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THE MARKEDNESS OVER FAITHFULNESS BIAS
Coda moraicity in early Hebrew speech

MA thesis submitted by

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February 2021

Acknowledgements

During the work on this thesis, I was lucky to be surrounded by supporting and encouraging people, to which I owe sincere gratitude and appreciation.

First and foremost, I would like to deeply thank my advisor, Prof. Outi Bat-El. In the past three years she has been a devoted guide, an outstanding teacher, and a source of endless knowledge and inspiration. Her ability to see the big picture, yet being aware of every small detail, has shaped and improved this study in countless levels. I am thankful to Outi for her continuous support, for always being available for any question or deliberation I had, for long hours of insightful meetings, and for providing me with everything I needed to complete this research, professionally and personally.

Dr. Galit Adam was the first to encourage me to explore the field of language acquisition. It was in her course on phonological acquisition that I discovered my interest in this field. I thank Galit for encouraging me, for sending me great reading materials and for her valuable input.

I thank Dr. Evan Cohen for many interesting and useful discussions, and for always being available for any question I had or thought I wanted to share. I also wish to thank Dr. Avivit Ben-David and Dr. Ezer Rasin for their very helpful questions and insights, which improved several aspects of my work.

I had the fortune of conducting my study as part of a larger research group, who made this journey a lot more enjoyable. Mor Haim and Noa Handelsman accompanied me from the very beginning of this research. I thank Mor and Noa for their useful thoughts and constant assistance, but most of all for our great friendship. I appreciate Chen Gafni for his consultations and for his great patience in helping me with the statistical issues. I also thank Radan Nasrallah, Ittamar Erb, Vered Cherkez and Ziv Plotnik for their consultations and suggestions throughout different stages of this research. I thank the participants of this study, IM and SM, and their families.

I thank Daniel Asherov, whose thoughts and questions led me to elucidate some of my arguments. Although we did not always agree, Daniel's comments challenged me to sharpen my ideas and to better establish my claims.

I deeply thank Hadas Yeverechyahu for always giving me good advice and valuable assistance, as a colleague but also as a friend. I highly appreciate Mandy Cartner's support throughout my studies, and her encouragements whenever I struggled.

I thank the participants of OCP 19 (Warsow, Poland 2019) for their comments on my presented work. I especially thank Prof. René Kager for his helpful thoughts on the theoretical analysis of the data.

I thank Ruti Zusman for always kindly assisting me with any issue I had.

Finally, I thank my dear family and friends for always being there for me, for their endless love and support, and for their enthusiastic interest in my research, even though they don't really care about linguistics.

Abstract

There are two opposing, though partially overlapping approaches to language acquisition: one approach holds that language learning is entirely *experience-dependent*, where learning is made by general cognitive capacities (Langacker 1987, Tomassello 2003); The other approach holds that in addition to the experience-dependent elements of the learning mechanism, there are also *experience-independent* elements which facilitate acquisition (Chomsky 1959, 1968, 1986).

These two approaches make different predictions with respect to the moraic structure of CVC syllables in early Hebrew speech, specifically, whether codas are moraic or not. Hebrew is considered a quantity insensitive language, and it does not provide evidence for moraic codas (Bat-El 1993, Bat-El et al. 2019 among others). Based on the children's input, the experience-dependent approach predicts non-moraic codas in the early speech of Hebrew-acquiring children. In contrast, the experience-independent approach predicts moraic codas; this prediction is based on the Markedness » Faithfulness bias (Tesar and Smolensky 2000) and the ranking of two conflicting constraints: the universal markedness constraint WEIGHT-BY-POSITION (Hayes 1989, 1995) which assign a mora to a coda consonant, and the faithfulness constraint DEPμ, which prohibits the addition of moras. Given the initial state of Markedness » Faithfulness, WEIGHT-BY-POSITION outranks DEPμ, which yields an initial state of moraic codas. Crucially, this initial state is expected to manifest children's grammar regardless of the moraicity status in their ambient language.

This study examines the moraic status of codas in corpus-based data drawn from the natural speech of two Hebrew acquiring children during early stages of their phonological development. The findings show a significant contrast between the development of final CV vs. CVC syllables in the children's early speech, a contrast which I attribute to syllable weight. This contrast was found in two prosodic aspects: the minimal word and stress.

The minimal word is addressed here in terms of number of syllables. During their early speech, both children produced C-final outputs as monosyllabic (CVC) while V-final outputs were disyllabic ((C)VCV), regardless of the structure of the target word. This contrast, which occurred during the minimal word stage, suggests that children analyze codas as moraic, as CVC productions with a moraic coda form the unmarked binary foot, which satisfies the MINIMAL WORD constraint (McCarthy and Prince 1986), known to play a key role in language acquisition (Demuth and Fee 1995). While monosyllabic CVC outputs form a binary foot, monosyllabic CV outputs do not, thus V-final outputs are disyllabic.

In the development of stress, the children showed a high degree of faithfulness to final stress in C-final outputs (CVCV́C) and a significantly lower degree of faithfulness to final stress in V-final outputs, in which stress-shift was frequent (CV́CV). Additionally, final codas were often deleted in outputs corresponding targets with non-final stress, while in outputs corresponding to targets with final stress final codas were usually preserved. Here as well, the results indicate moraic codas and a quantity sensitive system. Under a moraic analysis, C-final outputs with final stress and a moraic final coda correspond to the uneven iambic foot, while V-final outputs with final stress correspond to the even iambic foot. In such a case, the higher faithfulness to final stress in C-final productions is expected, as the uneven iamb, where the stressed syllable is also heavy, is less marked than the even iamb (Hayes 1995). The avoidance of final codas in outputs corresponding to targets with non-final stress also indicates coda moraicity; children cannot be faithful to non-final stress while producing final codas, since the final heavy syllable would naturally attract stress. Thus, children delete the final coda in outputs with non-final stress until codas are not moraic and their system is no longer quantity sensitive.

This study suggests that during early stages of Hebrew speech, a coda does not only extend the syllable structure, but also serves as a weight-bearing unit. An examination of Hebrew lexicon, as well as child directed speech and the children's targets, shows that the findings of this research cannot origin in the children's input, where the contrast between V-final and C-final words is not prosodically relevant. These findings thus support the experience-independent approach, as the Hebrew acquiring children assign a mora to codas following the universal constraint WEIGHT-BY-POSITION.

The findings of this study are analyzed within the framework of Optimality Theory (Prince and Smolensky 1993), and based on the Markedness » Faithfulness bias (Tesar and Smolensky 2000). The analysis shows the gradual transition of the children's productions from maintaining a quantity-sensitive system to being more and more faithful to the phonological patterns of their ambient language. The gradual transition, if so, shows the effect of universal principles during early speech, and the language-specific effects during later stages of acquisition.

THE MARKEDNESS OVER FAITHFULNESS BIAS:

CODA MORAICITY IN EARLY HEBREW SPEECH

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1. Introduction

It is uncontroversial that language is a complex system which requires many cognitive abilities, but there are yet some points of disagreement regarding the mechanism that facilitates its acquisition. Two opposing, though partially overlapping approaches of language knowledge and acquisition offer different proposals. One approach holds that language learning is entirely *experience-dependent*, where learning is made by general cognitive capacities, including statistical learning (Langacker 1987, Tomassello 2003). The other approach holds that in addition to the experience-dependent elements of the learning mechanism, there are also *experience-independent* elements, which I address here as universal principles, that are specific to the knowledge of language (Chomsky 1959, 1968, 1986). The debate thus boils down to *whether universal principles play a role in language acquisition*.

This study evaluates these two approaches with regard to coda moraicity in word final position during the early stages of Hebrew speech (ages 1-2 years). Hebrew does not have phonological phenomena that suggest that codas are moraic, and in particular, its stress system suggests that there is no weight contrast between CV and CVC syllables (Bat-El 1993, Bat-El et al. 2019 among others). Hebrew-acquiring children are thus exposed to input that does not provide evidence for moraic codas.

Given this input, the *experience-dependent* approach predicts that the contrast between word final CV and CVC syllables will not play a role in the prosodic development of Hebrew acquiring children (beyond the added complexity of a consonant in coda position), as it does not play a role in their input. The *experience-independent* approach, however, predicts that the contrast between CV and CVC syllables will be manifested in the children's early productions. This prediction is based on the initial state hypothesis (Tesar and Smolensky 2000) of Optimality Theory (Prince and Smolensky 1993), according to which markedness constraints are ranked above faithfulness constraints at the onset of language development (hereafter the M»F hypothesis). With the dominance of the markedness constraint WEIGHT-BY-POSITION (W-BY-P » DEPμ; Hayes 1989, 1995) during the initial state, it is predicted that all children, regardless of their ambient language, assume moraic codas, until they receive evidence for the contrary.

The findings of this research support the *experience-independent* approach, showing the effect of universal constraints during early stages of acquisition. The children studied here showed a significant contrast between C-final and V-final words in their productions. This contrast was found in two prosodic aspects – the minimal word and the stress patterns. With respect to the minimal word, which is addressed here with

reference to the number of syllables, the findings showed a period of time where C-final outputs were monosyllabic (CVC), while V-final outputs were already disyllabic ((C)VCV). With respect to stress, and considering disyllabic productions, C-final outputs were significantly more faithful to final stress than V-final outputs, where in the latter stress shift was common.

I attribute these findings to the Markedness » Faithfulness bias during the initial state, and specifically to the ranking of W-BY-P » DEPμ, which yields moraic codas. With respect to the results of the minimal word, CVC productions with a moraic coda correspond to the unmarked binary foot, which satisfies the MINIMAL WORD constraint (McCarthy and Prince 1986), known to be active during early stages of language acquisition (Demuth and Fee 1995). With respect to stress, C-final outputs with final stress and moraic codas correspond to an uneven iambic foot, in which the stressed syllable is also heavy. In contrast, V-final outputs with final stress correspond to an even iambic foot, in which both syllables bear the same weight. In such a case, the higher faithfulness to final stress in C-final productions is expected, since the uneven iamb is universally preferred over the even iamb, as stress naturally prefers to be hosted by a heavy syllable (Hayes 1995).

Crucially, the results of this study cannot be attributed to the children's input, as it does not provide evidence for moraic codas or a quantity sensitive system. Nevertheless, with the gradual increase of linguistic experience, the prosodic differences between C-final and V-final outputs decreases, and language-specific properties show their effect as the children gradually become more faithful to Hebrew's phonological patterns (where language-specific refers to patterns that are attributed to Hebrew grammar, but not to Universal Grammar).

The thesis is organized as follows. In §2, I present the two main approaches to language acquisition: the *experience-dependent* approach (§2.1) and the *experience-independent* approach (§2.2). I then continue to the relevant theoretical background in §3. I present the theory of Moraic Phonology and review its implications with reference to the phonological aspects examined here (§3.1). I then continue with the research question and the general predictions made by the two approaches (§3.2).

In §4, I provide the phonological background of Hebrew with respect to syllable structure and its distribution (§4.1), stress (§4.2), and the minimal word (§4.3). The following §5 is dedicated to the acquisition of Hebrew, where I discuss the acquisition of the prosodic word (§5.1), stress (§5.2) and codas (§5.3).

After providing the relevant background, I turn to the current study. I start with the methodology in §6, where I present the data collection (§6.1) and data selection (§6.2). I then continue in §7 to the results of the study, presenting the contrast between C-final and V-final words that were found in the children's productions, focusing on the minimal

word (§7.1.1), stress (§7.1.2), and the interaction between them (§7.1.3). I end this section with a theoretical analysis within the framework of Optimality Theory (§7.2). I conclude and discuss future implications in §8.

2. Approaches to language learning

The nature of the resources available to the child acquiring her/his mother tongue have been subject of heated debate between the *experience-dependent* approach (§2.1), associated with Cognitive Linguistics (also Usage-based Linguistics), and the *experience-independent* approach (§2.2), associated with Generative Linguistics. Both approaches assume that children are equipped with mechanisms that are essential for acquiring their first language, and both agree that these mechanisms require sufficient input in order to succeed in acquiring a language. They differ, however, as to whether these mechanisms are entirely experience-dependent, or include also experience-independent elements.

In what follows, I present the two approaches and their main claims. Though these approaches also refer to the linguistic knowledge in general, I focus on their differences regarding the acquisition of first language.

