), and therefore the transition to speech revealed the consonant-free words. However, the number of consonant-free words in this study is very small.

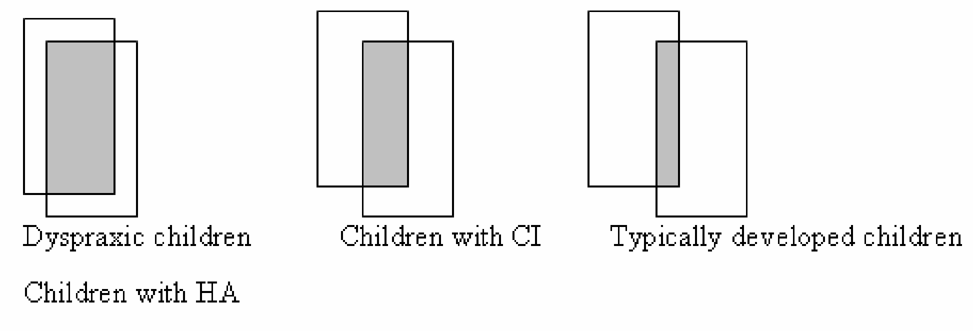
In comparison, in the speech of the hearing-impaired children, there was a large number of consonant-free words, which also appeared during the minimal word stage, i.e. beyond the initial state. This, I argue, is due to the fact that the children underwent the operation when they were at the babbling stage, which means that they started getting increased auditory information required for language development later than typically developed hearing children. That is, due to the late exposure to sufficient auditory information, the babbling stage (i.e. PCF stage) lasted longer than usual. This explanation is supported by the decrease in the number of consonant-free words as the children's language developed (from 51.5% to 22.8% and none in the subsequent stages). Ertmer and Mellon (2001) suggest that young implanted children exhibit a period of PCF before they produce meaningful speech on a regular basis. They claim that simpler and less speech-like vocalizations are established before more complex and speech-like forms are produced. In fact, PCF were the dominant form of vocalization before their subject's implantation and during the first four months of implant use. Production of these early-developing forms decreased significantly thereafter. Also, Gillis at al. (2002) and Moore and Bass-Ringdahl (2002) report that the implanted children of their study went through a babbling stage before they acquired their first conventional words. Also, they mention that PCF, characterizing the speech of hearing children, also occurred in the CI children's repertoire before they acquired their first words. Following the above studies, I assume that very young cochlear implant users have vocal development milestones similar to those of hearing infants and toddlers, thus the babbling stage is extended after implantation and continues for a short period.

The study of Kent et al. (1987) on the phonetic development in identical twins differing in auditory function may strengthen the above assumption. The authors compared twins – one with normal hearing and the other with profound hearing loss. At 8 months, the hearing child produced some consonant and consonant-vowel syllables, while the twin with hearing loss produced only vowels and diphthongs. These findings might reflect the effect of auditory feedback on the duration of the babbling stage and the transitional period between stages.

The hearing aid users, however, were very similar to the dyspraxic children in Tubul's (2005) study. The hearing aid children (of the current study), as well as the children with developmental dyspraxia (Tubul 2005) produced consonant-free words, which persisted even beyond the minimal word stage. For example, Elad (2;10) produced *e* for *ken* 'yes', *aó* for *caóv* 'yellow', and *ée* or *yéled* 'boy'. Orit (4;5) produced *aó* for *kaxól* 'blue', *yaʁók* 'green' and *adóm* 'red', *oiá* for *oniyá* 'ship', and *aió* for *aviʁón* 'airplane (Tubul 2005). Also, B2 (3;5.22) produced *o* for *kos* 'glass', *oí* for *oxlím* 'eat ms.pl.', *ái* for *máim* 'water', and B4 (3:0) produced *a* for *ʃam* 'there', and *ái* for *mispaʁáim* 'scissors' (the current study).

Following the above findings, I maintain the view that consonant-free words are not limited to disordered speech or to the speech of hearing-impaired children using the cochlear implant device. Rather, they characterize the period between babbling and speech, i.e. PCF stage. However, the distinction between the three groups mentioned above is in the degree of overlap between the stages: it is greater in dyspraxic children and children using hearing aids, less so in implanted children, and very small in typically developed hearing children. The degree of difference is described in figure (120) below. The figure presents the overlap (colored rectangle) between the first stage (I) and the second stage (II) in all groups discussed.

(120) The overlap between stages in all groups



Further studies of a variety of populations (developmental aphasia, retardation, specific language impairment etc.) are required to verify this account of consonant-free words.

Clinicians should be aware of the transition phase from babbling to meaningful speech at the beginning of the intervention program. This phase should be considered within normal development as long as it is a temporary period. Ertmer et al. (2002a, 2002b) suggest that an intervention program should emphasize prelinguistic vocalization in young children with cochlear implants. They emphasize the importance of presenting speech sounds, especially vowels and diphthongs, in isolation and in simple combinations at the beginning of the training program. Thus, during this period, the clinician should encourage the hearing-impaired child to babble and develop her/his vocal play. This can be done by joining the child in his/her vocal play, while adding meaningful words similar to the sounds produced by the child (Pollack 1970). Wallace et al. (2000) suggest that hearing-impaired children, who have not yet started speaking, would learn words that match their babble sound patterns (i.e. PCF ) better than words that do not. Thus, in planning an intervention program, the clinician should identify the preferred babble patterns of the child and then add real words that use those sounds and prosodic structures.

### 7.3.2. Long Vowels

As noted in §6.3.1, during the initial stage of coda development, where the coda is not produced, there is an appearance of long vowels in word-final position, instead of the coda. This phenomenon occurs both in monosyllabic and polysyllabic word production. Below are a few examples of monosyllabic and polysyllabic target words (for more examples see (91) in §6.3.1).

(121)

| *Monosyllabic* | | | *Polysyllabic* | | |
|---|---|---|---|---|---|
| Target | | Production | Target | | Production |
| pil | ‘elephant’ | i: | balón | ‘balloon’ | baó: |
| cav | ‘turtle’ | ta: | miʃkafáim | ‘glasses’ | pái: |
| xam | ‘hot’ | a: | ʃaón | ‘watch’ | yaó: |
| ec | ‘tree’ | e: | kapít | ‘spoon’ | kapí: |
| od | ‘more’ | o: | enáim | ‘eyes’ | enái: |

Hebrew does not have phonemic long vowels, and there are also no reports of long vowels in the speech of hearing Hebrew-speaking children. Therefore, the appearance of long vowels in the speech of the implanted children may be surprising. However, Hebrew has phonetic long vowels that may arise, in casual speech, from the loss of a medial glottal (e.g. *náʔaʁ* → *náaʁ* ‘adolescent’, *báʔa* → *báa* ‘came fm.sg.’). In addition, the phonetic correlate of stress in Hebrew is vowel length. That is, long vowels are not phonetically alien to the children.

Nevertheless, I argue that vowel length in the children’s speech is conditioned by the syllable structure of the target word. As the data above suggest, the long vowels in the children’s speech correspond to target vowels in a very specific environment: in a syllable with a coda. In other words, the long vowel compensates for the missing coda.

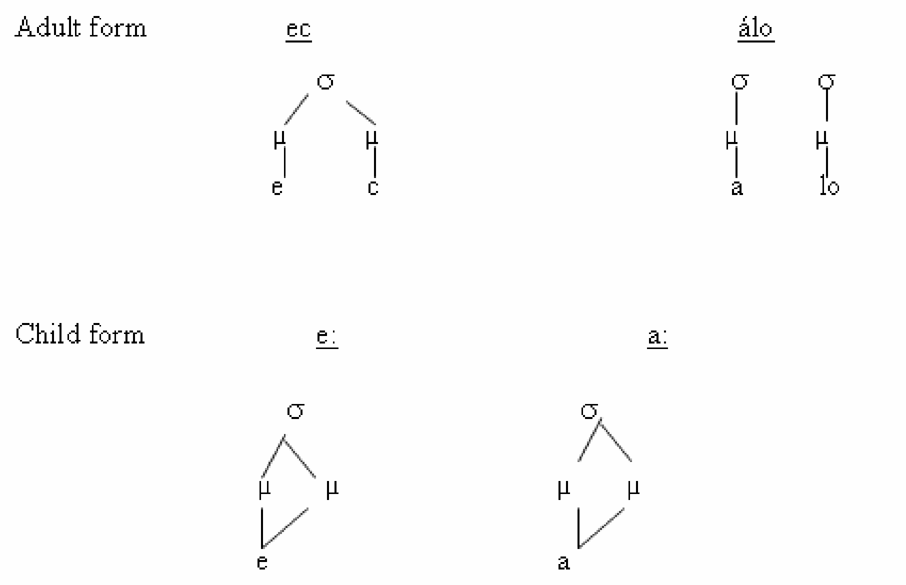
Compensatory lengthening is a familiar process in adult language (Hayes 1989) as well as children’s speech. Ota (1999) shows that learners of Japanese show compensatory lengthening when nasal codas or diphthongs are deleted, and similar findings are reported for English (Demuth and Fee 1995, Bernhardt and Stemberger 1998, Stemberger 1992), Dutch (Fikkert 1994), French (Demuth and Johnson 2003), and German (Kehoe and Lleo 2003). Children learning these languages show moraic conservation, preserving minimal word targets as binary feet even if they cannot produce word-final consonants.

Compensatory lengthening in Hebrew is, however, surprising. In the languages noted above there is independent evidence for moraic structure, i.e. phonemic length contrast. Hebrew, however, does not exhibit phonemic length contrast, and there is no phonological process that suggests moraic structure (see §1.1.2.1).

It is generally assumed that the unmarked syllable is mono-moraic, and that children construct bimoraic syllables only when they receive positive evidence from their ambient language (Fikkert 1994, cf. Hayes 1989 "weight by position").

My findings suggest the contrary, i.e. that a bimoraic structure for CVC syllables is innate. That is, even children whose target language does not distinguish between mono and bi-moraic syllables, have access to this structure during the earlier stages of development, until they get positive evidence that this unit is not relevant for the phonology of their target language. Thus, during the early stages, a target CVC syllable has two moras, and the loss of a segment in the coda leaves an empty mora, allowing the vowel to spread into its position; a vowel linked to two moras is long (see Hayes 1989).

(122) Vowel lengthening



The question to be asked is why there are no reports of long vowels in the studies of hearing Hebrew-speaking children? One simple explanation could be that the studies on the prosodic acquisition of Hebrew did not control vowel length, as it does not exist in adult Hebrew (both Adam and Ben-David p.c. informed me that they did not pay attention to vowel length, though Ben-David insisted that she would have noticed long vowels had they appeared). Adam and Bat-El, on the other hand, control the variable of long vowels and report in their ongoing study that their typically developed children do produce long vowels in the initial stage of word production (e.g. *pa:* and *papá:* for *paʁpáʁ*, *da:* for *day* ‘enough’ and *dag* ‘fish’, and also *xa:* for *xam* ‘hot’). However, at this stage of their study, there is no evidence that the long vowels compensate for a missing prosodic unit. In other words, according to their findings, long vowels do persist in the speech of hearing Hebrew-speaking children during the babbling stage and even during a short period beyond it. However, as suggested in §7.3.1, with respect to consonant-free words, due to the late onset of sufficient auditory feedback, there is a longer period of transition from babbling to speech with the hearing impaired children. Consequently, sounds and structures characterizing babbling exist throughout a longer period in their speech compared to that of hearing children.

It should be emphasized that the data of the implanted children were collected during therapy. It is often the case that clinicians speak to the child at a slower rate and a higher intensity and frequency than in normal speech, which may result in vowel lengthening. However, if intervention were the answer, I would expect long vowels in various environments, and not only in the environment given here, i.e. compensatory lengthening only before a target coda.

To conclude, the findings of the current study shed light on the prosodic development of hearing impaired children in general and on that of cochlear implant users specifically. The findings are encouraging, since they bring us to the conclusion that cochlear implant users follow the same developmental milestones of the prosodic development of hearing children. As long as the age of implantation is early enough, the rate of development is very similar to that of hearing children. These findings may contribute to planning the assessment and the intervention program of the hearing impaired child. The clinician should determine the exact prosodic level of the child and plan an intervention program accordingly.

## APPENDIX 1: HEARING AID USERS: THE MINIMAL WORD STAGE OF PROSODIC WORD DEVELOPMENT

a. Target: **Polysyllabic words** – Production: **Disyllabic words**

| Target | | Children's Productions | Child |
|---|---|---|---|
| Ultimate stress | | | |
| ʃalóm | 'hello' | ʃayó | B1 (1;5.21) |
| paʁpáʁ | 'butterfly' | papá | B1 (1;5.21) |
| kadúʁ | 'ball' | adú | B1 (1;5.21) |
| balón | 'balloon' | balón | B1 (1;5.21) |
| adóm | 'red' | adó | B2 (3;2.14) |
| axbáʁ | 'mouse' | abá | B2 (3;2.14) |
| sevivón | 'spinning top' | itó | B2 (3;2.14) |
| mitʁiyá | 'umbrella' | payá | B2 (3;2.14) |
| melafefón | 'cucumber' | atón | B1 (1;5.21) |
| | | epó | B2 (3;6.20) |
| Penultimate stress | | | |
| tíʁas | 'corn' | tíya | B1 (1;5.21) |
| gézeʁ | 'carrot' | géðe | B1 (1;5.21) |
| yéled | 'boy' | yéye | B1 (1;5.21) |
| báit | 'house' | bái | B1 (1;5.21) |
| péʁax | 'flower' | péax | B1 (1;5.21) |
| óʁen | 'proper name' | óye | B2 (3;2.14) |
| ʃémeʃ | 'sun' | ʃébe | B2 (3;2.14) |
| íma | 'mother' | íma | B4 (2;9.23) |
| álo | 'hello' | álo | B4 (2;9.23) |
| dúbi | 'teddy bear' | dúbi | B4 (2;9.23) |
| ába | 'daddy' | ába | B4 (2;9.23) |
| banána | 'banana' | nána | B1 (1;5.21) |
| gamáʁnu | 'finished ms.pl.' | mánu | B1 (1;5.21) |
| ʃamáim | 'sky' | máim | B4 (2;9.23) |
| tapúax | 'apple' | búa | B4 (2;9.23) |

### APPENDIX 1 (CONTINOUS)

b. Target: **Trisyllabic words** – Production: **Disyllabic words**

| Target | | Children's Productions | Child |
|---|---|---|---|
| Ultimate stress | | | |
| sevivón | 'spinning top' | itó, ibó | B2 (3;2.14) |
| mitʁiyá | 'umbrella' | payá, biyá, piyá, iyá | B2 (3;2.14) |
| mekaléf | 'peels ms.sg.' | alé | B2 (3;6.20) |
| taʁnegól | 'rooster' | tatól | B2 (3;7.10) |
| masaít | 'truck' | maí | B4 (3;1.1) |
| agalá | 'cart' | dadá | B2 (3;8.8) |
| Penultimate stress | | | |
| banána | 'banana' | nána | B1 (1;5) |
| gavóa | 'tall ms.sg.' | dóa | B1 (1;5) |
| gamáʁnu | 'finished ms.pl.' | mánu | B1 (1;5) |
| liftóax | 'to open' | fóa | B2 (3;2.14) |
| laʃévet | 'to sit' | ʃéve | B2 (3;5.22) |
| ǰiʁáfa | 'giraffe' | gápa | B2 (3;6.20) |
| tapúax | 'apple' | púa, búa | B4 (2;10.28) |
| Antepenultimate stress | | | |
| télefon | 'phone' | yáfo, láfo:, yápon | B2 (3;7.10) |
| ʃókolad | 'chocolate' | ʃóla | B2 (3;10.9) |
| bégale | 'pretzel' | máne | B2 (3;8.8) |

c. Target: **Quadrisyllabic words** – Production: **Disyllabic words**

| Target | | Children's Productions | Child |
|---|---|---|---|
| Ultimate stress | | | |
| melafefón | 'cucumber' | ató:n | B1 (1;5) |
| | | epón, epó | B2 (3;10.9) |
| agvaniyá | 'tomato' | yayá | B1 (1;5) |
| Penultimate stress | | | |
| televízya | 'television' | bída | B2 (3;8.8) |
| mispaʁáim | 'scissors' | páim, ái: | B4 (2;9.23) |
| mixnasáim | 'pants' | á:i | B2 (3;2.14) |

## APPENDIX 2: HEARING AID USERS – THE PRE-FINAL STAGE OF PROSODIC WORD DEVELOPMENT

### Target: **Tri- and quadrisyllabic words** – Production: **Trisyllabic words**

| Target | | Children's Productions | Child |
|---|---|---|---|
| Trisyllabic target words | | | |
| masaít | 'truck' | mataí | B1 (1;7.3) |
| baloním | 'balloons' | bayoí | B1 (1;7.3) |
| agalá | 'cart' | agayá | B1 (1;8.7) |
| ʁevitál | 'proper name' | ebitál | B2 (4;0.17) |
| mataná | 'present' | mananá | B2 (4;0.17) |
| | | matanа́ | B1 (1;7.3) |
| aviʁón | 'airplane' | abiʁón | B3 (3;5) |
| galgalím | 'wheels' | dadalí | B1 (1;7.3) |
| sukaʁyá | 'candy' | uayá | B2 (4;0.17) |
| tapúax | 'apple' | tapúax | B1 (1;7.3) |
| banána | 'banana' | banána | B1 (1;8.7) |
| ambátya | 'bath' | abátya | B1 (1;8.7) |
| gavóa | 'tall ms.sg.' | avóa | B2 (4:0.17) |
| caláxat | 'plate' | taláka | B3 (3;11.10) |
| ǰiʁáfa | 'giraffe' | yiápa | B2 (4;0.17) |
| télefon | 'phone' | téyeto | B1 (1;8.7) |
| ámbulans | 'ambulance' | áula | B1 (1;7.3) |
| ótobus | 'bus' | óbabu | B1 (1;7.3) |
| spáydeʁmen | 'Spiderman' | dáydeme | B3 (3;11.10) |
| bégale | 'pretzel' | bébale | B3 (3;5) |
| Quadrisyllabic target words | | | |
| melafefón | 'cucumber' | atetón | B1 (1;9.13) |
| xanukiyá | 'Chanuka lamp' | xakuyá | B1 (1;10.17) |
| ipopotám | 'hippopotamus' | popotám, poputám | B3 (3;10.5) |
| mispaʁáim | 'scissors' | babáim | B2 (3;10.9) |
| ofanóa | 'motorbike' | ofáya | B1 (1;7.3) |
| avatíax | 'watermelon' | abíya | B2 (3;10.9) |
| taʁnególet | 'hen' | sególe | B1 (1;9.13) |

## APPENDIX 3: HEARING AID USERS – THE FINAL STAGE OF PROSODIC WORD DEVELOPMENT

### Target: **quadrisyllabic words** – Production: **quadrisyllabic words**

| Target | | Childrn's Productions | Child |
|---|---|---|---|
| Target words with ultimate stress | | | |
| ipopotám | 'hippopotamus' | ipopotám | B1 (2;11.7) |
| melafefón | 'cucumber' | meyafefón, melafifón | B1 (2;2.7) |
| xanukiyá | 'Chanuka lamp' | kanukiyá | B3 (4;4.19) |
| akoʁdiyón | 'accordion' | akoʁdiyón | B1 (2;6.2) |
| baavodá | 'at work' | baavodá | B1 (2;3.10) |
| mexoniyót | 'cars' | mexoniyót | B1 (2;3.10) |
| agvaniyá | 'tomato' | agvaniyá | B3 (4;6.11) |
| Target words with penultimate stress | | | |
| mixnasám | 'pants' | misasáim | B1 (2:1) |
| mispaʁáim | 'scissors' | mispaʁáim | B1 (2;1) |
| | | mispaʁái | B3 (4;2.22) |
| taʁnególet | 'hen' | taʁnególet | B1 (2;11.7) |
| | | kakególe | B3 (4;2.22) |
| avatíax | 'watermelon' | avátiax | B1 (2;1) |
| miʃkafáim | 'glasses' | mikafáim | B1 (2;1) |
| televízya | 'television' | televíða | B1 (2;11.7) |

## APPENDIX 4: HEARING AID USERS – SIMPLE ONSET

### a. Onsetless words throughout all stages (B2 and B4 productions).

| Target: σ | | Productions | Child | Target: σσ(σσ) | | Productions | Child |
|---|---|---|---|---|---|---|---|
| kos | ‘glass’ | o | B2 (3;5.22) | oxlím | ‘eat ms.pl.’ | oí | B2 (3;4.16) |
| xum | ‘brown’ | u: | B2 (3;5.22) | máim | ‘water | ái | B2 (3;4.16) |
| sus | ‘horse’ | u | B2 (3;6.20) | oxél | ‘eats ms.sg.’ | oé | B2 (3;5.22) |
| pil | ‘elephant’ | i: | B2 (3;8.8) | ugá | ‘cake’ | uá | B2 (3;10.9) |
| xam | ‘hot’ | a | B4 (3;0) | koév | ‘painful’ | oé | B4 2;10.28) |
| li | ‘for me’ | i | B4 (2;10.28) | olím | ‘go up ms.pl.’ | oí | B4 (3;3.24) |
| ʃam | ‘there’ | a | B4 (3:0) | mispaʁáim | ‘scissors’ | ái | B4 (2;10.28) |

σ = Monosyllabic words
σσ(σσ) = Polysyllabic words

### b. Onset preservation in monosyllabic words productions

| Target: σ | | Productions | Child | Target: $\sigma\sigma_s$ | | Productions | Child |
|---|---|---|---|---|---|---|---|
| bay | ‘bye’ | ba: | B1 (1;5.21) | kivsá | ‘sheep’ | ta | B1 (1;5.21) |
| pil | ‘elephant’ | bi:, pi:, pi | B1 (1;5.21) | liʃtót | ‘to drink’ | tot | B2 (3;2.14) |
| po | ‘here’ | po | B2 (3;2.14) | migdál | ‘tower’ | da | B1 (1;5.21) |
| dag | ‘fish’ | da: | B2 (3;2.14) | kadúʁ | ‘ball’ | tu: | B1 (1;5.21) |
| cav | ‘turtle’ | ta | B1 (1;5.21) | axʃáv | ‘now’ | ʃav | B4 (2;9.23) |
| xam | ‘hot’ | xam | B4 (2;9.23) | liʃón | ‘to sleep’ | ʃo | B2 (3;2.14) |
| day | ‘enough’ | day | B4 (2;9.23) | Target: $\sigma_S\sigma$ | | Productions | Child |
| ʃam | ‘there’ | ʃam | B4 (2;9.23) | díyo | ‘ink’ | yo | B4 (3:0) |
| sus | ‘horse’ | tuθ | B2 (3;2.14) | íma | ‘mother’ | ma | B1 (1;5.21) |
| lo | ‘no’ | yo | B4 (2;10.28 | dúbi | ‘teady bear’ | bi | B1 (1;5.21) |

σ = Monosyllabic words
$\sigma\sigma_s$ = Disyllabic words with ultimate stress
$\sigma_s\sigma$ = Disyllabic words with penultimate stress

c. **Onset deletion** in disyllabic words productions for polysyllabic target words.

| Target | | Children's Productions | Child |
|---|---|---|---|
| Ultimate stress | | | |
| kadúʁ | 'ball' | adú | B1 (1;5.21) |
| leát | 'slowly' | eáθ | B1 (1;7.3) |
| limóʁ | 'proper name' | imó | B2 (3;2.14) |
| ʃotá | 'drinks fm.sg.' | otá | B2 (3;2.14) |
| xulcá | 'shirt' | utá | B2 (3;2.14) |
| tinók | 'baby' | ipó | B4 (2;9.23) |
| nigmáʁ | 'finished' | imá | B4 (2;9.23) |
| taím | 'delicious' | aím | B4 (2;10.28) |
| xaláv | 'milk' | alá | B4 (2;10.28) |
| mitá | 'bed' | itá | B2 (3;2.14) |
| simlá | 'dress' | imá | B2 (3;2.14) |
| limón | 'lemon' | imó | B2 (3;2.14) |
| liʃtót | 'to drink' | ipón | B4 (2;10.28) |
| sevivón | 'spinning top' | itó | B3 (3;2.14) |
| Penultimate stress | | | |
| géʃem | 'rain' | éːʃe | B2 (3;2.14) |
| kúmi | 'wake up! fm.sg.' | úmi | B4 (2;10.28) |
| kóva | 'hat' | óba | B2 (3;2.14) |

d. **Onset deletion** in tri- and quadrisyllabic words productions

| Target | | Children's Productions | Child |
|---|---|---|---|
| Ultimate stress | | | |
| mataná | 'present' | ataná | B1(1;7.3) |
| mebulbál | 'confused ms.sg.' | abubá | B1 (1;8.7) |
| sukaʁyá | 'candy' | uyayá | B2 (3;2.14) |
| Penultimate stress | | | |
| yadáim | 'hands' | adái | B4 (3;11) |
| laʃévet | 'to sit' | aʃévet | B4 (3;3.24) |
| banána | 'banana' | enána | B4 (3;4.21) |
| ʁakévet | 'train' | avéve, atéte | B2 (3;5.22) |
| lemála | 'above' | imála | B4 (3;2.19) |
| lemáta | 'below' | imáta | B4 (3;11) |
| yomulédet | 'birthday' | ulédede | B4 (3;8.8) |
| televízya | 'television' | evíða | B2 (3;5.22) |
| gavóa | 'tall ms.sg.' | avóa | B2 (4;0.17) |
| mispaʁáim | 'scissors' | ayái | B1 (1;5.21) |

## APPENDIX 5

### Complex onsets (word initial clusters) in the hearing aid group

a. Obstruent-liquid target clusters

| Target | | Children's productions | Child |
|---|---|---|---|
| pʁaxím | 'flowers' | paxím | B1 (1;8.7) |
| tʁáktoʁ | 'tractor' | káko, táʁtoʁ | B1 (1;9.13) |
| | | yáto, ʃáʃo, táto | B2 (3;7.10) |
| | | ʁákto | B3 (3;5) |
| tʁufá | 'medicine' | tofá | B2 (3;5.22) |
| dli | 'bucket' | gi | B1 (2;1) |
| | | di | B2 (4;10.17) |
| | | li | B3 (3;9) |
| klipá | 'peeling' | kipá | B1 (2;1) |
| glída | 'ice cream' | gída | B1 (1;9.13) |
| | | gída, lída | B3 (3;10.5) |
| | | dída | B2 (4;3.2) |
| ʃlulít | 'puddle' | ʃulí, ʃuí | B2 (3;6.20) |
| kwa | 'frog sound' | wa | B2 (3;2.14) |
| | | wa | B4 (2;9.23) |

b. Obstruent-nasal target clusters

| Target | | Children's productions | Child |
|---|---|---|---|
| tmuná | 'picture' | muná | B1 (2;6.2) |
| smixá | 'blanket' | mixá, sixá | B3 (3;7.17) |
| ʃmóne | 'eight fm.sg.' | móne | B1 (2;6.2) |
| ʃnáim | 'two ms.sg.' | ʃái | B2 (4;0.17) |

c. Obstruent-obstruent target clusters

| Target | | Children's productions | Child |
|---|---|---|---|
| pkak | 'cork' | ka, pa | B3 (3;7.17) |
| psantéʁ | 'piano' | pantéʁ | B1 (2;7.15) |
| | | paʁtéʁ | B3 (4;2.22) |
| dvoʁá | 'butterfly' | voʁá, doʁá | B1 (2;1) |
| | | doá, voá | B2 (3;2.14) |
| dvaʃ | 'honey' | va | B2 (3;7.10) |
| ktaná | 'little fm.sg.' | taná | B2 (4;7.23) |
| kfafót | 'gloves' | kefó, kafót | B3 (3;10.5) |
| kviʃ | 'road' | vi | B3 (3;9) |

| | | | |
|---|---|---|---|
| kxi | ‘take! fm.sg.’ | xi | B1 (1;8.7) |
| gdolá | ‘big fm.sg.’ | goyá | B1 (1;8.7) |
| | | delá | B4 (3;4.21) |
| gvoá | ‘tall fm.sg.’ | guá | B1 (1;10.17) |
| gviná | ‘cheese’ | viná | B2 (4;7.23) |
| spagéti | ‘spaghetti’ | paéti | B2 (4;7.23) |
| spáydeʁmen | ‘Spiderman’ | páydeʁmen | B3 (4;8.6) |
| skétim | ‘roller’ | kétim | B3 (4;8.6) |
| zvuv | ‘butterfly’ | zu, vu | B3 (3;5) |
| ʃtáim | ‘two fm.sg.’ | táim | B1 (2;6.2) |
| | | ʃáim | B2 (3;6.20) |

## APPENDIX 6

a. Codaless production of the hearing aid users

| Target | | Children's Productions | Child |
|---|---|---|---|
| Monosyllabic words | | | |
| dag | 'fish' | ta | B3 (3;5) |
| cav | 'turtle' | ta | B3 (3;5) |
| kos | 'glass' | ko | B3 (3;5) |
| en | 'none' | e: | B1 (1;5.21) |
| od | 'more' | o | B1 (1;5.21) |
| pil | 'elephant' | bi:, pi: | B1 (1;5.21) |
| ʃam | 'there' | ʃa | B2 (3;2.14) |
| sus | 'horse' | tu | B3 (3;5) |
| Penultimate stress | | | |
| máim | 'water' | pái: | B2 (3;2.14) |
| báit | 'home' | bái: | B1 (1;5.21) |
| tíʁas | 'corn' | tíya | B1 (1;5.21) |
| gézeʁ | 'carrot' | géðe | B1 (1;5.21) |
| yéled | 'boy' | yéye | B1 (1;5.21) |
| ʁakévet | 'train' | tatéte | B1 (1;5.21) |
| ʃémeʃ | 'sun' | méme | B1 (1;5.21) |
| éden | 'proper name' | é:ye | B2 (3;2.14) |
| óʁen | 'proper name' | óye | B2 (3;2.14) |
| géʃem | 'rain' | béte | B3 (3;5) |
| péʁax | 'flower' | péʁa | B3 (3;5) |
| Ultimate stress | | | |
| katán | 'little ms.sg.' | katá | B1 (1;5.21) |
| gadól | 'big ms.sg.' | gadó | B1 (1;5.21) |
| patíʃ | 'hammer' | patí | B1 (1;5.21) |
| ʃalóm | 'hello' | ʃayó | B1 (1;5.21) |
| migdál | 'tower' | da | B1 (1;5.21) |
| adóm | 'red' | adó | B2 (3;2.14) |
| kaxól | 'blue' | kaxó | B2 (3;2.14) |
| liʃón | 'to sleep' | ʃo | B2 (3;2.14) |
| limón | 'lemon' | imó: | B2 (3;2.14) |
| naxáʃ | 'snake' | naxá | B3 (3;5) |
| lecán | 'clown' | letá | B3 (3;5) |

b. Long vowels in the hearing aid users

| Target | Children's production | | Target | Children's Production | |
|---|---|---|---|---|---|
| Monsyllabic | | | Polysyllabic | | |
| pil | bi:, pi: | 'elephant' | cipóʁ | ió: | 'bird' |
| xum | u: | 'brown' | matós | mató: | 'airplane' |
| sus | u: | 'horse' | péʁax | péa: | 'flower' |
| dam | da: | 'blood' | yáin | yái: | 'wine' |
| en | e: | 'none' | ʃaón | o: | 'watch' |
| neʁ | de: | 'candle' | máim | mái: | 'water' |
| cav | ta: | 'turtle' | báit | bái: | 'home' |
| dag | da: | 'fish' | kadúʁ | tu:, tadú: | 'ball' |
| oʁ | o: | 'light' | aʁóx | aó: | 'long ms.sg.' |
| kos | ko: | 'glass' | baloním | baloí: | 'balloons' |

c. Coda production in monosyllabic target words.

| Target | | Children's Productions | Child |
|---|---|---|---|
| dag | 'fish' | gaθ | B1 (1;8.7) |
| od | 'more' | od | B1 (1;8.7) |
| ec | 'tree' | eθ | B2 (3;4.16) |
| sus | 'horse' | tuθ | B1 (1;8.7) |
| cav | 'turtle' | θav | B1 (1;8.7) |
| iʃ | 'person' | iʃ | B1 (1;8.7) |
| kos | 'glass' | oθ | B2 (3;4.16) |
| mic | 'juice' | piθ | B2 (3;4.16) |
| eʃ | 'fire' | eʃ | B2 (3;4.16) |
| op | 'hop' | op | B4 (2;10.28) |
| xam | 'hot' | kam | B3 (3;6.5) |
| kof | 'monkey' | koθ | B1 (1;8.7) |
| pil | 'elephant' | piy | B1 (1;8.7) |

d. Coda production in polysyllabic target words

| Target | | Children's Productions | Child |
|---|---|---|---|
| Target words with ultimate stress | | | |
| naxáʃ | 'snake' | maxáθ | B1 (1;8.7) |
| baʁváz | 'duck' | babáð | B3 (3;6.5) |
| gadól | 'big ms.sg.' | gadól | B3 (3;6.5) |
| taím | 'delicious' | taím, aím | B4 (2;10.28) |
| xatúl | 'cat' | xatún | B1 (1;8.7) |
| | | atúθ | B2 (3;4.16) |
| pasím | 'strips' | paθím | B1 (1;8.7) |
| ʃaón | 'watch' | ʃaón | B1 (1;8.7) |

| | | | |
|---|---|---|---|
| pʁaxím | ‘flowers’ | paxím | B1 (1;8.7) |
| xalón | ‘window’ | xayón | B1 (1;8.7) |
| lecán | ‘clown’ | liθán | B1 (1;8.7) |
| limón | ‘lemon’ | imóθ | B2 (3;4.16) |
| katóm | ‘orange’ | atóm | B2 (3;4.16) |
| sevivón | ‘spinning top’ | itóθ | B2 (3;4.16) |
| kadúʁ | ‘ball’ | atúθ | B2 (3;4.16) |
| liʃón | ‘to sleep’ | ʃon | B4 (2;10.28) |
| adóm | ‘red’ | adóm | B1 (1;8.7) |
| galgalím | ‘wheels’ | gagayím | B1 (1;8.7) |
| aviʁón | ‘airplane’ | abiʁón | B3 (3;5) |
| Target words with non-ultimate stress | | | |
| táiʃ | ‘goat’ | táiθ | B1 (1;8.7) |
| báit | ‘house’ | báiʃ | B1 (1;8.7) |
| máim | ‘water’ | máim | B1 (1;8.7) |
| pílpel | ‘pepper’ | pípel | B3 (3;5) |
| ʃémeʃ | ‘sun’ | ʃémeʃ | B1 (1;8.7) |
| mispaʁáim | ‘scissors’ | miθpaʁáim | B1 (1;8.7) |
| péʁax | ‘flower’ | péʁax | B3 (3;5) |
| kélev | ‘dog’ | kéyev | B1 (1;8.7) |

e. Coda production in polysyllabic target words in the penultimate syllable of the words

| Target | | Children's Productions | | Child |
|---|---|---|---|---|
| | | | Coda | |
| zébʁa | 'zebra' | zébʁa | b | B1 (2;11.7) |
| pílpel | 'pepper' | pípel | l | B3 (4;8.6) |
| tʁáktoʁ | 'tractor' | tʁáktoʁ | ʁ | B1 (2;11.7) |
| pásta | 'pasta' | pásta | s | B1 (2;11.7) |
| ámbuʁgeʁ | 'hamburger' | ámbungeʁ | ʁ/n | B1 (2;11.7) |
| baʁváz | 'duck' | baʁbá | ʁ | B1 (2;3.10) |
| paʁpáʁ | 'butterfly' | paʁpáʁ | ʁ | B1 (2;3.10) |
| psantéʁ | 'piano' | pantéʁ | n | B1 (2;11.7) |
| kivsá | 'sheep' | kivθá | v | B1 (2;11.7) |
| aʁyé | 'lion' | aʁyé | ʁ | B1 (2;11.7) |
| oxlím | 'eat ms.pl.' | oxyím | x | B1 (2:1) |
| mazlég | 'fork' | maglé | z/g | B3 (4;8.6) |
| axbáʁ | 'mouse' | axbáʁ | x | B3 (4;8.6) |
| sukaʁyá | 'candy' | sukaʁyá | ʁ | B1 (2;3.10) |

f. Coda deletion in the antepenultimate syllable of the words.

| Tri - and quadrisyllabic target words | | Children's Productions | Coda | Child |
|---|---|---|---|---|
| livyatán | 'whale' | liyatán | v | B1 (2:1) |
| maʁbicím | 'beat ms.pl' | mabisím | ʁ | B1 (2:1) |
| cfaʁdéa | 'frog' | cadéa | ʁ | B1 (2;2.7) |
| mitʁiyá | 'umbrella' | mikiyá | t | B1 (2;2.7) |
| | | piʁiyá | t | B3 (4;6.1) |
| galgalím | 'wheels' | gagayím | l | B1 (2;2.7) |
| taʁnegól | 'rooster' | taegól | ʁ | B1 (2;3.10) |
| kaʁbólet | 'crest' | kabólet | ʁ | B1 (2;3.10) |
| mitgaléʃ | 'slides ms.sg.' | migaléʃ | t | B3 (4;6.1) |
| ámbulans | 'ambulance' | ábulan | m | B3 (4;6.1) |
| ámbuʁgeʁ | 'hamburger' | ábugeʁ | m | B3 (4;6.1) |

## APPENDIX 7

The acquisition of the prosodic word - Profiles of the HA children

| Stage | B1 | T | B2 | T | B3 | T | B4 | T |
|---|---|---|---|---|---|---|---|---|
| Age of HA fitting | 0;6.0 | | 0;4.0 | | 2;8.0 | | 1;0.0 | |
| The initial stage | | | | | | | | |
| Minimal word stage | 1;5-1;7 | 2 | | | 3;2-3;10 | 8 | 2;9-3;2 | 5 |
| Pre final stage | 1;7-2;1 | 6 | 3;5-4;2 | 9 | 3;10-4;2 | 4 | 3;2- | |
| Final stage | 2;1- | | 4;2- | | 4;2- | | Hasn't finished | ??? |
| Total | 1;5-2;1 | 8 | 3;5-4;2 | 9 | 3;2-4;2 | 12 | 2;9- | |

T= the time (in months) between stage n and stage n+1

## APPENDIX 8

a. The segmental profiles of the CI group.