2.1. The experience-dependent approach – Cognitive Linguistics

The experience-dependent approach holds that the linguistic ability is part of the general cognitive capacity of humans. The knowledge and use of language employ cognitive processes and abilities that are used in non-linguistic phenomena as well (Langacker 1987, Gerken 1994, Saffran et al. 1996, Tomassello 2003). This approach is held by the Usage-based Linguistics approach, which has evolved from earlier research within Cognitive Linguistics framework, all of which share the hypothesis that language is an extension of other cognitive domains. Usage-based linguistics assumes that the knowledge of language consists of not only language structure, but the relation between linguistic structure and its usage, in human cognition and interaction (Langacker 1987). Thus, this approach examines the effects of frequency and processing, together with the symbolic dimension of language (i.e. the social and communicative intentions of humans when using language), on the development and organization of linguistic knowledge (Tomassello 2003, Diessel 2007).

In the field of language acquisition, the experience-dependent approach suggests that children use general cognitive skills and mechanisms, such as intention-reading, pattern-finding, statistical learning, induction and analogy, to construct a grammar based on generalizations and patterns, drawn from the input provided by the ambient language. With respect to statistical learning, Saffran, Aslin and Newport (1996) show the ability of young infants to extract word segmentation through transitional probabilities between different syllables, with a minimal exposure to their language. Crucial for the claim is that statistical learning is used in domains other than language, such as music and vision

(Saffran et al. 1999). The abilities of statistical learning, together with the understanding of the communicative intentions of adults, enables the efficient learning process that children show in acquiring their first language (Tomassello 2003).

Crucially, the experience-dependent approach rejects the innateness hypothesis of language, according to which some of the linguistic knowledge is specific to language and inherent to humans (Chomsky 1966, Putnam 1967). Although humans are biologically prepared for the significant task of language learning (as they are equipped with the cognitive abilities detailed above), this biological preparation is not specific to language and it does not include explicit types of linguistic representations (Tomassello 2003).

The outcome of the acquisition process is a system of patterns and generalizations of structural constraints. In this system, phonological patterns are the result of non-linguistic mechanisms that are not specialized for phonological computation (auditory perception, motor control etc.). Moreover, the common phonological characteristics across and within languages originate from phonetic constraints, and not from a phonological grammar (Gerken 1994, Hale and Reiss 1998, Tomassello 2003).

Within this approach, children acquiring a language are expected to follow the patterns available to them from the very early stages of development, subject to auditory and motoric limitations. That is, early productions are expected to show the frequent structures of the ambient language and the motorically less-complex ones (Tomassello 2003).

2.2. The experience-independent approach – Generative Linguistics

The experience-independent approach suggests that there is a biological nature of language, and that some aspects of the linguistic capacity are specific to language (Chomsky 1959, 1968, 1986). This claim is primarily based on two notions of Generative Linguistics: *the poverty of stimulus* (Chomsky 1986), according to which the linguistic data that children are exposed to is not rich enough to acquire such a complex system; and *the logical problem of language acquisition* (Chomsky 1981), which raises the question as to how do children learn their language so quickly and efficiently despite the impoverished input available to them.

According to the experience-independent approach, language learning is indeed based on linguistic experience and general cognitive abilities, but these are not sufficient, as learning a complex system such as language is not possible without a priori restrictions and biases on the learning scope. Innate linguistic representations may form such restrictions, making the ambient language a much more reachable destination. For example, in order for the children to draw conclusions from statistical information, they

need to know what kind of statistical information to consider out of the large range of statistical correlations exist to them. An innate knowledge of phonological structure, for example, is a prerequisite for drawing statistical conclusions about syllables (Yang 2004).

Universal Grammar (UG; Chomsky 1968) is one way to formulate the innate linguistic ability of humans. UG is the core linguistic knowledge that humans share; it contains linguistic principles and structural constraints, which formulate the use of language and restricts its learning, thus explaining the efficiency of acquisition (Yang 2004, Berent 2013). These principles are universal, as they describe the cross-linguistic similar structural properties, which are also the most frequent within a language and within the productions of children acquiring a language.

While UG accounts mainly for syntactic phenomena (Chomsky 1981), there are theoretical models applying UG to phonology as well, one of which is Optimality Theory (OT; Prince and Smolensky 1993). According to OT, the grammar is an input-output mechanism which yields the optimal output based on ranked constraints. Within OT, UG consists of universal constraints, and the differences among languages is manifested by the relative ranking of these constraints, resulting in different grammars. Constraints are divided into markedness constraints, which limit the output's structure, and faithfulness constraints, which require identity between the input and the output (see §7.2).

Within the framework of OT, Tesar and Smolensky (2000) argue that in the initial ranking in language development, faithfulness constraints are ranked below markedness constraints. This means that the child starts with the smallest phonological inventory, and early productions are expected to show the universal unmarked structures regardless of the target grammar. The final ranking in the ambient grammar is achieved when the child gets positive evidence for a marked structure, which promotes the demotion of the relevant markedness constraints below the competing faithfulness constraints.

3. Prosodic Phonology and coda moraicity

This study focuses on the moraic status of word final codas in the acquisition of Hebrew, addressed with respect to two phonological aspects: the minimal word and the stress patterns. In this section, I present the theory of Moraic Phonology, which is directly related to the phonological aspects examined here.

Moraic Phonology centers around the mora, a sub-syllabic weight unit within the prosodic hierarchy (Figure 1), which is, in turn, a finite set of universal phonological units organized in a hierarchical relation (Selkirk 1980, McCarthy and Prince 1986, Nespor and Vogel 1986). Every prosodic unit exists on an independent level within the hierarchy and consists of the element of the following lower level.

PrWd Prosodic Word
|
Ft Foot
|
σ Syllable
|
μ Mora

Figure 1 The prosodic hierarchy

In the following section, I address the prosodic categories below the level of the prosodic word; the mora and the syllable structure with reference to Moraic Phonology, and the foot with reference to Metrical Phonology.

3.1. Moraic Phonology and its implications

Moraic Phonology (Hyman 1985, Hayes 1989) is a theory of syllable quantity, representing the internal structure of syllables with weight units. Different syllables may bear different weight, where each weight unit is represented by one *mora* (μ). A syllable's quantity is a function of its number of weight-bearing units; a monomoraic syllable is light and a bimoraic syllable is heavy. Considering the internal structure of syllable, the following patterns apply: onsets are not moraic (see, however, Topintzi 2008 for a different approach), syllable nuclei are moraic, but the moraicity of codas is language specific. In some languages codas are moraic, in others they are non-moraic, and in a few others they are moraic in some contexts and non-moraic in others (Hyman 1985, Kager 1989, Hayes 1995). The difference between light and heavy syllables is presented in Figure 2.

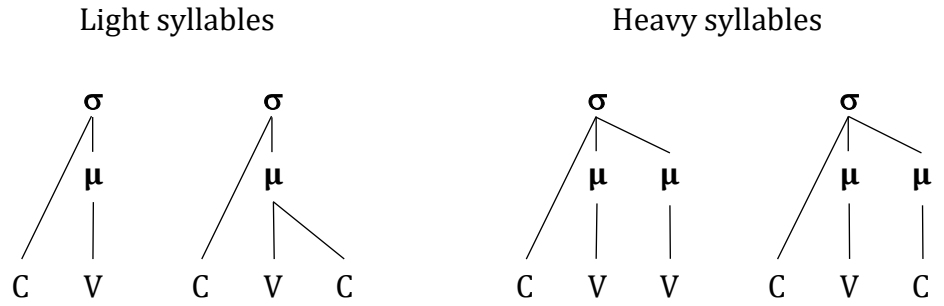


Figure 2 Syllable weight

Universally, as shown in Figure 2, CV syllables are monomoraic and thus light, while CVV syllables are bimoraic and thus heavy; as for CVC syllables – their weight depends on whether the coda consonant is moraic or not. The weight of the coda consonant is determined by the relative ranking of WEIGHT-BY-POSITION (W-BY-P), which assigns moras to coda consonants (Hayes 1989, 1995). W-BY-P conflicts with the faithfulness constraint, DEPμ, which prohibits the addition of moras to the representation. This interaction works under the assumption that moras are not presented in the underlying representation, unless the contrast between geminates and singletons or between glides and high vowels is phonemic (Hayes 1989).

Several prosodic aspects and phonological processes were shown to be closely related to syllable weight, two of them are relevant to this study: the minimal word and stress.

The minimal word is the universally unmarked structure of the prosodic word, representing the size restrictions languages apply on words (McCarthy and Prince 1986). The size restriction, acts in OT as the MINIMAL WORD constraint, which combines the constraint derived from the prosodic hierarchy (see §3), where every prosodic word contains a foot, and FOOT BINARITY, which requires feet to be binary, where binarity is considered at the moraic or syllabic level. When binarity is considered at the syllabic level, roots smaller than a disyllabic foot are often expanded via epenthesis, unless an affix is added (1a, 1b). When binarity is considered at the moraic level, a sub-minimal foot is expended with the addition of a mora, which does not necessarily entail an additional syllable. This can be done by lengthening the vowel (1c) or by adding a moraic coda (1d).

(1) Augmentation to satisfy the MINIMAL WORD constraint

a.	Hare	/jɛ/	[**hɛ**jɛ]$_{FT}$	'sing.3rd.sg'	(Rice 1990)
b.	Iraqi Arabic	/drus/	[**i**drus]$_{FT}$	'study'	(Broselow 1995)
c.	Levantine Arabic	/sʔal/	[sʔaːl]$_{FT}$	'ask.msc.sg'	(Broselow 1995)
d.	Huariapano	/kipin/	[ki**h**]$_{FT}$[pin]$_{FT}$	'open'	(Parker 1994)

Stress is another phonological aspect that is closely related to syllable quantity. In order to represent stress with relation to weight, I briefly review the theory of Metrical Phonology (Liberman and Prince 1977, Hayes 1980, 1995 Halle and Vergnaud 1987). According to Metrical Phonology, stress is a rhythmic phenomenon represented by strong–weak relations between syllables (or moras). The rhythmically strong syllable is the stressed one, and the weak syllable is the unstressed one. Metrical Phonology represents stress using the prosodic hierarchy, where each level bears one strong unit; the prosodic word bears a strong foot, which bears a strong syllable. The weak-strong relation between syllables is represented within the foot level, and the weak–strong relation between feet is represented on the next-higher prosodic level of the PrWd. These relations are represented in Figure 3, which shows a metrical tree for the English word *æləbǽmə* 'Alabama'. For each prosodic level, the strong unit is represented by 'S' and the weak unit by 'W'.

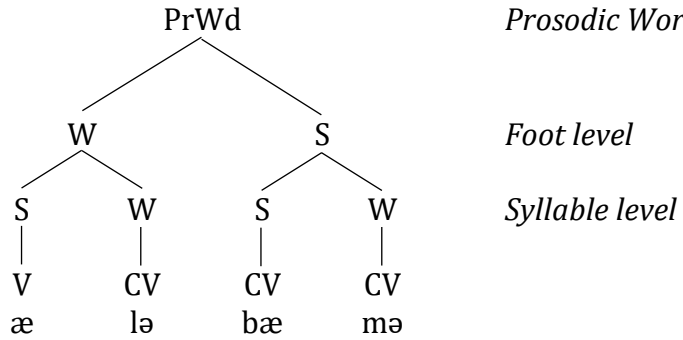


Figure 3 Metrical structure of *æləbǽmə* 'Alabama'

As noted above, stress is closely related to syllable weight. An extensive research on word stress shows that there is a strong tendency among stress languages to match syllable weight and prominence. That is, stress has a universal nature of being sensitive to quantity, and it naturally prefers to be hosted by a heavy syllable (Hayes 1995). The quantity sensitivity of stress is exhibited in two ways. The first is when prominence is being adapted to quantity, that is, when heavy syllables attract stress. The second is where quantity is being adapted to prominence, where the stressed syllable becomes heavy by an addition of a weight unit (e.g. vowel lengthening or coda addition).

Considering syllable quantity, Metrical Phonology assumes the universal inventory of feet presented in Figure 4 (Hayes 1985, McCarthy and Prince 1986, Kager 1993). Light syllables are represented by 'L' and heavy syllables by 'H'. The stressed syllables are marked in bold and the unmarked feet are shaded.

Trochaic feet:	[**L**L],	[**H**L],	[**H**]
Iambic feet:	[L**H**],	[L**L**],	[**H**]

Figure 4 Feet inventory

On his cross-linguistic research, Hayes (1995) shows that final stress is assigned in quantity sensitive systems, while non-final stress is assigned in quantity insensitive systems. Accordingly, even trochees are universally preferred over uneven trochees ([**L**L] > [**H**L]), and uneven iambs are preferred over even iambs ([L**H**] > [L**L**]).

Keeping in mind the theoretical background and universal principles addressed thus far, I continue to the current study.