Each segment is considered to be acquired if appears at least twice along the period.
Each period describes the additional segments in comparison to the previous stage

| Stage | A1 - Age | segments | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 1;5-2;2.16 | p,b,m,n,y,w(ʁ) | | | | | |
| 2 | 2;2.16-2;6.21 | p,b, m,n,y(l,ʁ),w(ʁ) | t(c,s),d,θ(s,c) | | | | |
| 3 | 2;6.21-2;8.15 | p,b, m,n,y(l,ʁ),w(ʁ) | t(c,s),d, θ(s,c) | k,g, ħ(x),ʃ | | | |
| 4 | 2;8.15-2;9.12 | p,b,m,n,y(l,ʁ),w | t,d,θ(c) | k,g, ʃ | ʁ,l,f,v,x | | |
| 5 | 2;9.12-3;4.24 | p,b, m,n,y,w | t,d, | k,g, ʃ | ʁ,l,f,v,x | s, ð(z),c | |
| 6 | 3;1.2-3;4.24 | p,b, m,n,y,w | t,d, | k,g, ʃ | ʁ,l,f,v,x | s, ð(z),c | z |

| Stage | A2- Age | segments | | | | |
|---|---|---|---|---|---|---|
| 1 | 1;5.27-1;9.12 | p,b,m,n,y,w | | | | |
| 2 | 1;9.12-2;2.27 | p,b,m,n,y(l,ʁ),w | t(c,s),d,ʃ,θ(s,c),ð(z) | | | |
| 3 | 2;2.27-2;7.24 | p,b,m,n,y(l,ʁ),w | t(c,s),d,ʃ,θ(s,c),ð(z) | k,f,v,x, | | |
| 4 | 2;7.24-2;9.14 | p,b,m,n,y,w | t,d,ʃ,θ(s,c),ð(z) | k,f,v,x | ʁ,l | |
| 5 | 2;9.14-2;11.2 | p,b,m,n,y,w | t,d,ʃ,θ(c),ð(z) | k,f,v,x | ʁ,l | g,s |
| 6 | 2;11.2-3;1.6 | p,b,m,n,y,w | t,d,ʃ,ð(z) | k,f,v,x | ʁ,l | g,s | c |

| Stage | A3 - Age | segments | | | | |
|---|---|---|---|---|---|---|
| 1 | 2;1.4-2;5.24 | p,b,t(k),d(g),m | | | | |
| 2 | 2;5.24-3;0.26 | p,b,t,d,m | n,y(l,ʁ),w,f,v,x,ʃ, | | | |
| 3 | 3;0.26-3;7.11 | p,b,t,d,m | n,y(l,ʁ),w,f,v,x,ʃ | k,g, θ(s,c),ð(z), | | |
| 4 | 3;7.11-4;4.14 | p,b,t,d,m | n,y,w,f,v,x,ʃ | k,g, θ(s,c),ð(z) | ʁ,l | |
| 5 | 4;4.14-4;10.27 | p,b,t,d,m | n,y,w,f,v,x,ʃ | k,g, θ(c),ð(z) | ʁ,l | s |
| 6 | 4;10.27-5;0.16 | p,b,t,d,m | n,y,w,f,v,x,ʃ | k,g | ʁ,l | s | z,c |

| Stage | A4 - Age | segments | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 2;3.23-2;7.13 | b,m,w | | | | | |
| 2 | 2;7.13-3;3.4 | b,m,w | p,t(s),d,k,f,v,ð(z),n,y(l) | | | | |
| 3 | 3;3.4-3;7.28 | b,m,w | p,t(s,c),d,k,f,v,ð(z),n,y(l,ʁ) | g,x,ʃ | | | |
| 4 | 3;7.28-3;11.7 | b,m,w | p,t(s,c),d,k,f,v,ð(z),n,y(ʁ) | g,x,ʃ | l | | |
| 5 | 3;11.7-4;5.3 | b,m,w | p,t(s),d,k,f,v,ð(z),n,y | g,x,ʃ | l | ʁ | |
| 6 | 4;5.3-4;11.5 | b,m,w | p,d,k,f,v,n,y | g,x,ʃ | l | ʁ | s,z,c |

| Stage | A5 - Age | segments | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 1;11.20-2;1.22 | b,m,w | | | | | |
| 2 | 2;1.22-2;8.2 | b,m,w | p,t(c,ʃ,s),d,k,θ(s),ð(z),ʃ n,y,l | | | | |
| 3 | 2;8.2-3;1.14 | b,m,w | p,t(c,ʃ,s),d,k,θ(s),ð(z),ʃ n,y, l(ʁ) | g,f,v, | | | |
| 4 | 3;1.14-3;4.0 | b,m,w | p,t(c,ʃ,s),d,k,θ(s),ð(z),ʃ n,y,l | g,f,v | ʁ,s | | |
| 5 | 3;4.0-3;8.20 | b,m,w | p,t(c,ʃ,s),d,k,θ(s),ð(z),ʃ n,y,l | g,f,v | ʁ,s | z | |
| 6 | 3;8.20-4;2.24 | b,m,w | p,t(c,ʃ,s),d,k,θ(s),ð(z),ʃ n,y,l | g,f,v | ʁ,s | z | c,x |

| Stage | A6- Age | segments | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 2;8.12-3;1.16 | t,k,m,w,y | | | | | |
| 2 | 3;1.16-3;10.8 | t,k,m,w,y | p,b,d,x,ħ(x),ʃ,θ(s,c),ð(z) n,y(l) | | | | |
| 3 | 3;10.8-4;4.21 | t,k,m,w,y | p,b,d,x,ħ(x),ʃ,θ(s,c),ð(z) n,y(l) | s | | | |
| 4 | 4;4.21-4;7.22 | t,k,m,w,y | p,b,d,x,ʃ,θ(s,c),ð(z) n,y | s | f,v,l | | |
| 5 | 4;7.22-4;10.7 | t,k,m,w,y | p,b,d,x,ʃ,θ(s,c),ð(z) n,y | s | f,v,l | g,ʁ | |
| 6 | 4;10.7-5;6.9 | t,k,m,w,y | p,b,d,x,ʃ,n,y | s | f,v,l | g,ʁ | c,z |

b. The segmental profiles of the HA group.

Each segment is considered to be acquired if appears at least twice along the period.
Each period describes the additional segments in comparison to the previous stage

| Stage | B1 - Age | segments | | | |
|---|---|---|---|---|---|
| 1 | 1;5.21-1;8.7 | p,b,m,n,k,g,d(v),x,t(f),θ(s,c),ð(z),y(l,ʁ) | | | |
| 2 | 1;8.7-1;10.17 | p,b,m,n,k,g,d(v),x,t(f),θ(c),ð(z),y(ʁ) | ʃ,l,s | | |
| 3 | 1;10.17-2;0 | p,b,m,n,k,g,d,x,t(f),θ(c),ð(z),y | ʃ,l,s | v,ʁ | |
| 4 | 2;0-2;11.7 | p,b,m,n,k,g,d,x,t(f),ð(z),y | ʃ,l,s | v,ʁ | c,z |

| Stage | B2- Age | segments | | | |
|---|---|---|---|---|---|
| 1 | 3;2.14 | p,b,m,t,d,y(l,ʁ),t(c),d,ʃ | | | |
| 2 | 3;4.16-3;7.10 | p,b,m,t(k),d,y(l,ʁ),t(c),d,ʃ | θ(s),ð(z),v,l,n | | |
| 3 | 3;7.10-4;8.26 | p,b,m,t(k),d,y(l,ʁ),t(c),d,ʃ | ð(z),v,l,n | f,g,s | |
| 4 | 4;8.26 | p,b,m,t(k),d,y(l,ʁ),t(c),d,ʃ | ð(z),v,l,n | f,g,s | k,x(ʁ) |

| Stage | B3 - Age | segments | | | |
|---|---|---|---|---|---|
| 1 | 3;5-3;6.5 | p,b,m,n,t(s,c),d,k,g,x,l,ʁ,y | | | |
| 2 | 3;6.5-3;10.5 | p,b,m,n,t(s,c),d,k,g,x,l,ʁ,y | f,v | | |
| 3 | 3;10.5-4;8.6 | p,b,m,n,t(s,c),d,k,g,x,l,ʁ,y | f,v | ʃ | |
| 4 | 4;8.6 | p,b,m,n,t(c),d,k,g,x,l,ʁ,y | f,v | ʃ | s,z |

| Stage | B4 - Age | segments | | |
|---|---|---|---|---|
| 1 | 2;9.23-3;2.19 | p,b,m,t(c),d,l,ʃ,v,y,w,θ(s),ð(z) | | |
| 2 | 3;2.19-3;11 | p,b,m,t(c),d,l,ʃ,v,y,w,θ(s),ð(z) | x(k),f,n | |
| 3 | 3;11 | p,b,m,t(c),d,l,ʃ,v,y,w,θ(s),ð(z) | x,f,n | k,g |

## REFERENCES

Abraham, S. 1989. Using a phonological framework to describe speech errors of orally trained hearing impaired school-agers. *Journal of Speech and Hearing Disorders,* 54. 600-609.

Adam, G. 2002, *From variable to optimal grammar: Evidence from language acquisition and language change*. Ph.D. dissertation, Tel-Aviv University.

Adam, G. 2003, *The prosody-morphology interface in the acquisition of Hebrew verbs.* A paper presented at the 2003 Child Phonology Conference. University of British Columbia.

Adam, G., and Bat-El, O. 2000. *Morphological knowledge without morphological structure: The emergence of inflectional suffixes in the acquisition of Hebrew verbs.* A paper presented in a workshop on Phonology and Prosodic Morphology of Semitic Languages. Tel-Aviv University.

Adi-Bensaid, L., and Bat-El, O. 2004. The development of the prosodic word in the speech of a hearing-impaired child with a cochlear implant device*. Journal of Multilingual Communication Disorders,* 2, 187-206.

Allen, G., and Hawkins, S. 1980, Phonological rhythm: Definition and development. In: G.H. Yeni-Komshian, J.F. Kavanagh, and C.A. Ferguson (eds) *Child Phonology* v.I. New York: Academic Press. pp. 227-56.

Amir, O. 1995. *Acoustic measurments of the modern Hebrew vowel system*. M.A. thesis, Department of Communication Disorders, Speech, Language and Hearing, Sackler Faculty of Medicine, Tel-Aviv University. [in Hebrew].

Andrew, N., and Fey, M. 1986. Analysis of the speech of phonologically impaired children in two sampling conditions. *Language, Speech, and Hearing Services in Schools,* 17, 187-198.

Apuzzo, M., and Yoshinaga-Itano, C. 1995. Early identification of infants with significant hearing loss and the Minnesota Child Development Inventory. *Seminars in Hearing,* 16, 124-139.

Barkai, M., and Horvath, J. 1978. Voicing Assimilation and the Sonority Hierarchy: Evidence from Russian, Hebrew and Hungarian. *Linguistics*, 212, 77-88.

Barlow, J.A. 1997. The representation of on-glides in American English: Evidence from phonologically disordered systems. *Indian University Linguistics Club Publications,* 25-44.

Barlow, J.A. 2001. Case study: Optimality Theory and the assessment and treatment of phonological disorders. *Language, Speech, and Hearing Services in Schools*, 32, (4), 242-256.

Barlow, J.A., and Dinnsen, D.A. 1998. Asymmetrical cluster development in a disordered system. *Language Acquisition,* 7, 1-49.

Barlow, J.A., and Gierut, J.A. 1999. Optimality theory in phonological acquisition. *Journal of Speech, Language, and Hearing Research,* 42, 1482-1498.

Barton, D., Miller, R., and Macken, M. 1980. Do children treat clusters as one unit or two? *Papers and Reports on Child Language Development,* 18, 105-137.

Bat-El, O. 1989. *Phonology and Word Structure in Modern Hebrew.* Ph.D Dissertation, UCLA.

Bat-El, O. 1993. Parasitic metrification in Modern Hebrew stress system. *The Linguistic Review,* 10,, 189-210.

Bat-El, O. 1994. Stem modification and cluster transfer in Modern Hebrew. *Natural language and Linguistic Theory,* 12, 571-596.

Bat-El, O. 2002. Semitic verb structure with universal prespective. In J. Shimron (ed.). *Language, Processing, and language Acquisition in a Root-based Morphology.* Amsterdam: John Benjamins.

Bat-El, O. 2005. The emergence of the trochaic foot in Hebrew hypocoristics. *Phonology* 22, 1-29.

Becker, M. 2003. Hebrew Stress: can't you hear those Trochees? *University of Pennsylvania working papers in Linguistics,* 9, 45-57.

Beers, M. 1993. *Development of consonant clusters in Dutch.* Paper presented at the Sixth International Congress for the Study of Child Language, Trieste, Italy.

Beers, M. 1995. *The phonology of normally developing and language-impaired children.* Amsterdam: IFOTT.

Ben-David, A. 2001, *Language acquisition and Phonological Theory: Universal and Variable Processes Across children and Across Languages*. Ph.D. dissertation, Tel-Aviv University [in Hebrew].

Ben-David, A. 2006. On the Acquisition of Hebrew #sC Onsets. A paper presented at the International Phonetics and Linguistics Association Meeting, Dubrovnik, Croatia.

Ben-Zvi, G. 1991. *The articulation of the sibilants segments - comparison between Kibbutz's children and city's children.* Unpublished thesis. Tel-Aviv University. Tel-Aviv. [in Hebrew].

Berg, T. 1992. Phonological Harmony as a processing problem. *Journal of Child Language,* 19, 225-257.

Berman, R.A. 1977. Natural phonological processes at the one-word stage. *Lingua,* 43, 1-21.

Berman, R.A. 1978. *Modern Hebrew Structure*. Tel Aviv: Universities Publishing Projects.

Bernhardt, B. H., and Stemberger, J.P. 1998. *Handbook of Phonological Development from the Perspective of Constraint-Based Nonlinear Phonology*. San Diego: Academic Press.

Bernhadt, B. H., and Holdgrafer, G. 2001a. Beyond the Basics I : the need for strategic sampling for In-depth Phonological Analysis. *Language, Speech, and Hearing Services in Schools,* 32, 18-27.

Bernhadt, B. H., and Holdgrafer, G. 2001b. Beyond the Basics II : Supplemental Sampling for In-depth Phonological Analysis. *Language, Speech, and Hearing Services in Schools,* 32, 28-37.

Bernthal, J.E, and Bankson, N.W. 1988. *Articulation and phonological Disorders*. New Jersey: Prentice Hall.

Bess, F.H., and Humes, L.E. 1990. *Audiology: The Fundamentals*. Chapter 8. Second Edition. Williams and Willkins.

Binnie, C.A., Daniloff, R.G. and Buckingham, H.W. 1982. Phonetic disintegration in a five-year-old following sudden hearing loss. *Journal of Speech and Hearing Disorders,* 47, 181-189.

Blamey, P.J., Barry, J.G., and Jacq, P. 2001a. Phonetic Inventory development in young cochlear implant users 6 years postoperation. *Journal of Speech, Language, and Hearing Research,* 44(1), 73-79.

Blamey, P., Barry, J., Bow C., Sarant, J., Paatsch, L., and Wales, R. 2001b. The development of speech production following cochlear Implantation. *Clinical Linguistics and Phonetics,* 15, 5, 363-382.

Bloch, V. 1996. *Children's phonological development: The importance of Roman Jacobson.* Omslag, Denemark: Audio-logopædisk Forening.

Bolozky, S. 1972. *Categorial Limitations on Rules in the Phonology of Modern Hebrew.* PhD Dissertation, University of Illinois.

Bolozky, S. 1978. Some aspects of Modern Hebrew phonology. In R.A. Berman(Ed.), *Modern Hebrew Structure* (pp. 11-67). Tel-Aviv: Universities publishing projects.

Bolozky, S. 1982. Remarks on Rhythmic Stress in Modern Hebrew. *Journal of Linguistics* 18, 275-289.