3.2. Research question and predictions

This study addresses the role of universal grammar and language-specific effects in acquisition, focusing on the moraicity of word final codas in Hebrew. As mentioned in §3.1, moraic codas are the effect of the markedness constraint WEIGHT-BY-POSITION (W-BY-P; Hayes 1989, 1995), which adds a mora to a coda consonant. W-BY-P conflicts with the faithfulness constraint DEPμ, which prevents the addition of moras. Under the assumption that markedness constraints are ranked above faithfulness constraints in the initial state of language development (Tesar and Smolensky 2000), the ranking predicted at the onset of speech is W-BY-P » DEPμ. That is, assuming the M»F bias, codas are predicted to be moraic in early stages of acquisition regardless of the ambient language.

In some languages, such as English, universals and language-specific effects converge, as the language provides data supporting moraic codas (Demuth 1996). In Hebrew, however, codas are not moraic (see §4), thus universals and language-specific effects conflict; the ranking of the initial state, where W-BY-P » DEPμ, is different from the ranking in Hebrew, in which DEPμ » W-BY-P. In the absence of evidence for moraic codas, the question addressed in the present study is: ***Do children assume moraic codas during early stages of speech?***

This question gives rise to two main hypotheses, which correspond to the two approaches reviewed in §2 – the *experience-dependent* approach and the *experience-independent* approach. With regard to the acquisition of phonology, these two approaches sometimes make the same predictions, as universal markedness constraints are often phonetically grounded (Gerken 1994, Hale and Reiss 1998, Hayes et al. 2004). However, these approaches make different predictions regarding coda moraicity in the acquisition of Hebrew.

The *experience-dependent* approach predicts that Hebrew acquiring children will not assign weight to codas, as there is no evidence for coda moraicity in the children's input. In which case, we do not expect early speech to show a prosodic contrast between V-final and C-final productions that is based on syllable weight.

The *experience-independent* approach assumes that codas will be moraic in early speech, regardless of the moraicity status of the ambient language. Thus, this approach predicts a contrast between final CV and CVC syllables in the prosodic development of Hebrew acquiring children. In such case, we would expect early speech to show a prosodic difference between V-final and C-final productions which is based on syllable weight. On the basis of positive evidence, Hebrew acquiring children will later on demote W-BY-P, gradually following Hebrew grammar.

As will be shown in §7, Hebrew acquiring children do show a prosodic contrast between C-final and V-final productions, a contrast which is attributed the the moraicity of final codas during early stages of development, thus supporting the notion of Universal Grammar and the M » F bias. However, before turning to the results of this study, I provide a brief background of Hebrew phonology and Hebrew acquisition, focusing on prosodic development.

4. Hebrew phonology

In this section, I lay out the relevant phonological background of Hebrew, starting with syllable structure and its distribution (§4.1), Hebrew stress system (§4.2) and Hebrew minimal word (§4.3). Throughout these sections, I address the phonology of open-class words, mostly nouns and verbs.

4.1. Syllable

A native Hebrew word usually consists of two-to-three syllables; words with more than three syllables are rare. There are also monosyllabic words, which are monomoraic and sub-minimal, but their frequency in the lexicon, as shown in Table 1, is rather low.[1]

	Nouns	*Verbs*	*CDS*
Monosyllabic	5%	3%	10%
Disyllabic	47%	83%	58%
Trisyllabic	35%	13.5%	30%
Quadrisyllabic	13%	0.5%	–

Table 1 Distribution of word-size (by syllable)

Most of Hebrew noun and verb stems are disyllabic, yet the addition of some inflectional suffixes increases the frequency of trisyllabic words, as the suffix forms an additional syllable (see Bat-El 1989, 2008 for inflectional and derivational paradigms of open-class words). Taking inflectional paradigms into account, an examination of word length in CDS shows the frequency of 10% monosyllabic, 58% disyllabic and 30% trisyllabic words within the open-class group (Segal et al. 2009).

Hebrew has a rich syllable inventory, but the most common syllables are CV and CVC, with a total frequency of ~86%. Syllables with a coda constitute about 45% of all syllables in Hebrew, and they appear mostly in word-final positions. Looking into the two main lexical categories, ~68% of Hebrew nouns (Bolozky 2008) and ~78% of Hebrew verbs (Asherov and Bat-El 2019) are C-final. Complex onsets and codas appear only at the edges of the word, and they are quite rare, more so complex codas than complex onsets (Asherov and Bat-El 2019). The following table, adopted from Asherov and Bat-El (2019), shows syllable structure by position in native Hebrew words.

[1] The count of nouns is based on Bolozky and Becker's (2010) dictionary of 12,043 Hebrew nouns. The count of verbs is based on Bolozky's (2008) list of 499 most frequent verbs (107,984 tokens). The distribution of syllable structure in CDS (Child Directed Speech) is based on Segal et al. (2009).

(2) Hebrew syllable structure

	Word initial		*Word medial*		*Word final*	
CV	**kó**.va	'hat'	ʁa.**ké**.vet	'train'	a.fu.**ná**	'pea
CVC	**χul**.t͡sá	'shirt'	hit.**bal**.bél	'got confused'	χa.**túl**	'cat'
V	**a**.dóm	'red'	ne.**e**.bád	'got lost'	ʁi.bú.**a**	'square'
VC	**áʁ**.tik	'popsicle'	ne.**el**.mú	'disappeared'	pá.**am**	'once'
VCC					ʃa.**ált**	'you.FM asked'
CCV	**kta**.ná	'small.FM'				
CCVC	**t͡sfaʁ.**dé.a	'frog'				
CVCC					a.**máʁt**	'you.FM said'

The frequency of syllable types in Hebrew complies with the universal markedness of syllables and the preference for the less marked structures (Clements and Keyser 1983). Overall, the less marked syllables are more frequent in the language.

There is no length contrast in Hebrew vowels, nor weight contrast between different types of syllables (see §4.2). These two properties indicate that *moras* do not have a prosodic role in Hebrew phonology, i.e. codas are not moraic (Bat-El 1993, Bat-El et al. 2019 and many others).

4.2. Stress system

Most Hebrew words bear final stress regardless of syllable structure. That is, syllables with and without a coda are treated alike with regard to stress, and thus the majority of C-final words does not affect Hebrew's stress system. Since stress is not sensitive to the internal structure of syllables, and there is no phonemic vowel length distinction, Hebrew is considered a quantity insensitive language where *mora* has no prosodic role in the grammar (Bat-El 1993, 2005, 2018; Bat-El et al. 2019). This generalization holds for nouns (§4.2.1), where stress is contrastive, as well as for verbs (§4.2.2), where stress is consistent and predictable.

4.2.1. Stress in nouns

Hebrew stress system is category-specific to a certain extent, distinguishing between the regular stress assignment in verbs and the somewhat chaotic stress assignment in nouns. The nominal stress system is contrastive and partially unpredictable. Stress in nouns is lexically specified for some nouns (Bat-El 1993), as there are many (near) minimal pairs (e.g. *mitá* 'bed' vs. *píta* 'pitta bread'). Stress in nouns can appear on any of the three rightmost syllables in the word, regardless of their structure, as shown in (3).

(3) Stress patterns in nouns

Stressed syllable	*Antepenultimate*		*Penultimate*		*Final*	
CV	**té**lefon	'telephone'	ʁa**ké**vet	'train'	sim**lá**	'dress'
	múzika	'music'	**kó**va	'hat'	afu**ná**	'pea'
(C)VC	**mík**ʁofon	'microphone'	**píl**pel	'pepper'	χa**túl**	'cat'
	ámbulans	'ambulance'	**sáv**ta	'grandma'	bak**búk**	'bottle'

When adding a suffix, stress can be mobile or immobile. In some nouns, stress remains on the stem (e.g. *pílpel-im* 'pepper-PL'), and in others it appears on the suffix (e.g. *bakbuk-ím* 'bottle-PL'). Additionally, some nouns show intra- and inter-speaker variation in stress (e.g. *balo**ním*** ~ *ba**ló**nim* 'balloons', *ʃam**pó*** ~ ***ʃám**po* 'shampoo'). That being said, final stress is very common in nouns, found in ~75% noun types, regardless of the structure of the final syllable (Adam and Bat-El 2009, Bat-El et al. 2019).

4.2.2. Stress in verbs

In contrast to nouns, the verbal stress system is regular and predictable. More than 95% of verb stems bear final stress, except for a small number of stems historically ending with a guttural. The stress patterns of suffixed verbs depend on the initial segment of the suffix, and the type of the stem. When a vowel-initial suffix is added, stress is final. When a consonant-initial suffix is added, stress is penultimate. In monosyllabic stems, and in stems in which the vowel in the final syllable is high, stress remines on the stem (Bat-El 2005, 2018; Bat-El et al. 2019).[2] That is, the addition of a suffix to such stems yields penultimate stress, as presented in (4). [3]

(4) Stress patterns in verbs

	Stem (3.MSC.SG.PST)	*V-initial suffix* (3.FEM.SG.PST)	*C-initial suffix* (1.SG.PST)	
High-V in stem final syllable	hi**píl**	hi**pí**l-a	hi**pál**-ti	'to drop'
Monosyllabic stem	ʃaʁ	**ʃáʁ**-a	**ʃáʁ**-ti	'to sing'
Elsewhere	ʃa**váʁ**	ʃav**ʁ-á**	ʃa**váʁ**-ti	'to break'

The above generalizations indicate that stress in verbs varies depending on syllable structure of the stem or the suffix, but not on the existence or absence of a coda.

[2] Only past and future tenses are considered in (4) since the present tense is participial and its stress patterns are similar to those of adjectives (Bat-El 2008).

[3] Other phonological processes in suffixed forms, such as vowel-deletion in */ʃavaʁ-a/* → *ʃavˈʁa*, are not relevant to this study and thus are not discussed.

To summarize, the above sections showed that Hebrew stress is mostly final, and it can reside on any syllable in terms of its structure. These patterns imply that Hebrew stress is not sensitive to weight, and that there are no data suggesting that codas are moraic.

4.2.3. Foot structure

Several different analyses were suggested to account for the Hebrew stress system, three of them within Optimality Theory: Becker (2002), Graf and Ussishkin (2003) and Pariente and Bolozky (2014). Crucially, all three analyses analyze feet as syllabic, that is, none of them assume moraic codas or a quantity sensitive stress system.

Becker's (2002) analysis assumes that feet are trochaic, and they are not necessarily aligned with the right edge of the prosodic word. FTBIN, which imposes binary feet, is ranked low in this analysis, thus feet can be either binary or degenerate; final stress forms a monosyllabic and monomoraic degenerate foot (e.g. *xa*[*túl*]$_{FT}$ 'cat'), and non-final stress forms either a binary syllabic foot (i.e. [*yéled*]$_{FT}$ 'boy') or a degenerate foot (i.e. [*yé*]$_{FT}$*led* 'boy'), both are applicable in this analysis.

Pariente and Bolozky (2014) offer an analysis of Hebrew nouns, which is similar to that of Becker (2002), also suggesting that feet are trochaic. The difference between the two analyses lays in the alignment of feet; while Becker (2002) does not assume an alignment of feet to the right edge of the prosodic word, Pariente and Bolozky (2014) do assume such an alignment, thus non-final stress necessarily corresponds to a binary syllabic foot (i.e. [*yéled*]$_{FT}$ 'boy'), and final stress corresponds to a monosyllabic foot (i.e. xa[*túl*]$_{FT}$ 'cat').

Pariente and Bolozky (2014) follow Graf and Ussishkin (2003) in assuming an alignment of feet with the right edge of the prosodic word. However, in contrast to the two other analyses, Graf and Ussishkin (2003) claim that all feet are binary syllabic. This entails two types of feet in the stress system: trochaic for non-final stress (e.g. [*yéled*]$_{FT}$ 'boy') and iambic for final stress (e.g. [*xatúl*]$_{FT}$ 'cat'). All three analyses are summarized in (5).

(5) Summarize of the analyses of Hebrew stress

	Feet type	*Alignment to the R edge*	*Binary feet*
Becker (2002)	Trochaic	No	No
Graf & Ussishkin (2003)	Trochaic & Iambic	Yes	Yes
Pariente & Bolozky (2014)	Trochaic	Yes	No

In this study, I adopt Graf and Ussishkin's (2003) analysis, since it better accounts for the inconsistent stress patterns in modern Hebrew. In contrast to other analyses proposed,

Graf and Ussishkin's (2003) analysis provides a unified account for the diverse stress patterns of different lexical categories in Hebrew lexicon, which in turn considers as regular stressed items many words that were previously analyzed as exceptions. Thus, according to Graf and Ussishkin's (2003) analysis, I assume both types of feet in Hebrew stress system – trochaic and iambic. Given that most Hebrew words bear final stress, the dominant foot is iambic. Another assumption I adopt in this study is that footing is not exhaustive (Becker 2002). Hebrew does not show phonetic realization of secondary stress (Becker 2002, Cohen et al. 2018, Bat-El et al. 2019), thus each prosodic word contains one foot, i.e. one stressed syllable. The table in (6) provides examples for each foot type.