Bolozky, S. 1990. On marking the vowels a and e and on marking the absence of a vowel in Modern Hebrew orthography. *Lashon ve Ivrit* 5, 34-37. [in Hebrew].

Bolozky, S. 1997. Israeli Hebrew Phonology. In A. S. Kaye & P. Daniels (eds.), *Phonologies of Asia and Africa* 1. Winona Lake: Eisenbrauns. 287-311.

Bolozky, S. 1999. On the Special Status of the Vowels a and e in Israeli Hebrew. *Hebrew Studies* 40, 233-250.

Bonnatti, L.L., Peña, M., nespor, M., and Mehler, J. 2005. Linguistic Constraints on Statistical Computations: The Role of Consonants and Vowels in Continuous Speech Processing. *Psychological Science*, 16, , 451-459.

Boothroyd, A., Nickerson, R., and Stevens, K. 1974. *Temporal patterns in the speech of the deaf – a study in remedial training.* Northampton, MA: Clarke School for the Deaf.

Boothroyd, A. 1998. The perception of speech by hearing impaired children. In Weizel, A. (Ed.). *Issues unresolved: New prespectives on language and deaf education.* Washington, D.C.: Gallaudet University Press, 103-116.

Borden, G.J. 1979. An interpretation of research on feedback interruption in speech. *Brain and Language*, 7, 307-319.

Bortolini, U., and Leonard, L.B. 1991. The speech of phonologically disordered children acquiring Italian. *Clinical Linguistics and Phonetics,* 5, 1-12.

Boysson-Bardies, B.D. 1996. *Comment la parole aux enfants.* Paris: Eitions odile Jacob.

Carney, A.E. and Moeller, M.P. 1998. Treatment efficacy: hearing loss in children. *Journal of Speech, Language, and Hearing Research,* 41, S61-S84.

Carter, A. and Gerken, L. 1998. Evidence for adult prosodic representations in weak syllable omissions of Young Children. In Clark, E.V. (Ed): *The Proceedings of the twenty-ninth Annual Child Language Research Forum. Pub for the standford linguistics Association by the center for the study of Language and Information*. pp. 101-109.

Carter, A.K., Dillon, M., and Pisoni, D.B. 2002. Imitation of nonwords by hearing impaired children with cochlear implants: suprasegmental analyses. *Clinical Linguistics and Phonetics,* 16, 619-638.

Chayen, M.J. 1973. *The phonetics of Modern Hebrew*. The Hague: Mouton and Co. N.V. Publishers.

Chervela, N. 1981. Medial consonant cluster acquisition by Telugu children. *Journal of Child Language,* 8, 63-73.

Chin, S.B. 1996. The role of the sonority hierarchy in delayed phonological systems. In T.W. Powell (Ed.), *Pathologies of Speech and Language*. New Orleans: ICPLA.

Chin, S.B. 2003. Children's Consonants inventories after Extended Cochlear Implant Use. *Journal of Speech, Language, and Hearing Research,* 46, 849-862.

Chin, S.B., and Dinssen, D.A. 1992. Consonant clusters in disordered speech: Constraints and correspondence patterns. *Journal of Child Language,* 19, 259-285.

Chin, S.B., and Pisoni, D. 2000. A phonological system at 2 years after coclear Implantation. *Clinical Linguistics and Phonetics,* 14, 1, 53-73.

Chin, S.B., and Kaiser, C.L. 2002. Measurment of articulation in pediatric users of cochlear implants. *The Volta Review*, 102, 145-156.

Chin, S.B., and Finnegan, K.R. 2002. Consonant Cluster Production by Pediatric Users of Cochlear Implants. *The Volta Review*, 102, 157-174.

Chin, S.B., Tsai, P.L. and Gao, S. 2003. Connected speech intelligibility of children with cochlear implants and children with normal hearing. *American Journal of Speech Language Pathology*, 12, 440-451.

Cleary, M., Pisoni, D.B., and Kirk, K.I. 2002. Working Memory Spans as Predictors Of Spoken Word recognition and Receptive Vocabulary in Children with Cochlear Implants. *The Volta Review,* 102, 259-280.

Clements, G.N. 1985. The geometry of phonological features. In C. Ewen, & E. Kaisse (Eds.). *Phonology Yearbook,* 2, 225-252.

Clements, G.N. 1990. The role of sonority cycle in core syllabification. In J. Kingston and M. Beckman (Eds.), *Papers in laboratory phonology I: Between the grammar and physics of speech* (pp. 283-333). Cambridge, MA.: Cambridge University Press.

Clements, A., and Fee, J. 1994. An Intra-Twin Phonological study: The phonologies f an SLI Twin and Her Normally Developing Brother. *First Language*, 14, 213-231.

Clements, G.N. and Keyser, S.J. 1983. *CV phonology: A generative theory of the syllable*. Cambridge, MA.: MIT Press.

Compton, A.J., 1970. Generative studies of children's phonological disorders. *Journal of Speech and Hearing Disorders,* 35, 315-339.

Costa, J., and Freitas, M.J. 1998. *V and CV as unmarked syllables: Evidence from the acquisition of Portuguese.* A paper presented at the Conference on Syllable Typology and Theory. Universidade de Lisboa.

Cruttenden, A. 1978. Assimilation in child language and elsewhere. *Journal of Child Language*, 5, 373-378.

Demuth, K. 1994. On the ‘underspecification’ of functional categories in early grammar. In: B. Lust, M. Suñer, and J. Whitman (eds) *Syntactic Theory and First Language Avquisition: Cross-Linguistic Perspectives*. Hillsdale, N.J.: Lawrence Erlbaum. pp. 119-134.

Demuth, K. 1995. Markedness and development of prosodic structure. In: J. Beckman (ed.) *Proceedings of the North East Linguistic Society* 25, pp. 13-25.

Demuth, K. 1996a. Stages in the development of prosodic words. In E. Clarck (Ed.) *Proceedings from the 27th Child Language Research forum*. Stanford University, CSLI. California.

Demuth, K. 1996b. The prosodic structure of early words. In J. L. Morgan and Demuth (eds) *Signal to Syntax: Boot-strapping from Speech to Grammar in Early Acquisition*. Mahwah, NJ: Lawrence Erlbaum Associates, pp. 171-184.

Demuth, K. 2001. Prosodic constraints on morphological development. In: J. Weissenborn and B. Höhle (eds.) *Approaches to Bootstrapping: Phonological, Syntactic and Neurophysiological Aspects of Early Language Acquisition.* Amsterdam: John Benjamins. 3-21.

Demuth, K. 2003. *Minimal and maximal words in early French.* A poster presented at the 2003 Child Phonology Conference. University of British Columbia.

Demuth, K., and Fee, E.J. 1995. *Minimal prosodic words in early phonological development*. Ms., Brown University and Dalhousie University.

Demuth, K., and Johnson M. 2003. *Truncation to subminimal words in early French*. Ms., Brown University.

Dinnsen, D., and Elbert, M. 1984. On the relationship between phonology and learning. In M. Elbert, D. Dinnsen, and G. Weismer (eds.). *Phonological theory and the misarticulating child* (pp. 59-68). (ASHA Monographs, 22). Rockville, MD: American Speech-Language-Hearing Association.

Dinssen, D.A., Chin, S.B., Elbert, M., and Powell, T. 1990. Some constraints on functionally disordered phonologies: phonetic inventories and phonotactics. *Journal of Speech and Hearing Research,* 33, 28-37.

Dodd, B. 1976. The phonological systems of deaf children. *Journal of Speech and Hearing Disorders,* 41, 185-198.

Dodd, B. 1995. Children’s acquisition of phonology. In B.Dodd (Ed.), *Diffrential diagnosis and treatment of speech disordered children* (pp. 21-48). London: Whurr.

Dodd, B.J., and So, L.K.H. 1994. The phonological abilities of Cantonese-speaking children with hearing loss. *Journal of Speech and Hearing Research,* 37, 671-679.

Dodd, B., Holm, A., Hua, Z., and Crosbie, S. 2003. Phonological development: a normative study of British English-speaking children. *Clinical Linguistics and Phonetics,* 17, 617-643.

Dore, J., Franklin, M.B., Miller, R.T., and Ramer, A.L.H. 1976. Transitional phenomena in early language acquisition. *Journal of Child Language,* 3, 13-28.

Dromi,. E. 1987. *Early lexical development.* London: Cambridge University Press

Dyson, A.T., and Paden, E.P. 1983. Some phonological acquisition strategies used by two-year-olds. *Journal of Childhood Communication Disorders*, 7, 6-18.

Dyson, A.T. 1988. Phonetic inventories of 2- and 3-year old children. *Journal of Speech and Hearing Disorders,* 53, 89-93.

Echols, C.H. 1987. *A perceptually-based model of children's first words*. PhD. Dissertation, University of Illinois.

Echols, C.H. 1988. The role of stress, position and intonation in the representation and identification of early words. *Papers and Reports on Child Language Development,* 27, 39-46.

Echols, C.H., and Newport, E. 1992. The role of stress and position in determinig first words. *Language Acquisition*, 2, 189-220.

Elbert, M. and Gierut, J. 1986. *Handbook of Clinical Phonology*, san-Diego, CA: College-Hill Press.

Ertmer, D.J. 2001. Emergence of a Vowel System in a Young Cochlear Implant Recipient. *Journal of Speech, Language, and Hearing Research,* 44, 803-813.

Ertmer, D.J., and Mellon, J.A. 2001. Beginning to talk at 20 Months: Early Vocal Development in a Young Cochlear Implant Recipient. *Journal of Speech, Language, and Hearing Research,* 44, 192-206.

Ertmer, D.J., Young, N., Grohne, K., Mellon, J., Johnson, C., Corbett, K., and Saindon, K. 2002a. Vocal Development in Young Children with Cochlear Implants: Profiles and Implications for Intervention. *Language, Speech, and Hearing Services in Schools,* 33, 184-195.

Ertmer, D.J., Leonard, J.S., and Pachuilo, M.L. 2002b. Communication Intervention for Children with Cochlear Implants: Two Case studies. *Language, Speech, and Hearing Services in Schools,* 33, 205-217.

Faingold, E.D. 1990. Acquisition of syllable and word structure: individual differences and universal constraints. *Language Sciences*, 12, 101-113.

Fee, E.J. 1995. The phonological system of a specifically language-impaired population. *Clinical Linguistics and Phonetics*, 9, 3, 189-209.

Fee, E.J. 1997. The Prosodic Framework for Language Learning. *Topics in Language Disorders,* 17, 53-62.

Fenson, L., Dale, P.S., Reznick, S., Thal, D., Bates, E., Hartung, J.P., Pethick, S., and Reilly, J.S. 1993. *MacArthur Communicative Development Inventories: user's guide and technical manual*. San Diego, CA: Singular Publishing Group.

Ferguson, C.A. 1978. Learning to pronounce: The earliest stages of phonological development in the child. In F.D. Minifie and L.L. Lloyd (Eds.), *Communication and early cognitive abilities: Early behavioral assessment* (pp.273-297). Baltimore: University Press.

Fikkert, P. 1994. *On the Acquisition of Prosodic Structure*. The Hague: Holland Academic Graphics.

Fikkert, P., and Freitas, M.J. 1997. Acquisition of syllable structure constraints: evidence from Dutch and Portuguese. In A. Sorace, C. Heycock, and R. Shillcock (Eds.), *Proceedings of the GALA '97 Conference on Language Acquisition* Edinburgh.

Fox, A.V., and Dodd, B.J. 1999. Der Erwerb des phonologischen systems in der deutschen Sprache [The acquisition of phonology in German-speaking children]. *Sprache-Stimme-Gehör,* 23, 183-191.

Frank, Y., Bergman, M., and Tobin, Y. 1987. Stress and intonation in a speech of hearing-impaired Hebrew-speaking children. *Language and Speech* 30, 339-356.

Freitas, M.J. 1996. Onsets in early productions. In: B. Bernhardt, J. Gilbert, and D. Ingram (Eds), *Proceedings of the UBC International Conference on Phonological Acquisition.* Somerville: Cascadilla Press. pp. 76-85.

Freitas, M.J. 1999. *Syllabic constituency and segmental emergence: Evidence from the acquisition of European Portuguese*. Paper presented as IASCL' 99, San Sebastian.

Fryauf-Bertschy, H., Tyler, R.S., Kelsay, D.M.R., and Gantz, B.J. 1992. Performance over time of congenitally deaf and postlingually deafened children using a multi-channel cochlear implant. *Journal of Speech and Hearing Research,* 35, 913-920.

Gabay, U. 1996. *The acquisition of the sibilants s and ʃ - A comparison between Hebrew-speaking children and English-speaking children.* Unpublished master's thesis. Tel-Aviv University. Tel-Aviv. [in Hebrew].

Garrett, S. 1998. Positional faithfulness in child speech. In: P. Tamanji, and K. Kusumoto, (eds) *Proceedings of the North East Linguistic Society* 28, pp. 63-76.

Geers, A.E., and Moog, J.S. 1992. Speech perception and production skills of students with impaired hearing from oral and total communication education settings. *Journal of Speech, and Hearing Research,* 35, 1384-1393.

Geers A.E., and Tobey, E. 1992. Effects of cochlear implants and tactile aids on the development of speech production skills in children with profound hearing impairment. *The Volta Review*, 94, 135-163.

Gerken, L. 1991. The metrical basis of children's subjectless sentences. *Journal of Memory and Language,* 30, 431-451.

Gerken, L. 1994. A metrical account of children's weak syllable omissions from multisyllabic words. *Journal of Child Language* 21, 565-584.

Gerken, L. 1996. Prosodic structure in young children's language production. *Language*, 72, 683-712.

Gierut, J.A. 1999. Syllable Onsets II: Clusters and Adjuncts in Acquisition. *Journal of Speech, Language, and Hearing Research,* 42, 708-726.

Gilbers, D. and Den-Ouden, D.B. 1994. Compensetory lengthening and cluster reduction in first language acquisition. *Language and Cognition 4*. University of Groningen. 69-82.

Gillis, S., Schauwers, K., Govaerts, P.J. 2002. Babbling Milestones and Beyond: Early Speech Development in CI Children. *Antwerp papers in Linguistics,* 102, 23-39.

Gnanadesikan, A.E. 1995. *Markedness and faithfulness constraints in child phonology.* Ms. University of Massachusetts, Amherst. [ROA-67, http://roa.rutgers.edu].

Goad, H. 1993. *On the configuration of height features.* Doctoral dissertation, University of Southern California.

Goad, H. 1997. Consonant harmony in child language: An optimality-theoretic account. In S.J. Hannahs and Martha Young-Scholten (eds). *Focus on phonological acquisition.* Benjamins, pp. 113-142.

Goad, H. 1998. On the status of final consonants in early child language. *Proceedings of the 22th Annual Boston University Conference on Language Development.* Ed. By Greenhill Annabel, Mary Hughes, Heather Littlefield, and Hugh Walsh, 269-280. Sommerville, MA: Cascadilla Press.

Goad, H. 2001. Assimilation Phenomena and Initial Constraint Ranking in Early Grammars. *Proceedings of the Annual Boston University Conference on Language Development,* 25, 1, 307-318

Goad, H., and Rose, Y. 2000. Headness versus Sonority in Cluster Reduction. CLS 6: *The Main Session*, 109-123.

Goad, H., and Rose, Y. 2001. Input elaboration, Head faithfulness and evidence for representation in the acquisition of left-edge clusters in West Germanic. In R. Kager, J. Pater and W. Zonneveld (Eds.), *Fixing priorities: Constraints in phonological acquisition.* CUP.

Gold, T. 1980. Speech production in hearing impaired children. *Journal of Communication Disorders,* 13, 397-418.

Goldstein, B., and Cintron, P. 2001. An Investigation of Phonological Skills in Puerto Rican Spanish Speaking 2-year olds. *Clinical Linguistics and Phonetics*, 15, 5, 343-361.

Govaerts, P.J., Schauwers, K., and Gillis, S. 2002. Language acquisition in very young children with a cochlear implant. *Antwerp papers in Linguistics,* 102, 1-10.

Graf, D. 2001. Stress assignment in the nominal system of Modern Hebrew. [ROA-443, http://roa.rutgers.edu].

Graf, D., and Ussishkin, A. 2001. Emergent Iambs: Stress in Modern Hebrew. *Lingua*, 113, 239-270

Grijzenhout, J. and Joppen, S. 1998. *First step in the acquisition of German phonology: A case study*. Ms., heinrich-Heine University, Düsseldorf.

Grijzenhout, J., and Joppen, S. 1999. First steps in the acquisition of German phonology: a case study. *[ROA-304, http://roa.rutgers.edu]*.

Grijzenhout, J., and Joppen, S. (to appear). The lack of onsets in German child phonology. In L. Ingeborg (Ed.), *The process of language acquisition.* Berlin/Frankfurt am Main: Peter Lang Verlag.

Grunwell, P. 1985. *Phonological Assesment of Child Speech.* San-Diego, CA: College-Hill Press.

Hammes, D.M., Novak, M.A., Rotz, L.A., Willis, M., and Edmondson, D.M. 2002. Early identification and cochlear implantation: Critical factors for spoken language development. *Annals of Otology, Rhinology and Laryngology, Supplement,* 189, 74-78.

Hart, B., and Risely, T. 1995. *Meaningful differences in the everyday experiences of young American children.* Baltimore: Paul H. Brooks Publishing.

Hayes, B. 1986. Inalterability in CV phonology. *Language* 62, 321-351.

Hayes, B. 1989. Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20, 253-306.

Hayes, B. 1995. *Metrical Stress Theory*. Chicago: The University of Chicago Press.

Hooper (Bybee), J.L. 1976. *An Introduction to Natural Generative Phonology*. New-York: academic Press.

Horsley, T. 1995. *Spontaneous and imitated utterances of children with phonological disorders*. Unpublished master's thesis. University of British Colombia, Canada.

Hudgins, C., and Numbers, F. 1942. An investigation of the intelligibility of the speech of the deaf. *Genetical Psychology Monograph*, 25, 289-392.

Huttunen, K.H. 2001. Phonological development in 4-6 year old moderately hearing Impaired children. *Scandinavian Audiology,* Supp., l 53, 79-82.