(6) Mix foot structure

Trochaic foot		***Iambic foot***	
[**ké**teʁ]$_{FT}$	'crown'	[ʃo**méʁ**]$_{FT}$	'guard'
[**dé**ʃe]$_{FT}$	'grass'	[ʁo**fé**]$_{FT}$	'doctor'
aʁ[**né**vet]$_{FT}$	'rabbit.FM'	maʃ[ʁo**kít**]$_{FT}$	'whistle'
ba[**ná**na]$_{FT}$	'banana'	ma[ta**ná**]$_{FT}$	'gift'

As noted at the beginning of this section, there are several different analyses for the Hebrew stress system, yet none of them claim that codas are moraic or that the stress system is weight sensitive. This is not a coincidence – Hebrew stress system does not show a contrast between C-final and V-final syllables, thus there is no reason to assume such a contrast in the analysis.

4.3. Minimal word

Recall from §3.1 that languages may apply a size restriction on feet to a binary word minimal and/or maximal size, known as the MINIMAL WORD constraint. The binarity restriction may be considered at the moraic level or at the syllabic level within the prosodic hierarchy. Since Hebrew codas are not analyzed as weight-bearing units (see §4.2), and vowel length is not contrastive (see §4.1), a monosyllabic word cannot form a binary foot, and thus Hebrew minimal word is disyllabic.

The requirement of the MINIMAL WORD constraint for a minimum and/or maximum number of syllables within a foot in Hebrew grammar is manifested in many environments, the main one of which is in the formation of verbs. For example, Hebrew verb stems are maximally disyllabic, as well as verbs in many verbal paradigms (Bat-El 1994, Ussishkin 1999), and denominative verbs are minimally and maximally disyllabic

(Bat-El 1994, Ussishkin 2000). That is, Hebrew shows the role of the MINIMAL WORD in both its minimal and maximal requirements.

5. The acquisition of Hebrew prosodic structure

The acquisition of phonology is addressed here in light of the prosodic hierarchy (see §3). In language development, prosodic units are acquired gradually, where each prosodic category may have its own development path. The prosodic units relevant to this study are the ones that constitute the prosodic word, namely *moras*, *syllables* and *feet*. In what follows, I address the acquisition of prosodic word, with reference to the minimal word and number of syllables (§5.1), the acquisition of stress, considering foot structure (§5.2), and the acquisition of codas, with reference to moras and syllable position (§5.3).

5.1. Prosodic word

The development of the prosodic word among Hebrew acquiring children follows four main stages (Ben-David 2001, 2012, Adam 2002, Ben-David and Bat-El 2016). All stages are associated with the stress patterns of the target words, as well as with the MINIMAL WORD restriction on the word size to a binary foot, known to be highly active in language acquisition (Demuth and Fee 1995). Recall from §4.3 that Hebrew codas are not moraic, and vowel length is not contrastive, and thus the Hebrew minimal word is disyllabic.

The first stage in the development of the prosodic word is the *sub-minimal word stage*, where productions are monosyllabic regardless of the number of syllables in the target word. Given that monosyllabic words in Hebrew are quite rare (see §4.1), the majority of monosyllabic outputs during this stage are a result of truncation. The non-truncated syllables are mostly the final and/or stressed ones, due to their acoustic prominence (Echols and Newport 1992). When these two properties do not converge, i.e. when the final syllable is not stressed, the final syllable is the one that is usually retained, and the non-final (stressed) syllables are truncated (Ben-David and Bat-El 2017).

The sub-minimal word stage is quite short for Hebrew-acquiring children (Ben-David 2001, 2012). However, an examination of the development of a child with slow phonological development shows that this stage can be longer in atypical development (Adam and Bat-El 2008a, Haim 2020).

The second stage is the *pre-minimal word stage*. During this stage, there are still monosyllabic productions, corresponding to the final syllable in targets with final stress, but there are also disyllabic trochaic productions for targets with penultimate stress. Outputs are maximally disyllabic during this stage, even if the target word consists of more than two syllables.

The third stage in the development of the prosodic word is the *minimal word stage*, where productions for polysyllabic targets are disyllabic and form a binary foot. In contrast to the pre-MW stage, productions during the minimal word stage are disyllabic regardless of the target's stress pattern, and there are productions of both types of feet – trochaic and iambic. During this stage, outputs are maximally disyllabic, thus targets with more than two syllables are truncated. Besides disyllabic productions, there are also some monosyllabic CVC outputs during this stage. Although CVC syllable in Hebrew is sub-minimal, Ben-David (2001) notes that it is possible that during early stages of acquisition, children consider CVC as binary and thus minimal. This suggestion will be supported by the current study.

The final stage in the development of the prosodic word is the *post-minimal word stage*. During this stage, there are productions that are longer than two syllables, as children try to be more faithful to the number of syllables in trisyllabic and quadrisyllabic targets. Examples of productions during each stage are presented in (7) (data obtained from Ben-David 2012).

(7) Stages of prosodic word development

	Trochaic targets				***Iambic targets***			
	Output		*Target*		*Output*		*Target*	
Sub-MW	1σ	ma	máim	'water'	1σ	du	kadúʁ	'ball'
Pre-MW	2σ	ége	ʁégel	'leg'	1σ	da	todá	'thank you'
MW	2σ	téfo	télefon	'telephone'	1σ	tos	matós	'plain'
	2σ	bája	ambátja	'bathtub'	2σ	anáv	aʁnáv	'rabbit'
Post-MW	3σ	agévet	magévet	'towel'	3σ	ataná	mataná	'present'

5.2. Stress

Recall from §4.2 that most Hebrew words bear final stress, regardless of syllable structure; the percentage of words with final-stress in Hebrew lexicon and in child directed speech (CDS) stands at about 75% (Ben-David 2012). Since most Hebrew words bear final stress, the iambic foot is the dominant foot in Hebrew. However, despite the high frequency of the iambic foot in adult speech and CDS, the acquisition of Hebrew stress starts with the trochaic foot (Ben-David 2001, Adam and Bat-El 2009).

As was shown by Adam and Bat-El (2009), during the *pre-MW stage*, children prefer the trochaic foot, avoiding the iambic one in both target selection and productions. In their target words, children select more targets with non-final stress, even though the majority of Hebrew words bear final stress. In their productions, children avoid the iambic foot

while attempting an iambic target, using three main strategies. The most common one is truncation to monosyllabic – children truncate non-final syllables and produce the final and stressed one (*ba* for *bubá* 'dall'). In addition, stress shift is also used to avoid the iambic structure in productions (*káta* for *katáʁ* 'engine'), as well as an addition of a vowel to the end of the word (*púze* for *tapúz* 'orange'); however the latter is rare (Bat-El 2012). Crucially, the last two strategies form a trochaic output for an iambic target.

Considering the above, children produce more disyllabic outputs with non-final stress than with final stress. While disyllabic trochaic targets are selected more than iambic ones and produced as disyllabic with penultimate stress, disyllabic iambic targets are selected less than trochaic ones, and are mostly truncated to monosyllabic. Crucially, the *pre-MW* stage, where there is a strong preference for the trochaic foot, precedes the *MW stage*, where children start to produce disyllabic outputs with final stress, i.e. disyllabic iambic feet.

While the frequency of Hebrew stress patterns predicts the acquisition of the iambic foot before the trochaic foot, Hebrew acquiring children retain the trochaic foot prior to the iambic foot. Thus, as argued in Adam and Bat-El (2009), the preference of Hebrew acquiring children for non-final stress supports the Trochaic Bias in language acquistiion (Allen and Hawkins 1978).

5.3. Codas

Recall from §4.1 that Hebrew has a diverse inventory of syllable structures, but the most common syllables are CV and CVC. Syllables with codas form about 45% of all syllables in Hebrew words, and they appear mostly in word-final positions.

The acquisition of codas follows a few main stages, which are linked to the position of the coda (final vs. medial) and the prominence of the syllable hosting the coda (stressed vs. unstressed), both serve as factors in the order of acquisition (Ben-David 2001, 2012). As predicted by the Markedness » Faithfulness hypothesis (see §2.2), during the first stage of coda acquisition, children's productions are coda-less, since coda-less syllables are less marked. That being said, codas tend to be preserved in monosyllabic words without an onset in order to avoid consonant-free words (Ben-David 2001, Ben-David and Bat-El 2016). On the second stage, codas are produced in monosyllabic outputs. During the third stage, codas are produced when they appear in the final-stressed syllable of targets with final stress, as final and stressed syllables are more prominent than non-final ones in both perception and production (Echols and Newport 1992). During the fourth stage, codas are produced in all final syllables, regardless of stress. A summary of final coda development is presented in (8).

(8) Stages of final coda development

Stage		*aʁnáv* 'rabbit'	*áʁtik* 'popsicle'
1st	No codas	*na*	*ti*
2nd	Final codas in monosyllabic outputs	*na**v***	*áti*
3rd	Final codas in final & stressed positions	*aná**v***	*áti*
4th	Final codas in all final positions	*aná**v***	*áti**k***

Productions of medial codas appear on a later phase of development. The first medial codas produced are the ones appearing in a penultimate stressed syllable. Later on, medial codas are produced in all prosodic positions, regardless of stress.[4] Overall, the acquisition of codas begins with no productions of codas at all, followed by the acquisition of final codas, and the last to be acquired are medial codas.

Recall from §4.3 that codas in Hebrew are not analyzed as moraic, in adult speech nor in acquisition, and thus they do not serve as an additional component in the formation of feet. This study challenges this general claim, suggesting that the codas not only extend the syllable structure, but also serve as a weight-bearing unit in early Hebrew speech, as predicted by the M»F hypothesis (see §2.2). This study addresses only final codas, since medial codas are acquired at latter stages and are not produced during early speech, where the effect of universal principles may emerge.

[4] The production of medial codas is also dependent on the segmental properties of the coda and the onset in the following syllable. However, these factors will not be addressed here as medial codas are not relevant to this study.

6. Research method

6.1. Data collection and transcription

This study is based on longitudinal data drawn from the early speech (age 1-3 years) of two monolingual typically developing Hebrew acquiring non-identical twin boys – IM and SM. Their speech was recorded and transcribed as part of a research project on phonological acquisition held in Tel-Aviv university (PI: Outi Bat-El; ISF 1059/17). The twins are first borns, and their parents are monolingual native Hebrew speakers.

IM and SM were recorded during weekly meetings in their natural environment. The recordings started at the onset of their speech and continued up to the age of 2;11:24 for both children. Each session lasted for approximately one hour and included mostly spontaneous speech while interacting with the research assistant, their parents or each other.[5] The sessions also included naming tasks of pictures and objects. Recordings were made with a high-quality recorder. In addition to the recording sessions, we also received occasional videos of the children, which were recorded and sent by their mother. All recordings were phonetically transcribed according to the International Phonetic Alphabet (IPA) by trained phoneticians.

In studies on language acquisition, it is not only important to examine the structure of the production itself, but also the faithfulness to the attempted target word. Identifying the target word for each production was not always easy, since recordings began at early age, when the children's productions are not always clear. Sometimes, the adult recording the children repeated their target word; in other cases, the target word was determined by the child's production, while taking into consideration the context within the recording session. If the transcriber could not identify the target word for a specific production, the target was marked as 'unknown', and the output was later removed from the database.

During early stages of speech, there is no overt morphological structure in the children's productions. Since children start by producing the stressed and final syllables (see §5.1), inflectional verb prefixes do not surface. In such cases, the output is ambiguous, since it may correspond to several forms in the paradigm. For example, the output *táχ* may correspond to *patáχ* 'to open 3.MS.SG.PAST', *ti-ftáχ* 'to open IMP', or four more future forms. When such ambiguity arose, the target was transcribed using the sign *$* to indicate a missing prefix. Considering the previous example, the target word for the output *táχ* was transcribed as *$táχ* 'open'.

[5] We thank Gal Bero for the weekly recordings.

During early speech, there are also cases where the context requires a specific suffix, but the child's production does not include it. For example, in the utterance *aní aláχ* 'I walked', the grammatically correct form of the verb is *aláχ-ti* 'to walk 1.SG.PAST' and not *aláχ* 'to walk 3.MS.SG.PAST'. However, the target of the child's production is meant to represent the child's phonological target, which is not necessarily the grammatically correct one. Thus, when a suffix was not produced, it was not transcribed in the target word. For example, in the utterance *aní aláχ* 'I walked', the target of *aláχ* was transcribed as *aláχ* 'to walk 3.MS.SG.PAST' and not *aláχ-ti* 'to walk 1.SG.PAST', which is the grammatically correct form for the given context. Outputs with such morphological errors were marked with a side note in order to enable a specific examination of their development.