Huttunen, K.H., and Sorri, M. 2004. Methodological aspects of assessing speech inteligibility among children with impaired hearing. *Acta Oto-Laryngologica,* 124, 4, May, 490-494

Hyman, L. 1985. *A Theory of Phonological Weight*. Dordrecht: Foris.

Ingram, D. 1971. Phonological rules in young children. *Pap. Rep. Child Language Development,* 3, Standford university.

Ingram, D. 1974. Phonological rules in young children. *Journal of Child Language*, 1, 49-64.

Ingram, D. 1976. *Phonological disability in children*. London: Edwards Arnold.

Ingram, D. 1989. *First language acquisition. Method, description and explanation.* Cambridge University Press.

Ingram, J.C.L., Pittam, J., and Newman, D. 1985. Developmental and Sociolinguistic variation in the speech of Brisbane school children. *Australian Journal of Linguistics,* 5, 233-246.

Jackobson, R. 1968. *Child Language, Aphasia and Phonological Universals.* The Hague: Mouton.

Jedwab, D. 1975. *An articulation test as a prognostic tool for functional articulation disorders in children ages 6-8.* Unpublished master's thesis. Tel-Aviv University. Tel-Aviv. [in Hebrew].

Jeperson, O. 1922. *Language: Its Nature, Development and Origin*, W.W. Norton, New-York.

Johnson, J.S., and Salidis, J. 1996. The shape of early words: A prosodic developmental analysis. *Proceedings of the Annual Boston University Conference on language development,* 20 (1)*,* 386-396.

Kager, R. 1999. *Optimality theory*. Cambridge, MA: Cambridge University Press.

Kappa, I. 2002. On the acquisition of syllabic structure in Greek. *Journal of Greek Linguistics* 3, 1-52.

Katz, J. 2002. *Handbook of Clinical Audiology.* Associate Editors: Burkard, R.F. and Larry M. Philadelphia : Lippincott Williams & Wilkins

Kaye, J., Lowenstamm, J., and Vergnaud, J.R. 1990. Constituent structure and government in phonology. *Phonology,* 7, 193-231.

Kehoe, M., and Stoel-Gammon, C. 2001. Development of syllable structure in English speaking children with particular reference to rhymes. *Journal of Child Language,* 28, 392-432.

Kehoe, M., and Lleó, C. 2003. The acquisition of nuclei: A longitudinal analysis of phonological vowel length in three German-speaking children. *Journal of Child Language,* 30, 527-556.

Kenstowicz, M. 1994. *Phonology in Generative Grammar*. Cambridge, MA: Blackwell.

Kent, R.D., Osberger, M.J., Netsell, R., and Hustedde, C.G. 1987. Phonetic Development in identical twins differing in auditory function. *Journal of Speech and Hearing Disorders*, 52, 64-75.

Kent, R.D., Weismer, G., Kent, J.F., and Rosenbek, J.C. 1989. Toward phonetic intelligibility testin of dysarthria. *Journal of Speech and Hearing Disorders,* 54, 482-499.

Kirk, K.I., and Hill-Brown, C. 1985. Speech and language results in children with a cochlear implant. *Ear and Hearing*, 6 (Suppl.), 36S-47S.

Kirk, K.I., Diefendort, E., Riley, A., and Osberger, M.J. 1995. Consonant production by children with multichannel cochlear implants or hearing aids. *Advances in Oto-Rhino-Laryngology*, 50, 154-159.

Kirk, K.I., Miyamoto, R.T., Lento, C.L., Ying, E., O'Neill, T., and Fears, B. 2002a. Effects of age at implantation in young children. *Annals of Otology, Rhinology and Laryngology,* 111, 69-73.

Kirk, I.K., Miyamoto, R.T., Ying, E.A., Perdew, A.E., Zuganelis, H. 2002b. Cochlear Implantation in Young Children: Effects of Age at Implantation and Communication Mode. *The Volta Review,* 102, 127-144.

Kopkalli-Yavuz, H., and Topbas, S. 1988. Phonological processes of Turkish phonologically disordered children: Language specific or universl? In W. Ziegler and K. Deger (Eds.), *Clinical Phonetics and Linguistics* (pp. 88-97). London: Whurr.

Kretschmer, R.R., and Kretschmer, L.W. 1978. *Language development and intervention with the hearing impaired.* Baltimore: University Park Press.

85-141.

Kuel, P.K. 2000. A new view of language acquisition. *Proceedings of the National Academy of Sciences* 97, 11850-11857.

Ladefoged, P. 1991. *A Course in Phonetics*. Third Edition. San Diego : Harcourt Brace College Publishers.

Laufer, A. 1984. *Torat hahege ʃel haivrit haxadaʃa* (units 5-7). Hauniversita Haptuxa. [in Hebrew].

Laufer, A. 1990. Hebrew. *Journal of the International Phonetic Association*. 20, 40-43.

Laufer, A. 1991. Cirufey fonemot-fonetica. In M., Goteshtein, S., Morag, and S., Kogot, (Eds.). *ʃay lexaim rabin, asufat mexkarey laʃon,* 179-193. Jerusalem: Ivrit University. [in Hebrew].

Laufer, A. 1992. *Mavo lebalʃanut: fonetika vefonologya* (units 4-5). Hauniversita Haptuxa. [in Hebrew].

Lavie, S. 1978. *Norms of the Hebrew consonants system between the age 3 to 5*. Master thesis. Tel-aviv University. Tel-Aviv. [in Hebrew].

Lee, L.L., and Canter, S.M. 1971. Developmental sentence scoring: a clinical procedure for estimating syntax development in children's spontaneous speech. *Journal of Speech and Hearing Disorders*, 36, 315-340.

Levelt, C. 1994. *On the acquisition of place*. Doctoral Dissertation. Leiden, Holland Institute of Generative Linguistics, Dissertation Series 8.

Levelt, C., and Van de Vijver, R. 1998. *Syllables types in crosslinguistic and development grammars*. Paper presented at the Third Utrecht Biannual Phonology Workshop. Utrecht, The Netherlands.

Levelt, C., Schiller, N.O. and Levelt, W.J. 1999/2000. The Acquisition of Syllable Types. *Language Acquisition*, 8 (3), 237-264.

Levitt, H., McGarr, N.S., and Geffner, D. 1987. Development of language and communication skills in hearing impaired children. *ASHA Monographs* 26 (Rockville: American Speech-Language-Hearing Association). pp.1-158.

Lleó, C. 1996. To spread or not to spread: Different styles in the acquisition of Spanish language. In B. Bernhardt, J. Gilbert, and D. Ingram (Eds.): *Proceedings of the UBC International Conference on Phonological Acquisition* (pp. 215-228). Somerville, MA: Cascadilla Press.

Lleó, C., and Prinz, M. 1996. Consonant clusters in child phonology and the directionality of syllable structure assignment. *Journal of Child Language,* 23, 31-56.

Locke, J.L. 1983. *Phonological acquisition and change.* New-York: Academic Press.

Lowenstamm, J. 1981. On the maximal cluster approach to syllable structure. *Linguistic Inquiry,* 12, 575-604.

Maassen, B., and Povel, D.J. 1984. The effect of correcting temporal structure on the intelligibility of deaf speech. *Speech Communication*, 3, 123-135.

Macken, M.A. 1978. Permitted complexity in phonological development: One child's acquisition of Spanish consonants. *Lingua*, 44, 219-253.

Macken, M.A. 1979. Developmental reorganization of phonology: basic units of acquisition. *Lingua*, 49, 11-49.

MacWhinney, B., and Snow, C. 1985. The Child Language Data Exchange system. *Journal of Child Language,* 12, 271-296.

Madison, C.L., and Wong, E.Y. 1992. Use the Clarck-Madison test of oral language with the hearing impaired: a content validity and comparative study. *Journal of Communication Disorders,* 25, 241-250.

Maital, S.L., Dromi, E., Abraham S. and Bronstein, M. H. 2000. The Hebrew Communicative Development Inventory: Language specific properties and cross-linguistic generalizations. *Journal of Child Language,* 27, 43-67.

Markides, A. 1970. The speech of deaf and partially-hearing children with special reference to factors affecting intelligibility. *British Journal of Communication Disorders*, 5, 126-140.

Matthei, E. 1989. Crossing Bounderies: More evidence for phonological constraints on early multi-word utterances. *Journal of Child Language*, 16, 41-54.

Mayne, A.M., Yoshinaga-Itano, C., Sedey, A.L., and Carey, A. 2000. Expressive vocabulary development of infants and toddlers who are deaf or hard of hearing. *The Volta Review,* 100, 1-28.

McCaffrey, H.A., Davis, B.L., MacNeilage, P.F., and Von hapsburg, D. 1999. Multichannel cochlear implantation and the organization of early speech. *The Volta Review,* 101, 5-28.

McCarthy, J.J. 1979. *Formal problems in Semitic Phonology and Morphology*. PhD. Dissertation. MIT.

McCarthy, J.J. 1988. Feature geometry and dependency: A review. *Phonetica, 43*, 84-108.

McCarthy, J. J., and Prince, A. 1986. *Prosodic Morphology*. Ms. University of Massachusetts, Amherst and Brandeis University, Waltham, Mass.

McCarthy, J. J., and Prince, A.1990. Foot and word in prosodic morphology: The

Arabic broken plural. *Natural Language and Linguistic Theory,* ,8, 209-283.

McCarthy, J. J., and Prince, A.1991. *Prosodic minimality*. A paper presented at the Conference on the Organization of Phonology. University of Illinois.

McCarthy, J. J., and Prince, A. 1993. Generalized alignment. In G. E. Booij, and J. Van Marle (Eds.). *Yearbook of Morphology* (pp. 79-153). Dordrecht: Kluwer.

McGarr, N., and Osberger, M. 1978. Pitch deviancy and intelligibility of deaf speech. *Journal of Communication Disorders*, 11, 237-247.

McGarr, N.S. 1983. The intelligibility of deaf speech to experienced and inexperienced listeners. *Journal of Speech and Hearing Research*, 26, 451-458.

McLeod, S., Van Doom, J. and Reed, V.A. 2001. Normal acquisition of consonant clusters. *American Journal of Speech and Language Pathology,* 10, 99-110.

Melčuk, I. and Podolsky, B. 1996. Stress in Modern Hebrew nominal inflection. *In Theoretical Linguistics,* 22, 155-194.

Meline. T. 1997. Description of Phonological Patterns for Nineteen Elementary-Age Children with Hearing Losses. *Perceptual and Motor Skills*, 85, 643-653.

Menn, L. 1971. Phonotactic rules in beginning speech. *Lingua,* 26, 225-251.

Menn, L. 1975. Counter example to ‘fronting’ as a universal of child phonology. *Journal of Child Language*, 2, 293-296.

Menn, L. 1976. *Pattern, Control, and Contrast in Beginning Speech: A Case Study in the Development of Word Form and Word Function,* Doctoral Dissertation, University of Illinois, Chamaign.

Menyuk, P. 1980. The role of context in misarticulations. In: G.H. Yeni-Komshian, J.F. Kavanagh, and C.A. Ferguson (eds), *Child Phonology* vI. New York: Academic Press. pp. 211-225.

Moore, J.A. and Bass-Ringdahl, S. 2002. Role of infant vocal development in candidacy for and efficacy of cochlear implantation. *Annals of Otology, Rhinology and Laryngology,* 111, 52-55.

Nespor, M., and Vogel, I.1986. *Prosodic Phonology*. Dordrecht: Foris.

Nespor, M., Peña, M., and Mehler, J. 2003. On the different roles of vowels and consonants in speech processing and language acquisition. *Lingue e Linguaggio*, pp. 221-247.

Nicolaidis, K. 2004. Articulatory Variability during Consonant Production by Greek Speakers with Hearing Impairment: An Electropalatographic Study. *Clinical Linguistics and Phonetics,* 18, 419-432.

Northern, J.L., and Downs, M.P. 1991. *Hearing in Children*. Baltomore: Williams and Wilkins. pp. 103-138.

Novak, M.A., Firszt, J.B., Rotz, L.A., Hammes, D., Reeder, R., and Willis, M. 2000. Cochlear implants in infants and toddlers. *Annals of Otology, Rhinology and Laryngology, Supplement,* 185, 46-49.

Obenchain, P., Menn, L., and Yoshinaga-Itano, C. 2000. Can speech development at 36 Months in children with hearing loss be predicted from information available in the second year of life? *The Volta Review* 100, 149-180.

Ohala, D. 1994. Hierarchies of environments for sound variation; plus implications for 'Neutral' vowels in vowel harmony. *Acta Linguistica Hafniensia,* 27, 2, 371-382.

Ohala, D. 1995. Sonority-Driven cluster reduction, in E. Clark, ed., *Papers and Reports on Child Language Development*. Standford University Press.

Ohala, D. 1996. *Cluster Reduction and Constraints in Acquisition.* Doctoral dissertation. University of Arizona.

Ohala, D. 1998. Medial Cluster Reduction in Early Child Speech. In Clark, E.V. (Ed): *The Proceedings of the twenty-ninth Annual Child Language Research Forum.* Pub for the standford linguistics Association by the center for the study of Language and Information.pp. 111-119.

Ohala, D.K. 1999. The influence of sonority on children's cluster reductions. *Journal of Communication Disorders,* 32, 397-422.

Oller, D.K. 1973. Regularities in abnormal child phonology. *Journal of Speech and Hearing Disorders*, 38, 36-47.

Oller, D.K., Jensen, H.T., and Lafayette, R.H. 1978. The relatedness of phonological processes of a hearing-impaired child. *Journal of Communication Disorders* 11, 97-105.

Oller D.K., and Kelly C.A. 1974. Phonological Substitution Processes of a Hard of Hearing Child. *Journal of Speech and Hearing Disorders*, 39, 65-74.

Olmsted, D. 1971. *Out of the mouth of babies: Earliest stages in language learning.* The Hauge, The Netherlands: Mouton.

Ornan, U. 1996. ʃitat hatxuniyot hamavxinot betorat hahege ʃel haivrit. In Bar-Asher, M. (ed.): *Mexkarim balaʃon*, 163-192. Jerusalem, The Ivrit University. [in Hebrew].

Osberger, M. 1978. *The effect of timing errors on the intelligibility of deaf children's speech*. Ph.D. thesis, City University of New-York, NY.

Osberger, M.J., Robbins, A.M., Berry, S.W., Todd, S.L., Hesketh, L.J., and Sedey, A.

1991. Analysis of spontaneous speech samples of children with cochlear implants or tactile aids. *American Journal of Otology*, 12 (Suppl.), 151-164.

Osberger, M.J., Maso, M., and Sam, L. 1993. Speech intelligibility of children with cochlear implants, tactile aids, or hearing aids. *Journal of Speech and Hearing Research,* 36, 186-203.

Ota, M. 1998. Phonological constraints and word truncation in early language acquisition. In: A. Greenhill, M. Hughes, H. Littlefield (eds) *Proceedings of the Boston University Conference on Language Development* 22. Somerville: Cascadilla Press. pp. 598-609.

Ota, M.. 1999. *Phonological theory and the acquisition of prosodic structure: Evidence fron child Japanese*. Doctoral dissertation, University of Georgetown.

Parker, F. 1994. Phonological theory. In Lowe R.J. (Ed): *Phonology: Assessment and Intervention Applications in Speech Pathology*. Williams and Wilkins. 17-34.

Parkhurst, B., and Levitt, H. 1978. The effect of selected prosodic errors on the intelligibility of deaf speech. *Journal of Communication Disorders*, 11, 249-256.

Parsier, S.C., and Chute, P. 1991. Cochlear Implants: Indications and Technology. *Med. Clinics of North America,* 75, 1267-1276

Pater, J. 1997. Minimal Violation and Phonological development. *Language Acquisition*, 6, 201-253.

Pater, J., and Barlow, J. 2002. A Typology of Cluster Reduction: Conflicts with Sonority. *BUCLD 26 Proceedings,* ed. Barbora Skarbela et al., 533-544. Somerville, MA: Cascadilla Press.

Pater, J., and Barlow, J. 2003. Constraint conflict in cluster reduction. *Journal of Child Language*, 30, 487-526.

Paul, P.V., and Quigley, S.P. 1990. *Education and Deafness*. Longman, New-York and London.

Paul, P.V., and Quigley, S.P. 1994. *Language and Deafness* (2nd ed.). San Diego: Singular Publishing Group.

Paul, R., and Jennings, P. 1992. Phonological behavior in toddlers with slow expressive language development. *Journal of Speech and Hearing Research*, 35, 99-107.

Peng, S-C., Spencer, L.J. and Tomblin, J.B. 2004. Speech Intelligibility of Pediatric Cochlear Implant Recipients with 7 Years of Device Experience. *Journal of Speech, Language and HearingResearch*, 47, 1227-1236.

Peters, A.M. 1977. Language learning strategies: Does the whole equal the sum of the parts? *Language,* 53, 560-573.

Peters, A.M. 1983. *The units of language acquisition*. Cambridge: Cambridge University Press.

Pfingst, B.E. 1986. Stimulation and encoding strategies for cochlear prostheses. *Otolaryngologic Clinics of North America*, 19, 220.

Pisoni, D.B. 2003-2004. Speech Perception Skills of Deaf Children with Cochlear Implants. *Research on Spoken Language Processing*, 26, 331-344

Plada, N. 1958/1959. Phoneme frequency in Hebrew. *Leshonenu 23,* 235-242. [in Hebrew].

Pollack, D. 1970. The development of a listening function. In: Pollack, D.(ed.): *Educational Audiology for the Limited Hearing Infant.* Charles C. Thomas. Pub: Springfield-Illinois-U.S.A. 68-88.

Pressnell, L. 1973. Hearing impaired children comprehension and production of syntax in oral language. *Journal of Speech and Hearing Research*, 16, 12-21.

Quigley, S.P., and King, C.M. 1982. The language development of deaf children and youth. In: S. Rosenberg (ed.) *Handbook of Applied Psycholinguistics.* Hillsdale: N.J.: Erlbaum Associates. pp. 429-475

Ravid, D. 1991. Modern Hebrew Spirantization and Language change. Paper presented the XIX North american Conference on afrosiatic Linguistics. University of california, Berkley.