6.2. Data coding and selection

A database composed of the children's productions was constructed for each child separately (see Table 2). Outputs with an unknown target, as well as disrupted utterances (i.e. speaking while crying, singing or speaking with a pacifier), completions of adult utterances (i.e. the production *ba* after the adult said *bu-* for *buba* 'doll', waiting for the child to complete) and onomatopoeias (e.g. *tikták* for the sound of a clock) were excluded from the database. Overall, each database contained over 20,000 tokens.

In this study, I focus on content words (also known as 'open-class words' or 'lexical words'), which include nouns, verbs, adjectives and adverbs. Thus, productions of function words ('closed-class' or 'grammatical words'), including articles, conjunctions, pronouns, prepositions, quantifiers and question words were excluded from the data examined here. The focus on content words and the exclusion of function words origins in their different phonological behavior. Function words are prosodically "weak" and they usually do not form an independent prosodic word – they are subject to phonological reduction and undergo cliticization to content words, which serve as the prosodic host (Selkirk 1995; Nespor and Vogel 1986). After filtering out function words, each child had about 10 thousand tokens in his major-lexical items database.

	First recording	*Last recording*	*Total number of tokens*	*Major lexical items*
IM	0;11:28	2;11:24	27778	12904
SM	0;11:28	2;11:24	20878	9109

Table 2 Database (age key: years;months:days)

This study takes into account not only the phonological development of the children, but also their lexical development, because the phonological development and the lexical development correlates and affect one another (Stoel-Gammon 2011). For this reason, the data were organized into periods of lexical development (see Table 3) based on

vocabulary size (Adam and Bat-El 2009). Each period was calculated according to the cumulative number of new targets (lemmas) attempted by the child. The first period corresponds to 10 new lemmas, the second period corresponds to 50 new lemmas, and every subsequent period corresponds to 50 additional new lemmas. The lexical development periods serve as a methodological tool, allowing a comparison between children according to their linguistic development, and not only based on their age. Below are the first 14 lexical periods, as these were relevant for the present study on early speech. A complete table of lexical periods is provided in Appendix A.

Period	*Cumulative Lemmas*	IM	SM
1	~10	1;01:08	1;01:08
2	~50	1;04:01	1;04:12
3	~100	1;05:07	1;05:23
4	~150	1;06:04	1;06:23
5	~200	1;07:01	1;07:04
6	~250	1;08:04	1;08:04
7	~300	1;08:18	1;08:19
8	~350	1;09:03	1;09:15
9	~400	1;09:17	1;09:18
10	~450	1;10:12	1;10:15
11	~500	1;10:22	1;11:07
12	~550	1;10:27	1;11:18
13	~600	1;11:17	1;11:21
14	~650	1;11:19	2;00:01

Table 3 Periods of lexical development relevant to the present study

Both target and output were coded for lexical categories and prosodic properties (e.g. syllable structure, number of syllables, stress), where both coding of the subsequent analysis were made using Child Phonology Analyzer program (Gafni 2015).

7. The emergence of the unmarked: Results and analysis

7.1. Results

In this section, I present the findings drawn from the productions of the two children studied here (see Table 2). The findings show a clear contrast between V-final and C-final productions, manifested in two prosodic aspects: the minimal word (§7.1.1) and stress patterns (§7.1.2).

7.1.1. The minimal word

In this section, I provide evidence from the development of the minimal word, supporting the claim that the mechanism of language acquisition is also *experience-independent.* On the basis of the results presented below, I argue that codas are moraic at the initial state, despite the absence of evidence for moraic codas in Hebrew. I do so by showing that after a short stage of CV words, children produce either monosyllabic outputs with codas (CVC) or disyllabic outputs without codas ((C)VCV). I argue that both word types are bimoraic, satisfying the MINIMAL WORD constraint, known to be active in the children's phonological grammar (see §5.1).

It has been argued that in the acquisition of Hebrew, the MINIMAL WORD restricts the maximal size of the word – allowing productions that are maximally disyllabic, but not the minimal one, as monosyllabic targets are not enhanced (Ben-David 2001). Considering a moraic analysis of final codas, I argue that during early periods of development, the MINIMAL WORD functions as a restriction not only on the maximal size of the word, but also the minimal one.

I start this section with two contrasting predictions regarding the development of the minimal word, given by the two approaches discussed in §2. I continue with the results and analysis, and rule out alternative explanations for the data.

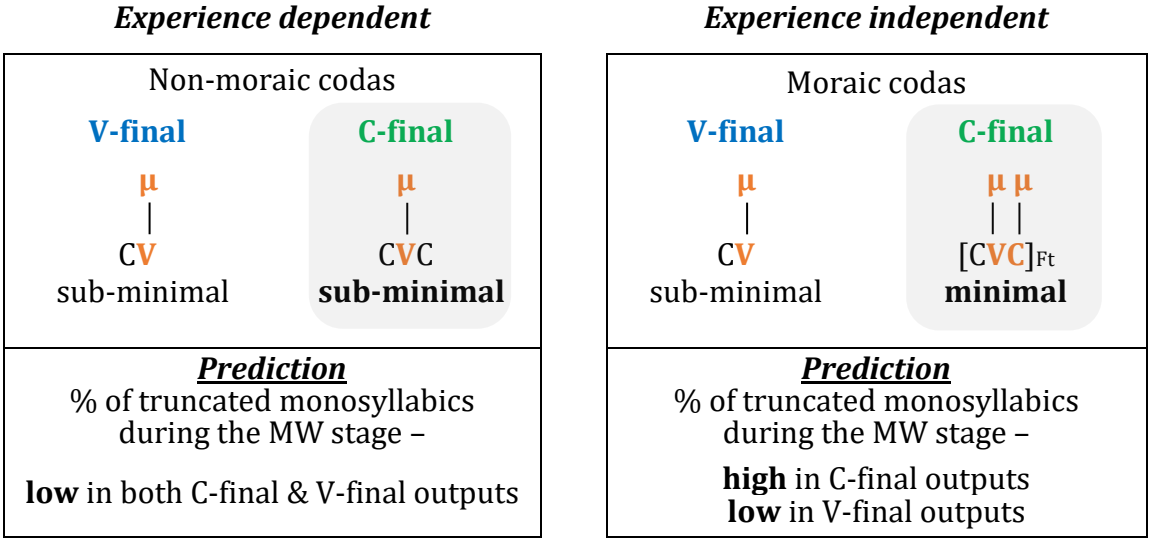
7.1.1.1. Predictions: As reviewed in §5.1, the development of the prosodic word up to the size of a minimal word (a binary foot) starts from the *sub-minimal word* stage, during which productions are monosyllabic, and gradually proceeds to the *pre-minimal word* and *minimal word stages*, where the maximal size of the children's productions is a binary foot, as children gradually add more syllables and produce disyllabic outputs.

The two approaches to language acquisition presented in §2 make different predictions with respect to the development of the minimal word in Hebrew-acquiring children.

Based on the children's input, the *experience-dependent* approach predicts non-moraic codas, because there are no data supporting a moraic contrast between C-final and V-final words. This means that both V-final and C-final monosyllabic productions (i.e. CV and CVC respectively) are mono-moraic and thus sub-minimal. In such a case, we expect productions with and without final codas to have a similar distribution, because both form the same sub-minimal structure, i.e. a monomoraic and monosyllabic word (the role of the additional consonant as a potential predictor is discussed in §7.1.1.2). At the sub-minimal word stage, the percentage of both V-final and C-final monosyllabic productions is expected to be high, and at the minimal-word stage, the percentage is expected to be low, as both types of productions do not form a binary foot.

Unlike the experience-dependent approach, the *experience-independent* approach predicts moraic codas, based on the Markedness » Faithfulness bias during the initial phase of development (see §2.2). During this phase, the universal markedness constraint WEIGHT-BY-POSITION assigns moras to codas, and consequently monosyllabic V-final productions correspond to a mono-moraic sub-minimal structure, while monosyllabic C-final productions correspond to a binary (moraic) foot. Due to mora assignment, CV and CVC differ with respect to the MINIMAL WORD constraint – CV violates it while CVC respects it, as it consists of a binary moraic foot. Thus, at the minimal word stage, we expect the percentage of CVC productions to be higher than that of CV, since the CVC productions form a bimoraic foot, thus satisfying the MINIMAL WORD constraint, while CV productions do not. Both predictions are presented below.

(9) Predictions for truncated monosyllabic productions during the minimal word stage



As shown below, the results obtained in the present study support the hypothesis based on the *experience-independent* approach, as there was a significant difference between CV and CVC syllables under several measures.

7.1.1.2. Results and account: Figure 5 below presents the percentage of truncated monosyllabic C-final vs. V-final outputs out of all C-final and V-final outputs (respectively), all corresponding to polysyllabic targets. The figures refer to truncated monosyllabic outputs for all polysyllabic targets, regardless of the final segment in the target word. That is, a V-final monosyllabic output was counted as part of V-final outputs regardless of whether its target was V-final or C-final. The figures display the results up to the 14th period since around that period both children gradually began to be more faithful in terms of number of syllables (see §6 for lexical periods). As emphasized in §2.2, the emergence of universal constraints is limited to early speech, before the children get closer to faithful productions. Since monosyllabic words are quite rare in Hebrew (see §4.1), the majority of monosyllabic productions are a result of truncation.[6] Thus, the following results provide an accurate picture with regard to the distribution of monosyllabic productions during early speech.

[6] The reference to monosyllabic words in Hebrew does not include monosyllabic function words, as function words were excluded from the dada due to their different phonological behavior (see §6.2).

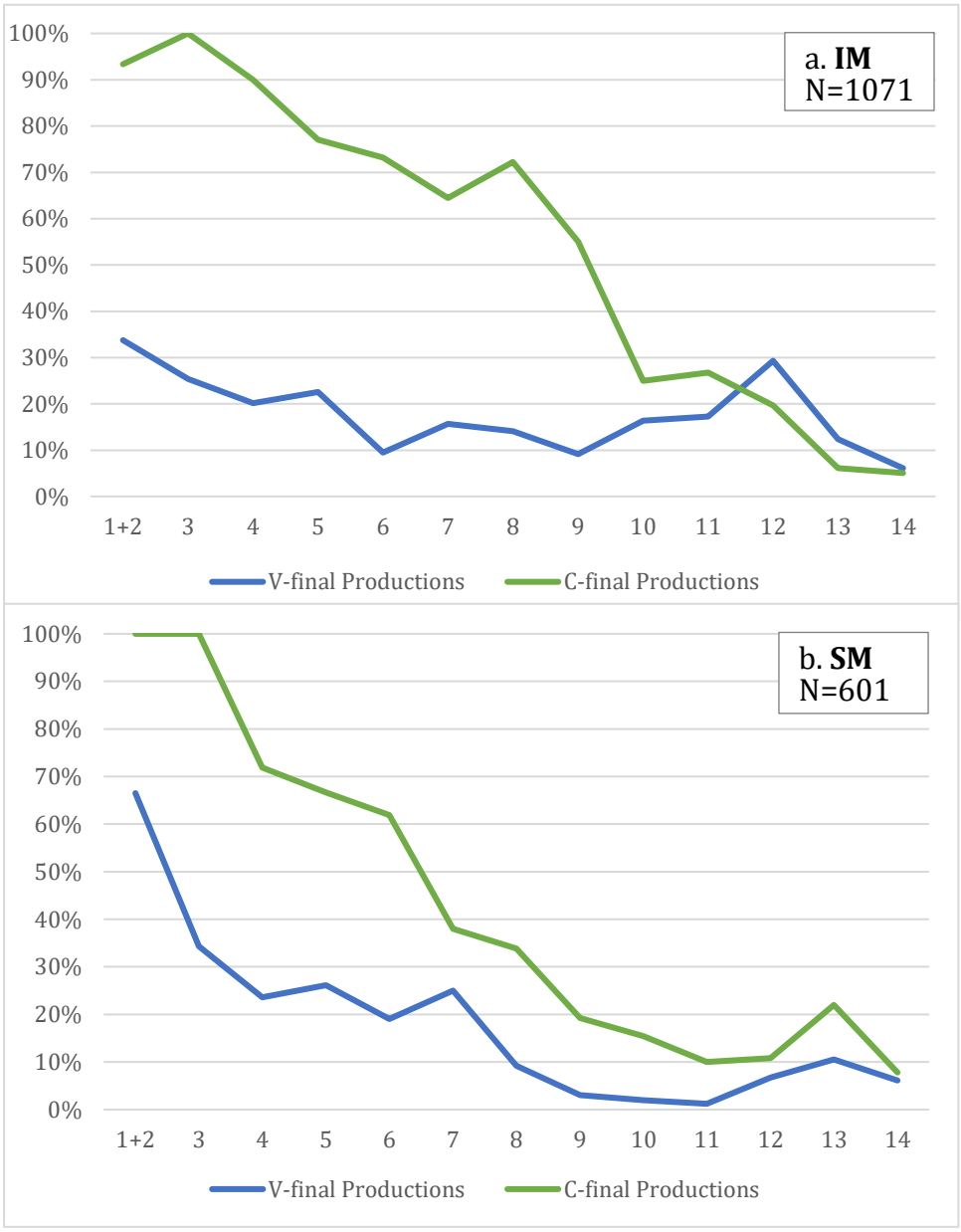


Figure 5 Percentage of truncated monosyllabic productions (tokens) corresponding to polysyllabic targets. C-final truncated monosyllabic productions out of C-final productions vs. V-final truncated monosyllabic productions out of V-final productions.

Examples for truncated monosyllabic productions are given in (10).

(10) Truncated to monosyllabic productions corresponding to polysyllabic targets

	Child	*Age*	*Output*	*Target*	
V-final productions	IM	1;04:30	ba	bubá	'doll'
		1;06:09	gi	agíl	'earring'
	SM	1;05:07	na	gviná	'cheese'
		0;05:27	pi	kapít	'teaspoon'
C-final productions	IM	1;05:00	tos	matós	'plain'
		1;05:00	ak	maʁák	'soup'
	SM	1;05:21	kik	maklít	'recorder'
		1;06:23	gan	mazgán	'air conditioner'

The graphs in Figure 5 show that throughout the periods examined, there were more truncated C-final monosyllabics than V-final, and that most C-final productions were monosyllabic while most V-final productions were polysyllabic. For both children, the majority of polysyllabic V-final productions throughout the 14 periods were disyllabic (86% for IM and 87% for SM). Overall, truncated monosyllabic productions during early speech tend to have a coda; V-final productions were mostly produced as disyllabic, either VCV or CVCV.[7] IM (Figure 5a) shows this pattern from the very first lexical periods. SM (Figure 5b) shows this tendency from period 3; during the first two periods he produces a relatively high percent of CV forms for polysyllabic targets (67%), avoiding final codas. As he began to produce more final codas, the gap between monosyllabic V-final and C-final increases.[8]

These results were statistically significant (see Appendix D). The number of syllables in IM's and SM's outputs corresponding polysyllabic targets was affected by the final segment of the output, that is, there were significantly more V-final than C-final polysyllabic outputs, and more C-final than V-final monosyllabic outputs. In addition, the number of polysyllabic outputs increased with the lexical period, that is, the older the children get the more faithful they were in terms of number of syllables.

Thus far, one main differences between C-final and V-final productions was presented: C-final outputs are produced as monosyllabic while V-final outputs are produced as disyllabic. I propose that this difference between C-final and V-final productions can be accounted for by the Markedness » Faithfulness bias during the initial state (see §2.2);

[7] The contrast between VCV and CVCV is subject to restrictions on the development of the onset (see Ben-David 2012, Karni 2012).

[8] Note that the sub-minimal word stage, during which productions are monosyllabic and sub-minimal, is not visible in IM and SM's data, as both produced many disyllabic V-final outputs from the first development period. This is not surprising, as the sub-minimal word stage is very short within Hebrew acquiring children, to the extent that some children even seem to skip it (Ben-David 2001). However, an examination of the development of a child with slow phonological development provides evidence for this stage (Adam and Bat-El 2008a).

the markedness constraint relevant here is W-BY-P, which assigns a mora to coda consonants. This constraint conflicts with the faithfulness constraint DEPμ, which prohibits the addition of a mora to the output. If W-BY-P outranks DEPμ, and final codas are indeed moraic during early stages of development, then CVC productions correspond to a binary moraic foot, while CV productions correspond to a mono-moraic sub-minimal word. Under this analysis, monosyllabic C-final productions satisfy the MINIMAL WORD constraint, but monosyllabic V-final productions do not. In order to satisfy the MINIMAL WORD constraint, V-final words are produced as disyllabic – VCV or CVCV. Assuming that final codas are moraic, the fact that children produce monosyllabic outputs with a coda but rarely without, and polysyllabic outputs as disyllabic but not as trisyllabic, indicates that in the acquisition of Hebrew, the MINIMAL WORD constraint limits the minimal as well as maximal size of the word.

Assuming codas are moraic during early stages of development, there are still several ways to satisfy the MINIMAL WORD constraint. The table below provides the possible options:[9]

(11) Potential target-output correspondences which satisfy the MW constraint

Targets	*Potential bimoraic outputs*		
	(C)VCV	CVC	
a. ...$CV_2C_2V_1C_1$	① (C)$V_2C_2V_1$ coda deletion – C_1	② $C_2V_1C_1$ –––	
b. ...$C_2V_2C_1V_1$	③ (C)$V_2C_1V_1$ –––	④ CVC_1 vowel deletion – V_1	⑤ $C_1V_1C_x$ coda addition – C_x

For C-final targets (a), both options ① and ② are selected by the children. For V-final targets (b), option ③ is selected most of the time (82% for IM and 85% for SM). Altogether, there is a tendency to avoid deletion at the right edge (④), unless necessary for segmental reasons (①), as discussed later on, and there is even a stronger tendency to avoid addition at the right edge (⑤).

The sensitivity to the right edge origins in its prominence. Studies have shown that the acquisition of the prosodic word starts from the right edge due to its acoustic accessibility (Echols and Newport 1992, Dinnsen and Farris-Trimble 2008, Bat-El 2014, Ben-David and Bat-El 2017). This prominence of the right edge is expressed with an ANCHOR constraint (McCarthy and Prince 1995), which requires the preservation of the right edge in productions. With the dominanace of ANCHOR-RIGHT and the MINIMAL WORD, option ②

[9] Vowel lengthening is another way to form a bimoraic production ($[CVV]_{Ft}$) and thus satisfy the MINIMAL WORD constraint (Demuth and Fee 1995). However, studies on Hebrew acquisition show that this strategy is not used among Hebrew acquiring children (see Ben-David 2001), with the exception of hearing impaired children, who lengthened the final vowel when a coda was deleted (Adi-Bensaid and Bat-El 2004).

for C-final targets (CVC) and option ③ for V-final targets ((C)VCV) are the optimal candidates and thus are more often selected by children. Options ④ and ⑤, which are not faithful at the right edge, are hardly ever selected by the children.

As noted above, both option ② and option ① are selected for C-final targets; in some cases the coda is deleted and a disyllabic CVCV word is produced, and in others it is preserved and a monosyllabic CVC word is produced. While both options satisfy the MINIMAL WORD constraint, option ① is less expected given the faithfulness to the right edge in acquisition. However, the difference between ① and ② is not sporadic but rather depends on the quality of the coda consonant in the target word.

An examination of coda in terms of input-output correspondence reveals that the deleted codas are mostly liquids (*ʁ* and *l*); liquids were deleted above average during most periods, and more than any other segment class (see Appendix F.a). The high deletion rate of liquids is not a result of their high frequency in the children's targets, since all four segment classes – liquids, nasals, fricatives and stops – display a similar distribution in the targets' coda position (see Appendix F.b). For both children, throughout all the periods examined, the number of targets ending with a liquid stands at about 25%, which is significantly lower than the percentage of their deletion. It should be noted that liquid deletion was not limited to codas – these segments are acquired relatively late in all prosodic positions (Altvater-Mackensen and Fikkert 2015).

The high deletion rate of liquids in final coda position suggests that the difference between a monosyllabic CVC production (option ②) and a disyllabic (C)VCV production (option ①) corresponding to C-final target is not random, but based on segmental markedness and the order of acquisition of segments in Hebrew. Liquids are more marked, and they are acquired late in all positions (Ben-David 2001, Ben-David and Bat-El 2016). The selection of option ①, if so, is based on the segmental properties of the coda in the target word. If the target has a liquid final coda, this coda is likely to be deleted in the output, resulting in a (C)VCV production of the final and penultimate syllables (e.g. *kadu* or *adu* for *kadúʁ* 'ball'). In addition to deletion, children may also avoid the liquid coda by replacement, in which case a CVC outputs is produced with a non-liquid coda (e.g. *goχ* for *lisgóʁ* 'to close INF').

7.1.1.3. Dismissing alternative accounts: The results thus far showed a phase in which productions were either monosyllabic with a coda (CVC), or disyllabic without a coda (CVCV). The vast majority of C-final productions correspond to the final syllable of C-final targets, while V-final productions correspond to both V-final and C-final targets (see examples in (10) and the distribution of productions in Appendix B). Given the above, an alternative explanation to the distribution of monosyllabic productions in Figure 5 could

be attributed to the stress patterns of the targets, i.e. that the children were exposed to more C-final targets with final stress than V-final. Numerous studies have shown that children tend to produce the stressed and final syllables due to their higher degree of acoustic prominence and accessibility, and omit the unstressed and non-final ones (see §5.1). Thus, a higher number of final-stressed C-final words in Hebrew could account for the pattern of more monosyllabic C-final outputs, since the final syllable of these targets is perceived better (and thus produced more so) than a final non-stressed syllable.

However, the distribution of stress in Hebrew and the accessibility of the final syllable cannot explain the distribution of C-final and V-final monosyllabic productions in the children's data, since Hebrew words are mostly stress-final regardless of syllable structure (see §4.2). Figure 6 displays the distribution of stress in V-final and C-final words in Hebrew child directed speech (see Appendix E.a for numeric data).[10] This figure shows that final stress is above chance in both V-final and C-final words, and the difference between final vs. non-final stress is statistically significant for both word types in both types and tokens (see Appendix E.b for statistical analysis). That is, the difference between C-final vs. V-final forms in the children's productions cannot be attributed to the children's input.

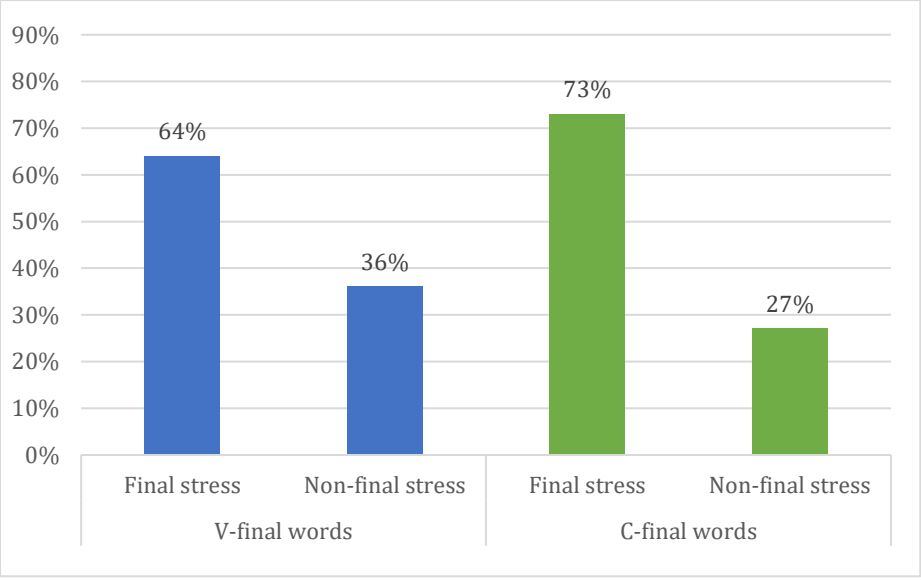


Figure 6 The distribution of stress by word type (C-final vs. V-final) in CDS (tokens)

The absence of difference between C-final and V-final words in CDS (Figure 6) is also manifested in the children's target selection. Figure 7 presents the percentage of V-final and C-final targets with final stress out of all polysyllabic V-final and C-final targets respectively, selected by the children during the designated period. This figure shows that the contrast between C-final and V-final productions does not origin in a selective

[10] The data (n=2383) are drawn from Ben-David et al. (2018).

learning (see §5.2), since the children do not select more C-final targets with final stress than V-final.