Rice, K., and Avery, P. 1995. Variability in a deterministic model of language acquisition: A theory of segmental elaboration. In Archibald, J. (Ed): *Phonological Acquisition and phonological theory* (pp23-42). Hillside,NJ: Lawrence Erlbaum Associates.

Rose, Y. 2000. *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology.* Doctoral dissertation. McGill University , Montréal.

Rosen, H. 1973. Mivne haivrit haisraelit. In U. Ornan (ed.). *Mikraa letorat hahege*. Jerusalem: Hebrew University, 138-253. [in Hebrew].

Rosenhouse, J. 1986. Intonation problems of hearing-impaired Hebrew-speaking children. *Language and Speech*, 29, 69-92.

Sagey, E.C. 1986. *The representation of features and relations in non-linear phonology.* Unpublished doctoral dissertation. MIT.

Salidis J., and Johnson, I.S. 1997. The production of minimal words: A longitudinal case study of phonological development. *Language Acquisition: A Journal of Developmental Linguistics* 6:1-36.

Samar, V.J., and Metz, D.E. 1991. [Reply:] Scaling and transcription measures of intelligibility for populations with disordered speech: Where’s the beef? *Journal of Speech and Hearing Research*, 34, 699-704.

Sander, E. 1972. When are speech sounds learned? *Journal of Speech and Hearing Disorders,* 37, 55-63.

Schwartz, R.G., and Goffman, L. 1995. Metrical Patterns of word and production accuracy. *Journal of Speech and Hearing Research*, 38, 876-888.

Schwarzwald, O. 1976. Giʃot konkretiyot umufʃtot be-nituax beged-kefet beʔivrit. *Leʃonenu*, 40, 211-232. [in Hebrew].

Schwarzwald, O. 1985. Mivtao ʃel hador hacair beisrael. *ʃevet Vaʕam*, 10, 66-75. [in Hebrew].

Schwarzwald, O. 1991. Nedidot teamim baivrit hamodernit. In M., Goteshtein, S., Morag, and S., Kogot, (Eds.). *ʃay lexaim rabin, asufat mexkarey laʃon,* 393-414. Jerusalem: Ivrit University. [in Hebrew].

Sehgal, S.T., Kirk, K.I., Svirsky, M., Ertmer D.J., and Osberger, M.J. 1998. Imitative consonant feature production by children with multichannel sensory aids. *Ear and Hearing,* 19, 72-84.

Selkirk, E. 1984. *Phonology and syntax: The Relation Between Sound and Structure*. Cambridge, MA: MIT Press.

Serry, T., Blamey, P., and Grogan, M. 1997. Phoneme acquisition in the first four years of implant use. *The American Journal of Otology,* 18, (Suppl.), S122-S124.

Serry, T.A., and Blamey, P.J. 1999. A 4-Year investigation into phonetic inventory development in young cochlear implants users. *Journal of Speech, Language and Hearing Research*, 42, 141-154.

Shahin, K. 2003. *Prosody –Segmentism in the acquisition of Arabic: Word-final Onsets and No Stress Effect.* Subbmitted to the 2003 UBC Child phonology Proceedings.

Shriberg, L., and Kwiatkowski, J. 1980. *Natural Process Analysis*. New-York: John Wiley.

Smit, A.B. 1993. Phonological errors distributions in the Iowa-Nebraska articulation norms project: Word-initial consonant clusters. *Journal of Speech and Hearing Research,* 36, 931-947.

Smit, A.B., Hand, L., Frellinger, J.J., Bernthal, J.E., and Bird, A. 1990. The Iowa Articulation Norms Project and its Nebraska replication. *Journal of Speech and Hearing Disorders*, 55, 779-798.

Smith, N.V. 1973. *The acquisition of phonology: A case study.* Cambridge, U.K.: Cambridge University Press.

Smith, C.R. 1975. Residual hearing and speech production in deaf children. *Journal of Speech and Hearing Research*, 18, 795-811.

Snow, D. 1998. A prominence account of syllable reduction in early speech development: the child's prosodic phonology of Tiger and Giraffe. *Journal of Speech, Language, and Hearing Research,* 41, 1171-1184.

Stach, B.A. 1998. *Clinical Audiology: An Introduction.* Singular Pub. Group. San-Diego, London.

Stark, R.E. 1983. Phonatory development in young normally hearing and hearing-impaired children. In I. Hochberg, H. Levitt, and M.J. Osberger (Eds.). *Speech of the Hearing-impaired: Research, training, and personnel preparation* (pp. 297-312). Baltimore: University Park.

Stemberger, J. 1992. A performance constraint on compensatory lengthening in child phonology. *Language and Speech*, 35, 207-218.

Stemberger, J.P. 1996. Syllable structure in English, with emphasis on codas. In B. Bernhardt, J. Gilbert, and D. Ingram (Eds.), *Proceedings of the UBC international Conference on Phonological Acquisition* (pp. 62-75). Somerville, MA: Cascadilla Press.

Stemberger, J.P. and Stoel-Gammon, C. 1991. The underspecification of coronals : evidence from language acquisition and performance errors. In : C. Paradis 7 J.F. Prunet (Eds.), *The special status of coronals* (pp. 181-199). San Diego, CA : Academic Press.

Steriade, D. 1982. *Greek prosodies and the nature of syllabification.* Doctoral dissertation, Massachuesetts Instite of Technology, N.Y: Garland Press.

Steriade, D. 2000. Directional asymmetries in place assimilations: a perceptual account. In E. Hume and K. Johnson (eds.). *Perception in Phonology,* Academic Press.

Stevens, C. 2002. *Stability of language development from 36 to 48 months in children who are deaf or hard of hearing*. Unpublished master's thesis, Boulder, CO: University of Colorado.

Stoel-Gammon, C. 1985. Phonetic inventories, 15-24 months: A longitudinal study. *Journal of Speech and Hearing Research* 28, 505-512.

Stoel-Gammon, C., and Dunn, C. 1985. *Normal and disordered phonology in children.* Austin, TX: PRO-ED.

Stoel-Gammon, C. 1987. Phonological skills of 2-year olds. *Language, Speech, and Hearing Services in School,* 18, 323-329.

Stoel-Gammon, C. 1998. The role of babbling and phonology in early linguistic development. In A.M. Wetherby, S.F.Warren, and J. Reichle (Eds.), *Transitions in prelinguistic communication: Preintentional to intentional and presymbolic to symbolic* (pp. 87-110). Baltimore: Paul H. Brooks Publishing.

Stoel-Gammon, C., and Otomo, K.1986. Babbling development of hearing-impaired and normally hearing subjects. *Journal of Speech and Hearing Disorders* 51, 33-41.

Stoel-Gammon, C., and Kehoe, M.M. 1994, Hearing impairment in infants and toddlers: Identification, vocal development, and intervention. In: J.E. Bernthal NW Bankson (eds) *Child Phonology: Characteristics, Assessment, and Intervention with Special Populations*. NewYork: Thieme Medical Publisher Inc.

Taelman, H. 2004, *Syllable Omissions and Additions in Dutch Child Language: An Inquiry into the Function of Rhythm and the Link with Innate Gra*mmar. Ph.D. dissertation, University of Antwerpen.

Templin, M.C. 1957. *Certain language skills in children* (Monograph Series No. 26). Minneapolis: University of Minnesota, The Institue of Child welfare.

Tobey, E., Angelette, S., Murchison, C., Nicosia, J., Sprague, S., Staller, S., Brimacombe, J.A., and Beiter, A. L. 1991. Speech production performance in children with multichannel cochlear implants. *Journal of Otology*, 12 (Suppl.), 165S-173S

Tobey, E.A., and Hasenstab, M.S. 1991. Effects of nucleus multichannel cochlear implant upon speech production in children. *Ear and Hearing*, 4 (Suppl.), 48S-54S.

Tobey, E., Geers, A., and Brenner, C. 1994. Speech production results: Speech feature acquisition. *The Volta Review* 96, 5, (monograph), 109-129.

Tobey, E.A., Geers, A.E., Brenner, C.B., Altuna, D., and Gabbert, G. 2003. Factors associated with development of speech production of skills in children implanted by age five. *Ear and Hearing,* 24, 36S-45S.

Tobin, Y. 1997. *Phonology as Human Behavior: Theoretical Implications and Clinical Applications*. Durham: Duke University Press.

Tranel, B. 1991. CVC light syllables, geminates and moraic theory. *Phonology,* 8, 2, 291-302.

Tubul, G. 2005. *The Phonology of Hebrew-speaking Dyspraxic Children*. PhD. dissertation, Tel-Aviv University [in Hebrew].

Tye-Murray, N., and Kirk, K.I. 1993. Vowel and diphthong production by young users of cochlear implants and the relationship between the phone level evaluation and spontaneous speech. *Journal of Speech and Hearing Research*, 36, 488-502.

Tye-Murray, N, Spencer, L., and Woodworth, G. 1995. Acquisition of speech by children who have prolonged cochlear implant experience. *Journal of Speech and Hearing Research*, 38, 327-337.

Ussishkin, A. 2000. *The Emergence of Fixed Prosody.* Ph.D dissertation. University of California, Santa Cruz.

Vihman, M.M. 1978. Consonant Harmony: Its scope and function in child language. In Joseph H. Greenberg (ed.), *Universals of Human Language,* Vol. 2: Phonology. Stanford University Press, pp. 281-334.

Vihman, M.M., and McCune, L. 1994. When is a word a word? *Journal of Child Language,* 21, 517-542.

Vihman, M., and Velleman, S. 2000. Phonetics and origins of phonology. In: Burton-Roberts, N., P. Carr, and G. Docherty (eds) *Phonological Knowledge: Conceptual and Empirical Issues*. New-York: Oxford University Press.

Wallace, V., Menn, L., and Yoshinaga-Itano, C. 2000, Is babble the gateway to speech for all children? A longitudinal study of children who are deaf or hard of hearing. *The Volta Review* 100, 121-148.

Waltzman, S.B., and Cohen, N.L. 1998. Cochlear implantation in children younger than two years old. *American Journal of Otology* 19, 158-162.

Watson, M.M., and Scukanec, G.P. 1997. Phonological changes in the speech of two-year olds: A longitudinal investigation. *Infant-Toddler Intervention*, 7, 67-77.

West, J., and Weber, J. 1973. A phonological analysis of the spontaneous language of a four year old, hard of hearing child. *Journal of Speech and Hearing Disorders,* 38, 25-35.

Wijnen, F., Krikhaar, E.. and Den Os, E. 1994. The (non) realization of unstressed elements in children's utterances: Evidence for a rhythmic constraint. *Journal of Child Language,* 21, 59-83.

Wood, D. 1984. Aspects of the linguistic competence of deaf children. *British Journal of Audiology*, 18, 23-30.

Yaremko, R.L. 1993. Cochlear implants and children under the age of three. *Volta Review,* 95, 51-61.

Yavas, M., and Lamprecht, R. 1988. Processes and intelligibility in disordered phonology. *Clinical Linguistics and Phonetics,* 2, 329-345.

Yoshinaga- Itano, C. 2000. Development of Audition and speech: implications for early Intervention with Infants who are Deaf or hard of hearing. *The Volta Review,* 100, Monograph, 213-234.

Yoshinaga- Itano, C. 2002. Cochlear implantation below 12 months of age: challenges and considerations. *Antwerp papers in Linguistics,* 102, 61-76.

Yoshinaga- Itano, C., Sedey, A., Coulter, D., and Mehl, A. 1998. Language of early-and latter –identified children with hearing loss. *Pediatrics,* 102, 1161-1171.

Yoshinaga- Itano, C., Coulter, D.,and Thomson, V. 2000. The Colorado Hearing Screening Program: Effects on speech and language for children with hearing loss. *Journal of Preinatology (Supplement),* 20, S132-142.

Zamuner, T., and Gerken, L. 1998. Young children's production of Coda Consonants in Different prosodic Environments. In Clark, E.V. (Ed): *The Proceedings of the twenty-ninth Annual Child Language Research Forum.* Pub for the standford linguistics Association by the center for the study of Language and Information.pp. 121-128.

אוניברסיטת תל-אביב
הפקולטה למדעי הרוח ע"ש לסטר וסאלי אנטין
בית הספר למדעי התרבות ע"ש שירלי ולסלי פורטר

# ההתפתחות הפרוזודית של ילדים לקויי שמיעה דוברי עברית

**חיבור לשם קבלת התואר "דוקטור לפילוסופיה"**

מאת

**לימור עדי-בן סעיד**

**הוגש לסנאט של אוניברסיטת תל-אביב**
**נובמבר 2006**

עבודה זו נעשתה בהדרכת

**ד"ר אותי בת-אל**

# תוכן העניינים

# תקציר

## 1. הקדמה

עבודה זו בוחנת את ההתפתחות הפרוזודית של ילדים לקויי שמיעה דוברי עברית. במרכז העבודה מתוארת ההתפתחות ההדרגתית של המילה הפרוזודית (על פי מספר הברות) ומבנה ההברה בדיבור של ילדים לקויי שמיעה דוברי עברית לאחר שעברו את ניתוח שתל השבלול. בנוסף, בוחנת העבודה את יעילותו של סוג השיקום על תהליך הרכישה. לשם כך, מושווים הממצאים של הילדים המושתלים לאלו של ילדים המרכיבים מכשירי שמיעה רגילים (קבוצת נבדקים נוספת במחקר זה) וכן לאלו של ילדים שומעים דוברי עברית (Ben-David 2001, Adam 2002) ודוברי שפות אחרות, למשל: הולנדית (Fikkert 1994, Wijnen, Kirkhaar and den Os 1994), אנגלית (Demuth and Fee 1995, Demuth 1995,1996, Johnson and Salidis 1996), ספרדית (Garret 1998, Demuth 2001), יפנית (Ota 1998, 1999), צרפתית (Demuth 2003) ועוד.

אחד המרכיבים הבסיסיים של תפיסה והפקת דיבור הוא תפקוד תקין של המערכת השמיעתית. בתהליך התפתחות השפה, ילדים חשופים לתשומה מהסביבה ובנוסף נעזרים במשוב השמיעתי שלהם, המאפשר להם לשפר את ההפקות הקוליות שלהם ולהתאימן בהדרגה להפקות של המבוגר (Borden, 1979, Northern and Downs 1991, Stoel-Gammon and Kehoe 1994, Wallace et al. 2000, Kuel 2000, Obenchain et al. 2000).

פגיעה במשוב השמיעתי כתוצאה מירידה בשמיעה בשלבי החיים הראשונים, משפיעה על ההיבטים השונים של התפתחות השפה, כולל מאפיינים של הפקת דיבור (Lee and Canter 1971, Pressnell 1973, McGarr and Osberger 1978, Oller et al. 1978, Quigley and King 1982, Wood 1984, Levitt et al. 1987, Madison and Wong 1992, Tobin 1997). הפקת הדיבור של ילדים לקויי שמיעה מאופיינת במגוון של שינויים סגמנטלים וסופרה-סגמנטליים בהשוואה לשפת המטרה. שינויים סגמנטלים יכולים לכלול השמטות, חוסר דיוק בהגייה והחלפות של הגה אחד באחר (Hudgins and Numbers 1942, Markides 1970, Smith 1975, Monsen 1976, Stevens et al. 1978, Geffner 1980, Osberger and McGarr 1982, Tobin 1997). שינויים סופרה-סגמנטלים נמצאים במרכיבי האינטונציה והטעם, המשפיעים על הפרוזודיה וקצב המבע (Boothroyd et al. 1974, Osberger 1978, Parkhurst and Levitt 1978, Rosenhouse 1986, Frank et al. 1987).

מכשירי השיקום של אוכלוסיית לקויי השמיעה מגוונים וכולם מספקים משוב דרך מערכת סנסורית, המסייעת בהתפתחות מיומנויות התקשורת הדבורה. ואולם, שתל השבלול הוא מכשיר ההגברה המתקדם

ביותר הידוע כיום ויש לו ההשפעה הגדולה ביותר בשיפור הפקת הדיבור של ילדים לקויי שמיעה (Tobey et al. 1994). המידע השמיעתי על הדיבור דרך הגרוי החשמלי באמצעות שתל השבלול הוא רב יותר בהשוואה לזה המתקבל דרך ההגברה של הגירוי האקוסטי באמצעות מכשירי שמיעה רגילים. כלומר השתל מספק נגישות לצלילים שאינם נגישים בלעדיו, וכך מאפשר קיום של פוטנציאל גדול יותר להתפתחות מיומנויות תפיסה והפקת דיבור בהשוואה למכשירי השיקום האחרים (Parsier and Chute 1991, Chin and Pisoni 2000).

מרבית המחקרים אודות הפקת דיבור של ילדים לקויי שמיעה מצביעים על שיפור ניכר בעקבות השימוש בשתל השבלול בהשוואה למכשירים סנסוריים אחרים. מספר מחקרים בחנו את הפקת הדיבור של ילדים לקויי שמיעה המשתמשים בשתל השבלול, במכשירי שמיעה טקטילים ובמכשירי שמיעה רגילים. מחקרים אלו, העוסקים ברובם במאפיינים הסגמנטליים של המערכת הפונולוגית, מצביעים על כך שהפקת הדיבור של ילדים המשתמשים בשתל השבלול טובה יותר מזו של ילדים המשתמשים במכשירים טקטילים (Osberger et al., 1991, Geers and Tobey 1992, Tye-Murray and Kirk 1993, Tobey et al. 1994, Sehgal et al. 1998) ומזו של ילדים המשתמשים במכשירי שמיעה רגילים (Geers and Tobey 1992, Tobey et al. 1994, Kirk et al. 1995).

המאפיינים הסופרה-סגמנטלים בדיבור של ילדים מושתלים נחקרו אף הם (Kirk and Hill-Brown 1985, Tobey et al. 1991, Tobey and Hasenstab 1991, Tobey et al. 1994). המחקר הרלוונטי ביותר למאמר הנוכחי, הוא זה של Carter et al. (2002), שבדק את תפקודם של ילדים דוברי אנגלית במשימת חיקוי של מילות טפל. ממצאי המחקר הצביעו על יכולת ביצוע גבוהה יחסית במשימות אלו: בכשני שליש מניסיונות חיקוי הברות הטפל הפיקו הילדים את מספר ההברות הנכון ומיקמו את הטעם על ההברה הנכונה. יתרה מכך, הטעויות במספר ההברות הראו מאפיינים הדומים לאלו של ילדים שומעים, כלומר הייתה נטייה להשמיט ולא להוסיף הברות, וביצוע טוב יותר במילים עם טעם ראשוני, בהשוואה למילים עם טעם שאינו ראשוני (Fikkert 1994, Demuth 1995, 1996a, Gerken 1994, 1996).

בחלק הראשון של העבודה מוגש הבסיס התיאורטי של הפונולוגיה הפרוזודית (פרק 1) תוך התייחסות לרכישת השפה (פרק 2). בנוסף, מוצגת סקירה רחבה על אוכלוסיית לקויי שמיעה המשתמשים במכשירי שיקום שונים, והיכולות הפונולוגיות (סגמנטליות וסופרה-סגמנטליות) של אוכלוסייה זו (פרק 3). שיטת המחקר כוללת תיאור מפורט של הנבדקים, איסוף הנתונים, קידודם וניתוחם (פרק 4). ניתוח הממצאים מתחיל עם התפתחות המילה הפרוזודית (פרק 5), וממשיך עם מרכיבי ההברה (ראש הברה וזנב הברה) של הילדים המושתלים (פרק 6), עם דגש על המאפיינים המופיעים גם בדיבורם של ילדים

שומעים וכן תוך השוואה לילדים המשתמשים במכשירי שמיעה רגילים. בדיון (פרק 7) נעשה ניסיון למצוא קשר בין משתני רקע של הנבדקים לבין הביצוע שלהם בשלבי הרכישה השונה. בנוסף, מוצגות התופעות המיוחדות שנמצאו בדיבורם של הילדים לקויי השמיעה בהשוואה לילדים שומעים. את העבודה חותמים המלצות ויישומים קליניים.

## 2. רקע תיאורטי

### 2.1 היחידות הפונולוגיות

בבסיס התיאוריה של הפונולוגיה הפרוזודית עומד המבנה ההירכי של המילה, המורכב מיחידות פרוזודיות. ההירכיה הפרוזודית, כפי שהוצגה בעבודותיהם של Selkirk (1984) ו- Nespor and Vogel (1986), מניחה את המבנה המוצג בתרשים 1.

תרשים1: ההירכיה הפרוזודית של המילה

המורה היא היחידה הנמוכה ביותר בהירכיה הפרוזודית. היא מייצגת את כובד/משקל ההברה. הברות קלות כוללות מורה אחת, בעוד שהברות כבדות כוללות שתי מורות (Hyman 1985, Hayes 1986). הפונולוגיה של העברית אינה מספקת עדויות לקיומה של המורה, שכן לא קיימת בשפה הבחנה פונימית בין תנועות ארוכות וקצרות, והברות עם עיצור סוגר אינן מתנהגות שונה מהברות ללא עיצור סוגר, כלומר אין הבדלי כובד. השוו לערבית, בה הברות כבדות, הכוללות הברות עם עיצור סוגר מושכות טעם לכן ההנחה הרווחת היא שהמורה אינה רלוונטית לפונולוגיה של העברית.

ההברות מאורגנות תחת רגל, כאשר הרגל המועדפת היא בינארית, משמע דו-הברתית או דו-מוראית. כפי ש-Adam (2002) מציינת, בעברית הרגל היא דו-הברתית (שהרי המורה אינה רלוונטית), בעוד שבהולנדית ואנגלית, למשל, הרגל יכולה להיות דו-הברתית או דו-מוראית. הרגל רלוונטית לשלב המילה המינימאלית. בתוך כל רגל יש הברה אחת חזקה, וזו ההברה המוטעמת. הרגל יכולה להיות מלרעית (iambic) או מלעילית (trochaic). בהנחה שמילים דו-הברתיות מורכבות מרגל אחת, העברית מציגה את שני סוגי הרגליים, רגל מלרעית כאשר הטעם על ההברה האחרונה במילה או הימנית ברגל (למשל:

mi.tá), ורגל מלעלית כאשר הטעם על ההברה הלפני אחרונה במילה או השמאלית ברגל (למשל: dú.bi).

הרגליים מאורגנות תחת המילה הפרוזודית, המייצגת את הרמה הגבוהה ביותר בהירכיה הפרוזודית, הרלוונטית לדיון בעבודה זו. המילים חייבות להכיל לפחות רגל אחת, וכיון שהרגליים בד"כ בינאריות, המילה המינימאלית יכולה להכיל שתי הברות, או שתי מורות (McCarthy and Prince 1986, 1990, 1991).

השלבים ברכישת המבנה הפרוזודי של המילה מוגדרים במושגים של מספר הברות, מבנה הברה ומבנה רגל. ילדים מגדילים באופן הדרגתי את מספר ההברות במילה ומפיקים הברות בעלי מורכבות גדולה יותר (מוסיפים ראש וזנב הברה), ככל שהשפה שלהם מתפתחת. כאמור, במחקר הנוכחי עקבנו אחר גדילה במספר ההברות במילה, וכן התפתחות המרכיבים בתוך ההברה תוך השענות על התיאוריה הפרוזודית.

### 2.2 רכישת המילה הפרוזודית על פי ההירכיה הפרוזודית

ההירכיה הפרוזודית (ראו תרשים 1) משמשת בסיס לתיאוריה של Demuth and Fee (1995) לגבי הרכישה הפונולוגית. החוקרות מתארות ארבעה שלבים עיקריים בהתפתחות המילה הפרוזודית, ברכישת המילים הראשונות. בכל שלב יש עלייה הדרגתית במספר ההברות במילה:

**א. הברות גרעין (Core Syllables):** בשלב הראשון ברכישה מפיקים הילדים צורות חד-מוראיות מסוג CV. צורות אלו אינן מכילות את זנב ההברה (coda) ואורך התנועה אינו מהווה ערך מבחין (Fikkert 1994). Demuth and Fee (1995) מכנות את השלב הזה "השלב התת מינימאלי". שלב זה קצר יחסית וממנו עוברים הילדים במהירות לשלב הבא.

**ב. שלב המילה המינימאלית (Minimal Words):** שלב זה מוזכר בהרחבה בספרות ומתועד בשפות רבות (ראו פרק 2.1.2§). במהלך שלב זה, מפיקים הילדים רגל דו-הברתית (CVCV) או דו-מוראית – חד הברתית, כאשר הברה מכילה זנב (CVC) או תנועה ארוכה (CVV). בשלב זה המילה המינימאלית היא גם המילה המקסימאלית. שלב זה הוא מרכזי ולעיתים ממושך יחסית בתהליך הרכישה של הילדים.

**ג. מעבר למילה המינימאלית (Beyond Minimal Word):** במהלך שלב זה המילה מתרחבת הן במונחים של מספר ההברות במילה והן מבחינת מורכבות ההברה. הילדים מפיקים שתי רגלים במילה. בשלב ההתחלתי, הילדים שומרים על הטעם המילעלי (penultimate stress). בהמשך, הם מטעימים את כל הרגלים במילה באופן שווה, תוך שהם ממקמים את הטעם הראשי בהברה הראשונה של הרגל. רק

לקראת סוף השלב, הם תופסים את המילה כיחידת טעם נפרדת ועצמאית ושומרים על הטעם בהתאם למיקומו במילת היעד.

ד. **המילה הפונולוגית (Phonological Word)**: בשלב זה הילדים מפיקים מבנים פרוזודיים מלאים ונכונים מבחינת מספר ההברות במילה.

מחקרים, שעסקו בהתפתחות המילה הפרוזודית, בקרב ילדים דוברי עברית בעלי התפתחות תקינה (Ben-David 2001, Adam 2002) ובעלי התפתחות לקויה (Tubul 2005) מציגים שלבים דומים לאלו המדווחים בספרות. ואולם, החוקרות מדווחות, כי בשלב הראשוני, לצד הפקות חד-הברתיות, מופיעות גם הפקות דו-הברתיות. בשלב זה, הפקות הילדים נאמנות להברה המוטעמת ולהברה הסופית של מילות המטרה (ראו פרק 2.1.4 העוסק ברכישה הפרוזודית של ילדים דוברי עברית).

### 2.3 רכישת מרכיבי ההברה

במקביל להתפתחות המילה הפרוזודית, קיימת התפתחות של המרכיבים בתוך ההברה. פרק 2.2.1 מתאר את התפתחות ראש ההברה (onset), בעוד שפרק 2.2.2 מתאר את התפתחות זנב ההברה (coda).

### 2.3.1 רכישת ראש ההברה

בשלב הרכישה הראשוני הברות עם ראש הברה פשוט הן ההברות הלא-מסומננות במרבית השפות. יתרה מזו, בשפות אחדות מוסיפים הילדים עיצור להברות מחוסרות ראש הברה, בעוד שבשפות אחרות הם משארים את ההברה ריקה, ללא עיצור פותח (ראו פרק 2.2.1.1).

המעבר ממילים חד הברתיות למילים דו-הברתיות, מאופיין בהוספה של גרעין להברה השכנה השמאלית ללא ראש הברה (למשל: *ubá ← ba* 'בובה'). תופעה זו מאפיינת גם את המעבר ממילים דו-הברתיות למילים תלת הברתיות.

המחקר הנוכחי מתעד שלב ראשוני בקרב הילדים לקויי השמיעה (שאינו נפוץ בדיווחי הספרות), שבו נמצאו מילים חד ודו-הברתיות המורכבות מתנועות בלבד ללא עיצורים כלל. תופעה זו נידונה בהרחבה בפרק 7.3.1 בדיון.

### 2.3.2 רכישת זנב ההברה

בשלבי הרכישה הראשונים מפיקים הילדים מילים ללא זנב הברה, ללא קשר לשפת המטרה (ראו פרק 2.2.2.1). השמטת זנב ההברה בשלב זה הינה על בסיס פרוזודי, קרי מיקום העיצור במילה, ולא על בסיס

סגמנטלי (משמע סוג העיצור). אולם, לפי דיווחה של בן דוד (2001) הילדים שומרים על זנב ההברה במילים ללא העיצור הפותח, כלומר במילים בעלות מבנה הברתי מסוג VC (למשל: *af, od*).

בשלב הבא מופיע זנב ההברה במיקום סופי במילה, בעוד שזנב הברה במיקום מצעי מושמט. רק בשלבים מאוחרים מופיע זנב ההברה במיקום מצעי במילה.

## 3. שיטת המחקר

### 3.1 נבדקים

בעבודה השתתפו 6 ילדים דוברי עברית, שעברו את ניתוח שתל השבלול (3 בנים ו-3 בנות). המחקר עקב אחר השלבים ההתפתחותיים של הילדים מייד לאחר ההשתלה (מס' חודשים לאחר הניתוח), כלומר מרגע הופעת המילים הראשונות, עד לרכישה מלאה של היחידות הפונולוגיות (על נתוני הילדים המושתלים ראו פרק 4.1.1).

קבוצת הילדים עם מכשירי השמיעה הרגילים כללה 4 ילדים (2 בנים ו-2 בנות). בשל הקושי למצוא ילדים המרכיבים מכשירי שמיעה בשלבי רכישה ראשוניים, איסוף הנתונים של קבוצה זו היה פחות הומוגני והחל בשלבים שונים של ההתפתחות הפונולוגית של כל ילד (ראו פרק 4.1.2).

### 3.2 שיטה

נתוני המחקר נאספו במהלך מפגשים בני 45 דקות כל אחד. דיבוב הילדים נעשה באמצעות דיבור ספונטאני ושיום תמונות וחפצים. הילדים שיחקו בחדר הטיפולים עם הקלינאית, שעודדה אותם להפיק דיבור ספונטאני תוך שימוש בצעצועים שונים. משימת השיום התבססה על סט תמונות וחפצים, שהוצגו לילדים (לרשימת המילים במבחן השיום ראו אצל Ben-David 2001).

כל המפגשים הוקלטו באמצעות אודיו-טייפ ותועתקו. כ-80% מהקלטות הילדים נבחרו באופן אקראי ותועתקו ע"י נסיינית שנייה. ההסכמה בין הבודקות לגבי התעתוק הייתה גבוהה והעידה על מהימנות התעתיק.

קידוד הנתונים וניתוחם נעשה באמצעות מערכת ה- Child Language Data Exchange System (CHILDES; Brian MacWhinney and Catherine Snow 1985). התעתוק והקידוד נעשו תוך שימוש בשני כלים של ה- CHILDES:

ה- CHAT (Codes for the Human Analysis of Transcripts) - מערכת לתעתוק וקידוד הנתונים.

ה- CLAN (Computerized Language Analysis) - מערכת לניתוח הנתונים.

הנתונים נותחו במונחים של היחידות הפרוזודיות: התפתחות המילה הפרוזודית, התפתחות ההברה והתפתחות היחידות בתוך ההברה (ראש ההברה וזנב ההברה). ניתוח היחידות הסגמנטליות, קרי עיצורים, נעשה תוך התייחסות להתפתחות הפרוזודית.

## 4. תוצאות

### 4.1 התפתחות המילה הפרוזודית

ממצאי המחקר מצביעים על כך שאבני הדרך בהתפתחות המילה הפרוזודית בקרב ילדים מושתלים דומות לאלו של ילדים שומעים דוברי עברית ושפות אחרות, כמו גם לאלו של ילדים לקויי שמיעה המרכיבים מכשירי שמיעה רגילים.

השלב הראשוני (ראה פרק 5.1) מאופיין בעיקר בהפקות חד- הברתיות ללא קשר למספר ההברות של מילת המטרה. נראה שבחירת ההברה נעשית בעיקר על בסיס שיקולים פונטיים וסגמנטלים (ראו גם Adam 2002, Tubul 2005). בשלב הבא, שלב המילה המינימאלית (ראו פרק 5.2), הפיקו הילדים מילים דו-הברתיות למילות מטרה רב הברתיות. כמו הילדים בעלי השמיעה התקינה, הילדים בחרו ממילת המטרה את שתי ההברות האחרונות, שאחת מהן היא מוטעמת. בשלב הטרום סופי (ראו פרק 5.3), מרחיבים הילדים את מספר ההברות במילה ומפיקים מילים בנות שלוש הברות. מילות יעד בנות שלוש וארבע הברות מופיעות כמילים תלת הברתיות בדיבור של הילדים. בשלב זה, כל שלוש ההברות במילים תלת הברתיות מופיעות, אולם מילים בנות ארבע הברות אינן מלאות עדיין. בשלב הסופי (ראו פרק 5.4), כל ההפקות של הילדים נכונות מבחינה פרוזודית במונחים של מספר הברות במילה: למשל *ofanái* למילה *ofanáim*, וגם *miʃiʃáim* למילה *miʃkafáim*, וגם :*mispaʁái* למילה *mispaʁáim*. יחד עם זאת, ההתפתחות של מבנה ההברה והמרכיבים הסגמנטלים במילה, לא הגיעו לשלב הסופי.

### 4.2 התפתחות ראש ההברה

השלבים של התפתחות ראש ההברה של הילדים המושתלים דומים לאלו של ילדים שומעים וכן לאלו של ילדים לקויי שמיעה המרכיבים מכשירי שמיעה רגילים. אולם, במחקר הנוכחי, התפתחות ראש ההברה של הילדים המושתלים מאופיינת בשלב ראשוני, המתועד אך בקושי בספרות, והמכונה בעבודה זו: 'Free-consonant words stage' (ראו פרק 6.1.1). במהלך השלב הראשוני ובשלב המילה המינימאלית, הפיקו הילדים מילים המכילות תנועות בלבד ללא עיצורים (תופעה זו דווחה ע"י מספר קלינאיות העובדות עם ילדים מושתלים דוברי עברית). להלן מס' דוגמאות:

(2)

| | | | | | |
|---|---|---|---|---|---|
| *o* | *lo* | ‘no’ | *aá* | *paʁpáʁ* | ‘butterfly’ |
| *i* | *mi* | ‘who’ | *íi* | *imʁí* | ‘proper name’ |
| *a* | *dag* | ‘fish’ | *aá, iá* | *aviyá* | ‘proper name’ |
| *e* | *en* | ‘none’ | *ée* | *ʁégel* | ‘foot’ |
| *o* | *op* | ‘hop’ | *áo* | *álo* | ‘hello’ |

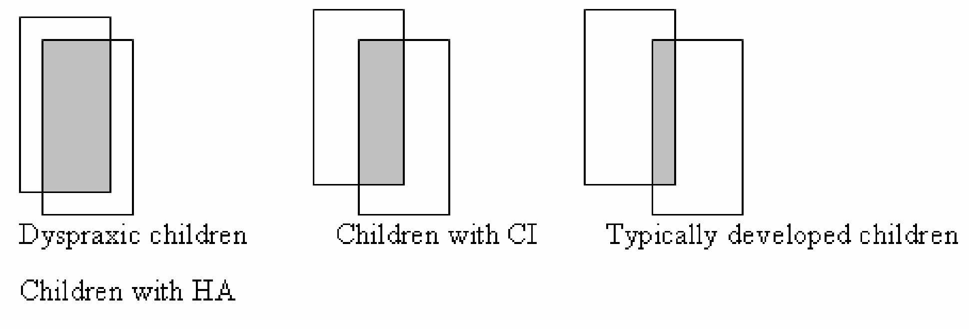
לפי Ben-David (2001), לא היה שום שלב ברכישה בו הילדים השומעים הפיקו מילים ללא עיצורים. בהסתמך על Tobin (1997), הופעה (אפילו מינימאלית) של עיצורים הכרחית לסיפוק מידע תקשורתי (ראו גם Nespor et al. 2003, Bonatti et al. 2005 בדבר חשיבות העיצורים בדיבור). העיצורים הסוגרים הראשונים מופיעים במבנה הברה מסוג VC כמו במילים *af* 'אף' ו-*od* 'עוד'. כלומר, בשלב בו לכל המילים האחרות אין עיצור סוגר, למילים מסוג VC יש עיצור סוגר וזאת כדי להימנע מהפקה של מילים ללא עיצורים.