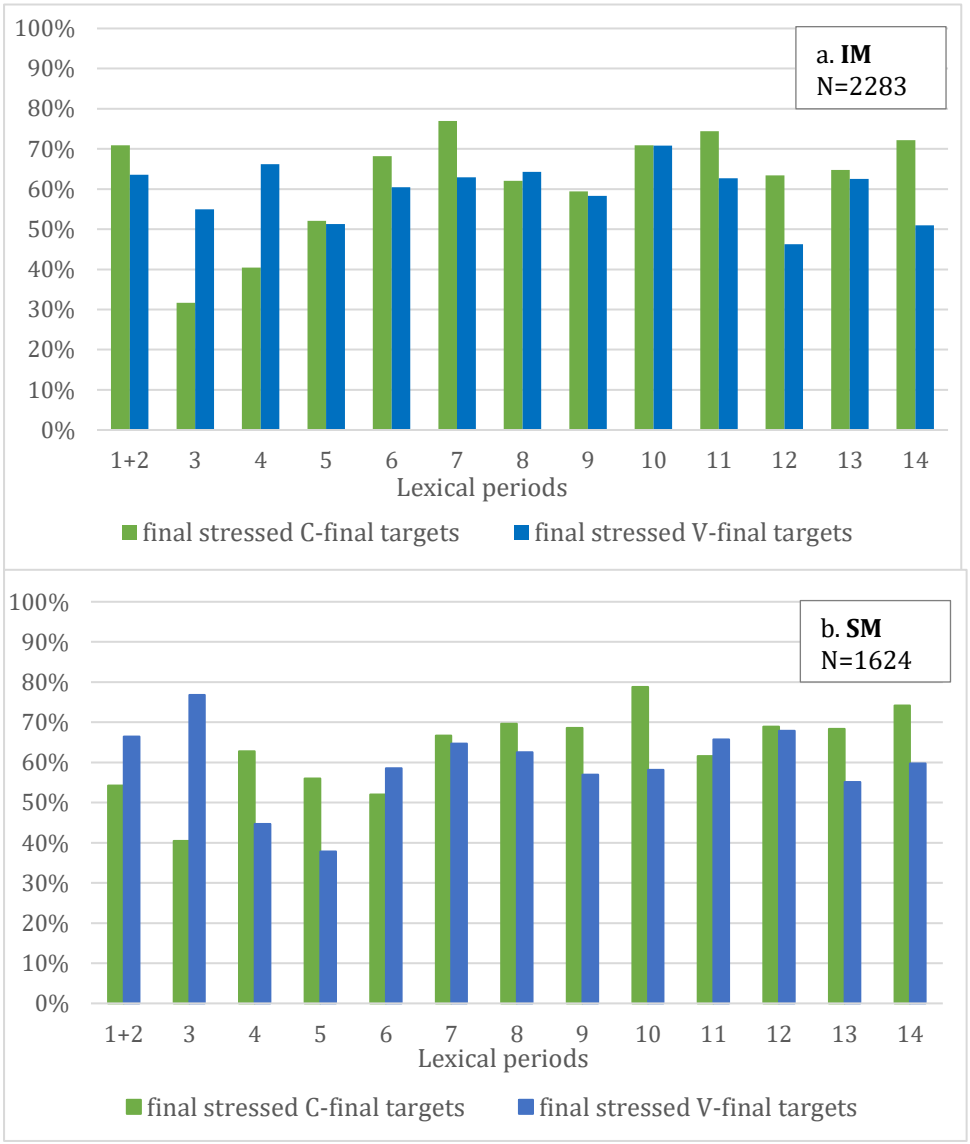


Figure 7 Target selection: Targets with final stress (tokens) – C-final vs. V-final

Given the data in Figures 6 and 7, which show the absence of contrast between C-final and V-final words in their input and selections, the contrast in the children's productions displayed in Figure 5 cannot be attributed to the input.

The findings in this section thus indicate that for both children, there was a phase in development where C-final outputs were monosyllabic (CVC) and V-final outputs were disyllabic ((C)VCV). What is crucial is that both types of output may form a binary foot, which suggests that children assign a mora to codas during early speech despite the absence of evidence for moraic codas in Hebrew. In the following section I provide additional evidence for moraic codas from the development stress in the acquisition of Hebrew.

7.1.2. Stress

In this section, I provide further support for the *experience-independent* approach with evidence from the development of stress. I show that the assignment of a mora to final codas during early speech leads children to maintain a quantity sensitive stress system, which is different from the system in their input. I start this section by addressing monosyllabic outputs with regard to the stress pattern of their targets. I then focus on polysyllabic outputs and present the predictions regarding the development of stress in these productions, followed by the results and their analysis.

As with other prosodic structures, the acquisition of stress starts with the less marked structure – the trochaic foot (Allen and Hawkins 1978, Fikkert 1994, Kehoe 1998). This is also the case with the acquisition of Hebrew stress; although over 70% of Hebrew words bear final stress, Hebrew-acquiring children start with non-final stress, which is analyzed here as a trochaic foot (see §5.2).

In their study of the trochaic bias in the acquisition of Hebrew stress, Adam and Bat-El (2009) show that truncation to monosyllabic productions is one of the strategies children employ to avoid an iambic foot. This strategy is also manifested in the data presented in the current study, where the majority of truncated monosyllabic productions correspond to targets with final stress. The table below displays the distribution of truncated outputs corresponding targets with final vs. non-final stress. The table reveals that for both children, during early speech, the percentage of truncated productions was higher in outputs corresponding to targets with final stress than it was in outputs corresponding to targets with non-final stress.

	Targets with final stress		**Targets with non-final stress**	
	Total targets	*Monosyllabic outputs*	*Total targets*	*Monosyllabic outputs*
IM	562	255 45%	512	133 26%
SM	465	208 48%	373	133 35%

Table 4 The distribution of truncated monosyllabic productions (tokens) corresponding to polysyllabic targets during the first 5 periods

These results were examined in the generalized linear mixed-effects model (GLMM) (see Appendix D), which showed that the stress pattern of the target significantly affected the number of syllables in the output: targets with final stress had significantly more monosyllabic outputs, while the opposite was true for targets with non-final stress.

Here I focus on the development of stress, from the unmarked trochaic foot towards the dominant iambic foot. For this purpose, I record the data from the onset of polysyllabic productions with final codas (the 5th period for IM and the 4th for SM). During the periods

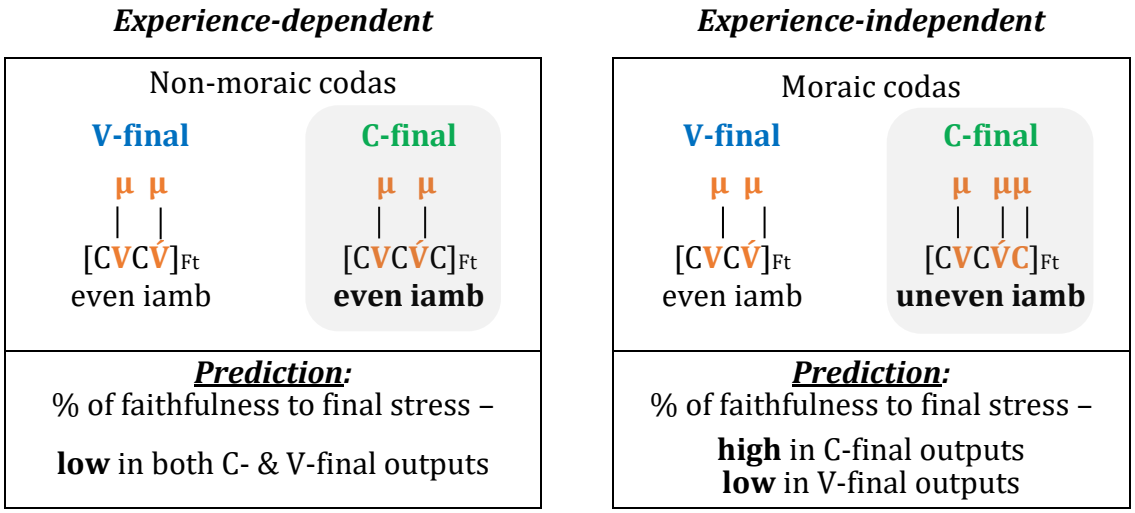
examined, the majority of polysyllabic productions are disyllabic, whether the output is V-final (86% for IM and 87% for SM) or C-final (87% for IM and 82% for SM).[11]

Recall from §3.2 that the experience-dependent and the experience-independent approaches differ with respect to coda moraicity, whereby only for the experience-independent approach codas are moraic during early stages of acquisition. In the absence of evidence for moraic codas, the *experience-dependent* approach predicts similarity in faithfulness to final stress in disyllabic V-final (CV.CV) and C-final (CV.CVC) productions, as both consist of an iambic syllabic foot $[[CV.C\acute{V}(C)]_{Ft}]_{\omega}$. Given that the acquisition of stress starts with the trochaic foot, the degree of faithfulness to final stress in both V-final and C-final is expected to be relatively low during early stages, where the trochaic bias is manifested in the children's speech.

However, an initial state of moraic codas, as predicted by the *experience-independent* approach, implies that disyllabic V-final and C-final productions do not form the same foot; final stress in V-final productions yields the more marked even iambic foot – $[[CV.C\acute{V}]_{Ft}]_{\omega}$, while final stress in C-final productions yields a less marked structure – either a monosyllabic foot, which is consistent with both iambic and trochaic feet – $[CV.[C\acute{V}C]_{Ft}]_{\omega}$, or a disyllabic foot, which forms an uneven iamb – $[[CV.C\acute{V}C]_{Ft}]_{\omega}$ (see (12) below). In both cases, a monosyllabic foot and an uneven iamb are less marked than an even iamb in quantity sensitive systems (see §3). Thus, at the onset of polysyllabic productions, I expect a high degree of faithfulness to final stress in C-final productions, where the less marked structure is present, and a low degree of faithfulness in V-final productions. Both predictions are presented below.

[11] Recall that medial codas are not discussed in this study, because both children hardly produce them during the designated periods (see §5.3).

(12) Predictions of stress patterns for disyllabic productions



Here again, the results support the hypothesis based on the experience-independent approach. As shown below, there is a significant contrast between C-final and V-final forms in the children's productions with respect to faithfulness to final stress.

Figure 8 presents faithfulness to final stress in polysyllabic productions – the percentage of V-final and C-final productions with final stress out of all V-final and C-final polysyllabic productions (respectively) corresponding targets with final stress, regardless of the final segment in the target word. Recall from §5.3 that polysyllabic productions start without final codas, thus in order to compare the development of C-final and V-final productions, the evaluation of faithfulness starts from the period at which each child began to produce polysyllabic outputs with final codas.

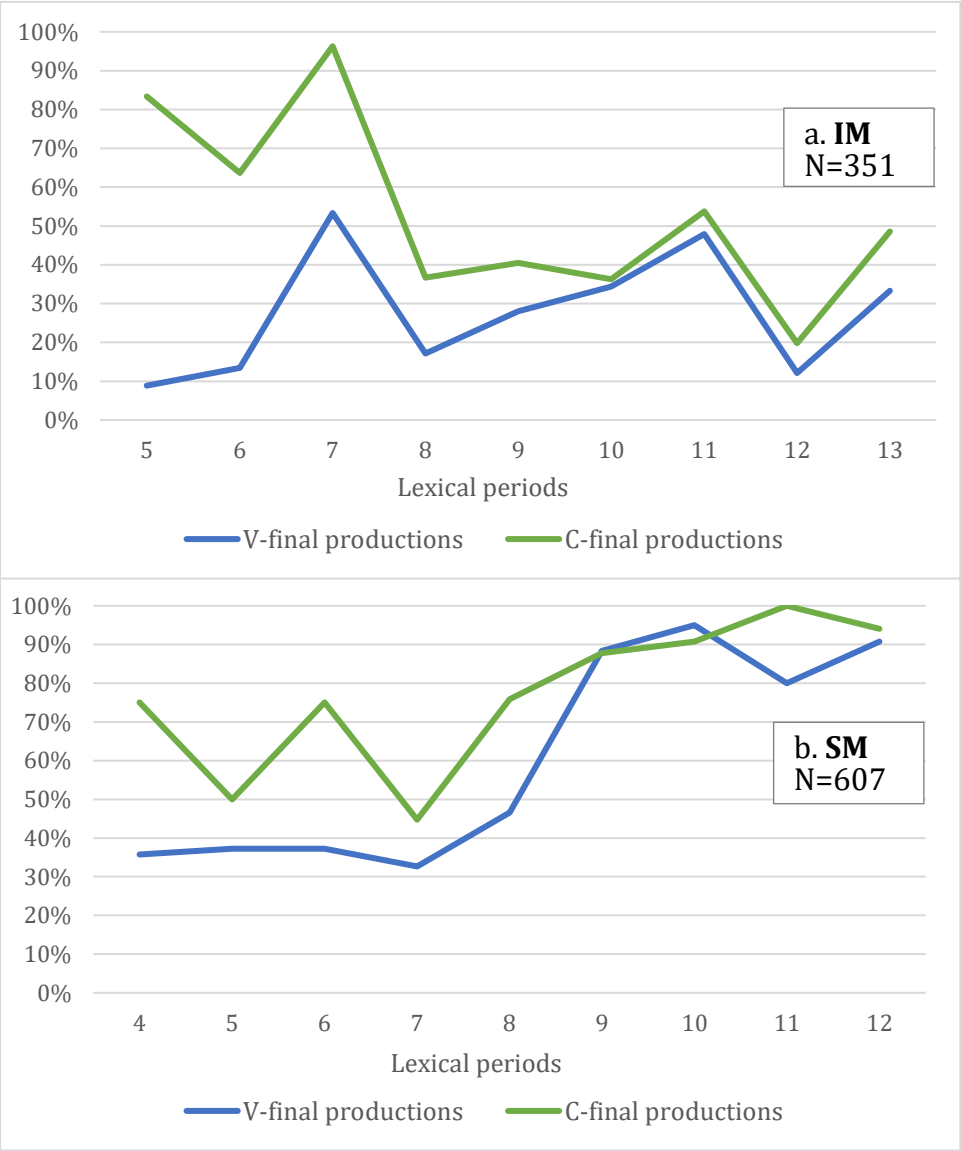


Figure 8 Percentage of faithfulness to final stress in C-final vs. V-final productions (tokens); % of V-final and C-final productions with final stress out of all V-final and C-final productions (respectively).