למיטב ידיעתי, אין הסבר גורף לתופעה זו, וגם מספר המחקרים שעוסק בה זעום למדי. מחקרים אחדים טוענים כי מילים ללא עיצורים עשויות להופיע בדיבור של ילדים בעלי התפתחות תקינה (Bernhardt and Stemberger 1998, Vihman and Velleman 2000 לאנגלית, Freitas 1996 Costa and Freitas 1998 – לפורטוגזית), אחרים לעומתם טוענים שמילים מסוג זה מופיעות רק בהתפתחות לקויה (Menyuk 1980, Grijzenhout and Joppen 1999).

כפי שהוסבר ע"י Adi-Bensaid and Bat-El (2004) (בעקבות הצעתה של פיונה מרגליות ממודיעין), אני מניחה שמילים ללא עיצורים הן שאריות משלב המלמול. הברות ללא עיצורים (כמו גם הברות מסוג CV) מופיעות בשלב המלמול (Stoel-Gammon and Otomo 1986, Paul and Quigley 1994) והן יכולות להופיע גם בשלב המעבר מהמלמול לדיבור (Oller et al. 1978, Stoel-Gammon 1985). Dore et al. (1976) מתארים שלב בהתפתחות הדיבור, אותו הם מכנים Phonetically Consistent Forms (או PCF). לטענתם, שלב זה מופיע בין שלב המלמול לשלב הופעת המילים הראשונות. החוקרים מתארים צורות שונות של PCF, אשר תנועה בודדת היא אחת מהן. ה- PCFs יותר מוגבלות ומצומצמות ממילים אמיתיות אך משמעותיות יותר בהשוואה למלמול. כאמור, אין דיווחים בקרב ילדים שומעים דוברי עברית על הימצאותם של מילים ללא עיצורים (Adam 2002, Ben-David 2001) ויתכן שהדבר נובע מהעובדה, שהמעקב אחר התפתחות הדיבור של ילדים אלו החל מעט מאוחר. ואכן, ממצאים חדשים בנושא מעידים על קיומם של תנועות ללא עיצורים בדיבור של ילדים שומעים דוברי עברית במעבר משלב המלמול לשלב הדיבור (Adam and Bat-El, p.c.).

אולם, מילים מסוג זה מופיעות אצל הילדים לקויי השמיעה גם בשלב המילה המינימאלית, כלומר, שני שלבים אחרי המלמול. הסיבה לכך נעוצה אולי בעובדה, שהילדים עברו את הניתוח בהיותם צעירים, והחלו לקבל גירוי שמיעתי מוגבר הדרוש להתפתחות שפה מעט מאוחר בהשוואה לילדים שומעים. כלומר, בשל המידע השמיעתי המאוחר שקיבלו הילדים, שלב ה- PCF נמשך מעבר לרגיל. הסבר זה, נתמך בעובדה שככל ששפת הילדים התפתחה, חלה הפחתה במספר המילים ללא העיצורים. נראה, שהילדים המושתלים ממשיכים את שלב המלמול זמן-מה גם לאחר הניתוח לפני שהם מתחילים לפתח דיבור (Ertmer and Mellon 2001, Gillis 2002, Moore and Bass-Ringdahl 2002).

התופעה של מילים ללא עיצורים, נראתה גם בדיבור של הילדים, שהרכיבו מכשירי שמיעה רגילים (במחקר הנוכחי) וגם במחקר על ילדים עם דיספרקסיה התפתחותית (Tubul 2005) אולם אצל האחרונים היא נמשכה זמן רב יותר. בעקבות כל הנאמר לעיל, אני מניחה שמילים ללא עיצורים, הן שלב התפתחותי המאפיין את הדיבור של ילדים שומעים כמו גם של ילדים עם לקויות שונות. מדובר בשלב מעבר בין המלמול לדיבור, כלומר שלב ה- PCF. ואולם ההבחנה בין הקבוצות השונות מקורה בגודל הממשק בין השלבים: הוא גדול במיוחד בקרב הילדים הדיספרקסים וילדים המרכיבים מכשירי שמיעה רגילים, גדול אך פחות בקרב הילדים המושתלים ומאוד קטן בקרב ילדים שומעים בעלי התפתחות רגילה (תרשים 3 למטה). נדרש מחקר נוסף עם אוכלוסיות בעלי התפתחות תקינה והתפתחות מאוחרת כדי לאשש הנחה זו.



תרשים 3: הממשק בין שלב המלמול לשלב הדיבור באוכלוסיות השונות

### 4.3 התפתחות זנב ההברה

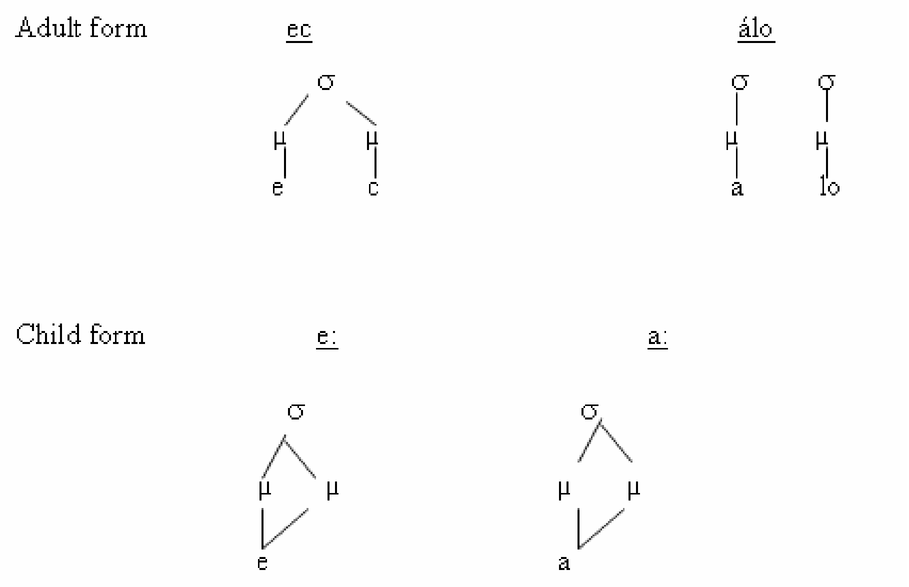
השלבים של התפתחות זנב ההברה של הילדים המושתלים דומים אף הם לאלו של ילדים שומעים וכן לאלו של ילדים לקויי שמיעה המרכיבים מכשירי שמיעה רגילים. ואולם, במחקר הנוכחי, השלב הראשוני

של התפתחות זנב ההברה, והמכונה בעבודה זו: "Codaless words" (ראו פרק 6.3.1), מאופיין בהארכה של התנועה המופיעה לפני הזנב המושמט (ראו פרק 7.3.2). תופעה זו נראתה הן בהפקות חד-הברתיות והן בהפקות רב הברתיות. להלן מספר דוגמאות:

(4)

| | | | | | |
|---|---|---|---|---|---|
| *i:* | *pil* | ‘elephant’ | b*aó:* | *balón* | ‘ballon’ |
| *ta:* | *cav* | ‘turtle’ | *pái*: | *miʃkafáim* | ‘glasses’ |
| *a:* | *xam* | ‘hot’ | *yaó:* | *ʃaón* | ‘watch’ |
| *e:* | *ec* | ‘tree’ | *kapí:* | *kapít* | ‘spoone’ |
| *o:* | *od* | ‘more’ | *enái*: | *enáim* | ‘ey*es’* |

בעברית אין הבחנה פונימית בין תנועות ארוכות וקצרות, כלומר אין מילים שנבדלות באורך התנועה. כמו-כן, אין דיווחים על תנועות ארוכות בדיבורם של ילדים שומעים דוברי עברית. לפיכך, ההופעה של תנועות ארוכות בדיבור של הילדים המושתלים הייתה מפתיעה, בעיקר לאור ההתפתחות שתוארה לעיל, שהייתה זהה לזו של ילדים שומעים. אולם, מצאנו שההופעה של תנועות ארוכות בשפת הילדים מותנית במבנה ההברה של מילת המטרה. מתוך הנתונים המוצגים למעלה, ניתן לראות שהתנועות הארוכות מופיעות בסביבה מאוד מסוימת במילת המטרה: בהברה עם עיצור סוגר (כלומר CV: ← CVC). כלומר, אני מניחה שהילדים השתמשו בתנועות ארוכות כדי לפצות על יחידה פרוזודית חסרה מימין להברה המופקת, קרי העיצור הסוגר של ההברה (ראו Hayes 1989 לגבי הארכה מפצה בשפות מבוגרים). כדי להסביר את התופעה עלינו להניח שהילדים מתייחסים להברה CVC כאל הברה דו-מוראית, למרות שכפי שצוין לעיל, אין בעברית הבחנה מוראית בין CV ו-CVC. אולם, אפשר להניח שהמבנה המוראי של CVC הוא ברירת המחדל האוניברסאלית, שהילדים בוחרים עם תחילת הרכישה, עד שהם צוברים עדויות שאין למבנה זה תפקיד בשפה. כלומר, במהלך השלב הראשוני של הרכישה, מילת מטרה עם הברה מסוג CVC מכילה שתי מורות (שתי יחידות משקל), וההשמטה של העיצור הסוגר משאירה מקום ריק, המאפשר לתנועה להתפשט למיקום הריק (Hayes 1989 ) (תרשים 5).



תרשים 5: הארכת התנועה

השאלה הנשאלת היא, מדוע אין דיווחים על תנועות ארוכות במחקרים על ילדים דוברי עברית שומעים? אפשרות אחת היא, שתנועות ארוכות קיימות בדיבורם של ילדים שומעים דוברי עברית, אך המחקרים לא שלטו באורך התנועה, כיון שאינה קיימת בשפת המבוגרים בעברית (Adam ו- Ben-David דיווחו, שהן לא התייחסו לאורך התנועה). ואכן, במחקר עכשווי, השולט במשתנה אורך התנועה, נמצא כי ילדים שומעים דוברי עברית מפיקים תנועות ארוכות בשלבים הראשונים של התפתחות הדיבור שלהם (Adam and Bat-El, p.c.).

אפשרות אחרת היא, שתנועות ארוכות אינן קיימות בדיבור של ילדים שומעים מעבר לתקופת המלמול. כמו שהוסבר בפרק הקודם (4.2) בשל המחסור בפידבק השמיעתי, יתכן שתקופת המעבר בין תקופת המלמול לדיבור הייתה ממושכת יותר. כתוצאה מכך, צלילים ומבנים המאפיינים את תקופת המלמול, המשיכו להתקיים גם בתקופות הבאות. יש לציין כי איסוף הנתונים של הילדים המושתלים נעשה במהלך טיפול. במקרים רבים, קלינאיות תקשורת מדברות אל הילדים בקצב דיבור איטי, בעוצמה ובתדירות גבוהים יותר בהשוואה לדיבור רגיל, דבר שיכול להשפיע על אורך התנועות. אולם, אם זו היא הסיבה להימצאות התנועות הארוכות לא היינו מצפים לעקביות במקום הופעתן (כלומר, במקום עיצור סוגר).

## 5. דיון והשלכות קליניות

המחקר הנוכחי מראה, בהתייחס להתפתחות הפרוזודית, שמסלול הרכישה של הילדים ליקויי השמיעה בכלל והמושתלים בפרט דומה לזה של ילדים בעלי שמיעה תקינה.

## 5.1 קצב ההתפתחות ושונות בין הילדים המושתלים

כל הילדים החלו להפיק את המילים הראשונות מייד לאחר הניתוח או כחודש חודשיים לאחר הניתוח (ראו פרק 4.2 ובפרק הדיון 7.2.1 העוסק בקשר בין קצב הרכישה של המילים לבין גיל האיתור של הליקוי השמיעתי והתחלת השיקום, קרי התאמת מכשירי שמיעה, של הילדים המושתלים. פרק 7.2.2 בדיון עוסק בקשר בין קצב רכישת המילים לבין גיל ההשתלה של הילדים.

לגבי גיל התחלת השיקום השמיעתי של הילדים המושתלים (התאמת מכשירי השמיעה), נראה שככל שגיל האיתור והשיקום מוקדמים יותר, קצב רכישת המילים של הילדים מהיר יותר בהשוואה לגיל איתור והתחלת שיקום מאוחרים. ואכן מחקרים רבים מראים, כי ילדים המאותרים בגיל צעיר ומשוקמים, מציגים יכולות טובות יותר של מובנות דיבור (Apuzzo and Yoshinaga-Itano 1995, Yoshinaga-Itano et al. 2000), התפתחות שפה (Yoshinaga-Itano et al. 2000) והתפתחות רגשית-חברתית (Yoshinaga-Itano 2002) טובים יותר בהשוואה לילדים המאותרים ומשוקמים בגיל מאוחר יותר.

נראה שקיים גם קשר בין **גיל ההשתלה** לבין קצב הרכישה של המילים: ככל שגיל ההשתלה מוקדם יותר, קצב הרכישה מהיר יותר, בעוד שככל שגיל ההשתלה מאוחר יחסית, קצב הרכישה איטי.

יחד עם זאת קיימת שונות בין הנבדקים. שונות זו מתועדת גם במחקרים אחרים. Pisoni (2003-2004) מדגיש את העובדה, שלמרות הצלחת ניתוח שתל השבלול בקרב מושתלים, ישנם הבדלים רבים בין הילדים. הבדלים אלו כוללים בין היתר, גיל ההתחרשות (Fryauf-Bertschy et al. 1992), משך השימוש במכשיר (Blamey et al. 2001b), סוג התקשורת של הילד (Chin and Kaiser 2002, Kirk et al. 2002b), כמו גם הבדלים בסיסיים בקידוד הפונולוגי המהיר ובתהליכי השליפה הורבליים של זיכרון העבודה (Cleary et al. 2002, Pisoni 2003-2004).

זאת ועוד, נראה שהילדים שגיל ההשתלה שלהם היה מוקדם במיוחד צמצמו את הפער לקראת סוף תקופת ההתפתחות. הילדים הללו הגיעו לשלב האחרון של התפתחות המילה הפרוזודית מוקדם יותר בהשוואה לילד האיטי ביותר במחקרה של Ben-David (2001), שכזכור עקב אחרי ילדים שומעים בעלי התפתחות תקינה.

המחקרים מדגישים, שלגיל השתלה מוקדם השפעה מכרעת על התפתחות הדיבור והשפה של ילדים לקויי שמיעה (Kirk and Hill-Brown 1985, Tobey et al. 1991, Tye-Murray et al. 1995, Kirk et al. 2002b). זאת ועוד, ילדים שהושתלו לפני גיל 18 חודשים הגיעו להישגים קרובים ואפילו דומים לאלו של ילדים שומעים בעלי התפתחות תקינה בהשוואה לילדים, שהושתלו בגיל מאוחר יותר (Kirk and Hill-Brown 1985, Tobey et al. 1991, Tye-Murray et al. 1995, Kirk et al.

2002b). היתרון של גיל ההשתלה המוקדם ניכר ביכולות תפיסת הדיבור של הילדים (Yaremko 1993, Waltzman and Cohen 1998), כמו גם ביכולות הפקת הדיבור שלהם (Tye-Murray et al. (1995, McCaffrey et al. 1999, Ertmer and Mellon 2001, Ertmer 2001.

ממצאי המחקר הנוכחי תומכים אף הם בטענה זו. כלומר, ככל שגיל ההשתלה מאוחר קצב הרכישה והתפתחות הדיבור איטי יותר. ואולם, כשגיל ההשתלה מעבר ל-18 חודשים משתנים נוספים עשויים להשפיע ולגרום לשונות רבה בין הילדים.

### 5.2 השלכות קליניות

נתוני המחקר עשויים להצביע על השלכות קליניות באבחון וטיפול של ילדים מושתלים. ניתוח הנתונים מציג סדר רכישה של המילה הפרוזודית הדומה לזה של ילדים שומעים. Fee (1997) מציעה, ששלבים פרוזודיים מספקים מודל להערכה וטיפול של ילדים עם איחור בהתפתחות הפונולוגית. אין ספק שהדבר נכון גם לגבי אבחון והערכה של ילדים לקויי שמיעה. בשלב הערכה, הקלינאית צריכה לקבוע את השלב הפרוזודי בו נמצא הילד ולהוביל אותו בהדרגה לשלב הבא.

הימצאות של מילים ללא עיצורים בשלב הראשוני, מחזקת את ההנחה שבשלבי הטיפול הראשונים, הקלינאית צריכה להיות מודעת לשלב המעבר מהמלמול למילים משמעותיות. Ertmer et al. (2002a,2002b) מציעים, שתוכנית אימון צריכה לכלול הפקות קדם-מילוליות בדיבור של ילדים מושתלים. הם מדגישים את חשיבות הצגת צלילי דיבור בבידוד ובצירופים פשוטים בתחילת האימון. לפיכך, במהלך תקופה ראשונית זו, הקלינאית צריכה לעודד את הילד לקוי השמיעה למלמל ולפתח את המשחק הקולי שלו. הדבר יכול להיעשות ע"י הצטרפות למשחק הקולי של הילד, תוך הוספה של מילים משמעותיות הדומות בצלילים לאלו המופקים ע"י הילד (Pollack 1970). Wallace et al. (2000) מציעים ללמד ילדים לקויי שמיעה, שאינם מדברים עדיין, מילים המתאימות במרכיבים שלהן לצלילי המלמול שלהם (כלומר PCF).

יחד עם זאת, עלינו לזכור שאוכלוסיית לקויי השמיעה היא הטרוגנית, וישנם הרבה משתנים שעשויים להשפיע על התפקוד השמיעתי שלהם (למשל: גיל החרשות, מידת הירידה בשמיעה, גיל התחלת השיקום השמיעתי ועוד) (Tobin 1997, Quigley and King 1982, Mayne et al. 2000).

Ertmer et al. (2002b) למשל, מתארים תוכנית טיפול לשני ילדים מושתלים. הילדים היו שונים זה מזה במספר רב של משתנים (למשל: גיל התחרשות, מיומנויות תקשורת טרום ניתוחיות, גיל ההשתלה ועוד). שני הילדים התקדמו בעקבות הניתוח, אבל היו הבדלים בשיעור ובמידת ההישגים שלהם.