Figure 8 shows that V-final productions were much less faithful to final stress than C-final productions. That is, there were more cases of stress shift in V-final productions than in C-final. In (13) below are examples of faithful productions and productions with stress shift.

(13) Productions corresponding targets with final stress: faithful stress and stress shift

	Child	*Age*	*Output*	*Target*	
V-final productions	IM	1;06:02	adá	jaldá	‘girl’
		1;06:23	káta	katáʁ	‘engine’
	SM	1;06:09	titá	mitá	‘bed’
		1;05:27	áje	aʁjé	‘lion’
C-final productions	IM	1;06:23	agáθ	agás	‘pear’
		1;08:07	kékin	sakín	‘knife’
	SM	1;07:08	tatán	lejt͡sán	‘clown’
		1;06:26	ánav	aʁnáv	‘rabbit’

As shown in Figure 8, the children tended to shift stress from the final to the penultimate syllable in V-final productions more than they did in C-final productions. That is, productions like *ánav*, where stress is shifted in C-final forms, were less frequent than productions like *áje*, where stress is shifted in V-final forms. The statistical analysis (see Appendix D) reveals that the stress patterns in the children’s productions were affected by the final prosodic position in the output. Namely, there were significantly more C-final than V-final outputs with final stress, and more V-final than C-final outputs with non-final stress.

This pattern also appears when we focus on productions corresponding to C-final targets with final stress, i.e. CVCV́C targets. As mentioned in §7.1.1, productions corresponding to these targets can be with or without a final coda. Figure 9 shows the percentage of productions with final stress out of all outputs corresponding to C-final targets with final stress – C/V-final productions with final stress out of all C/V-productions (respectively) corresponding to C-final targets with final stress.

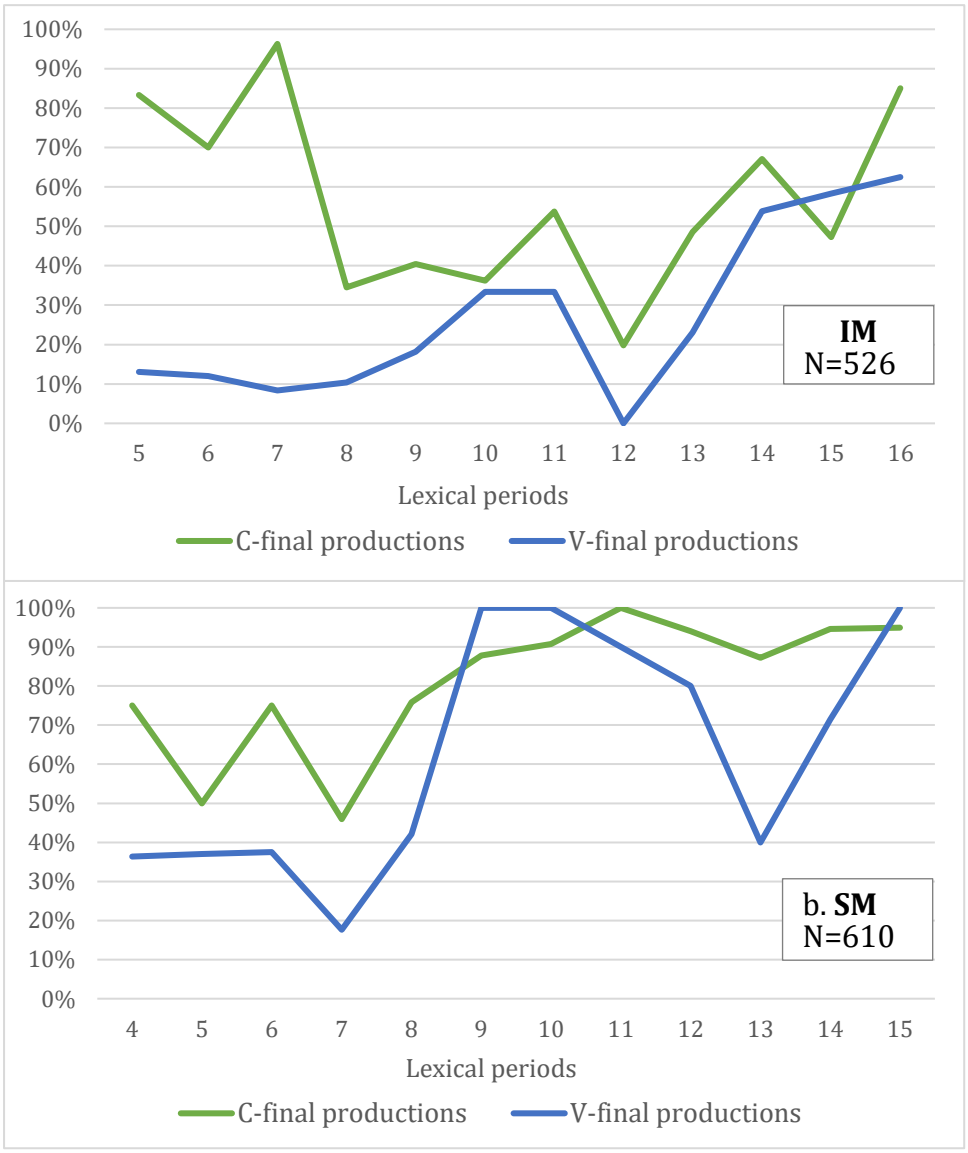


Figure 9 Percentage of faithfulness to final stress in productions corresponding to C-final targets (tokens with final stress)

Figure 9 provides the same pattern as in Figure 8, namely that C-final outputs are more faithful to final stress than V-final outputs are. Since the data in Figure 9 correspond to C-final targets solely, these results show that the low faithfulness to final stress in V-final productions is not affected by the target, i.e. whether it is C-final or V-final, but rather by the prosodic structure of the production itself. That is, V-final outputs are not faithful to final stress regardless of the input.

As discussed in §5.2, the early productions of Hebrew-acquiring children retain non-final stress, even though over 70% of Hebrew words bear final stress, in all kind of corpora, including CDS. Thus, unfaithfulness to final stress is expected in early productions. However, the effect of the final prosodic position evident in the children's productions is not expected considering their input, in which there is no evidence for contrast between V-final and C-final words in stress assignment. As noted in §4.2.3, Hebrew stress does not

distinguish between CV and CVC syllables, and both C-final and V-final words can be assigned final and non-final stress. In addition, as shown in §7.1.1, an examination of CDS shows that both V-final and C-final words are mostly final stressed, and the difference between final vs. non-final stress is statistically significant for both word types. An examination of the children's target selection showed that both children do not select more C-final targets with final stress (Figure 7). Thus, the different development of V-final and C-final outputs exhibited by the children is not expected, given the language-specific data to which they are exposed.

Here again, an initial ranking of W-BY-P » DEPμ, which yields moraic codas, can account for the findings presented here. Assuming that final codas are moraic during early speech, final stress in C-final productions corresponds to the less marked foot structure, either a monosyllabic moraic foot – $[\sigma^{CV\mu C\mu}]_F$, or an uneven iamb – $[\sigma\sigma^{CV\mu C\mu}]_F$. However, final stress in V-final productions corresponds to the more marked even iamb – $[\sigma\sigma^{CV}]_F$. Under this analysis, the relatively high level of faithfulness to final stress in C-final productions is expected, since stress naturally prefers to fall on a heavy syllable in quantity-sensitive systems (see §3.1). In order to avoid the more marked even iamb in V-final outputs, children shift the stress, which results in many non-faithful V-final productions.

It is important to note that most productions corresponding to targets with non-final stress were faithful in their stress pattern, from the onset of polysyllabic productions. The figures below present faithfulness to the target's stress, for C-final and V-final targets separately: the percentage of final and non-final stressed outputs for final and non-final stressed targets, respectively, throughout the first 14 periods.

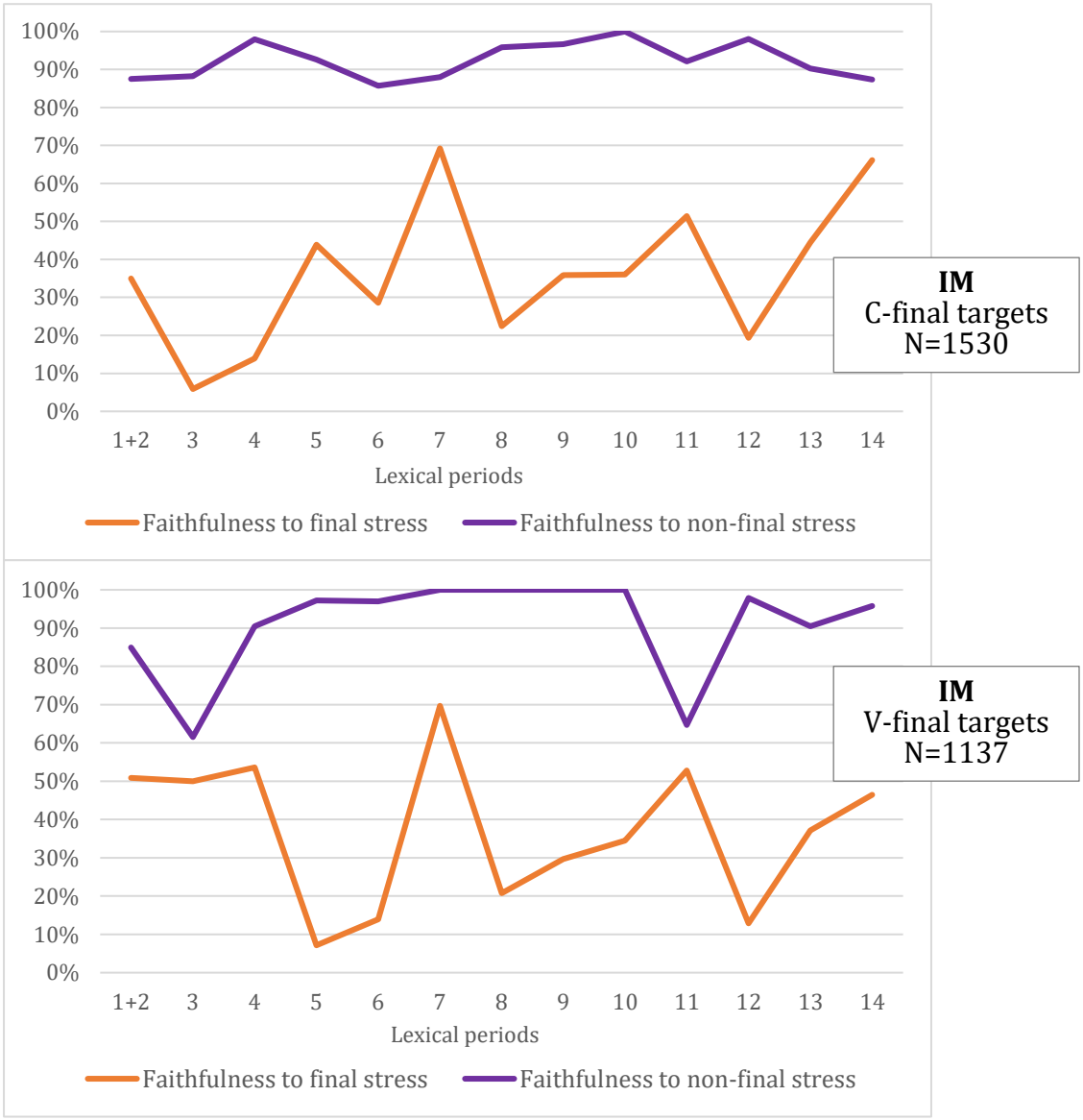


Figure 10 IM's faithfulness to the target's stress

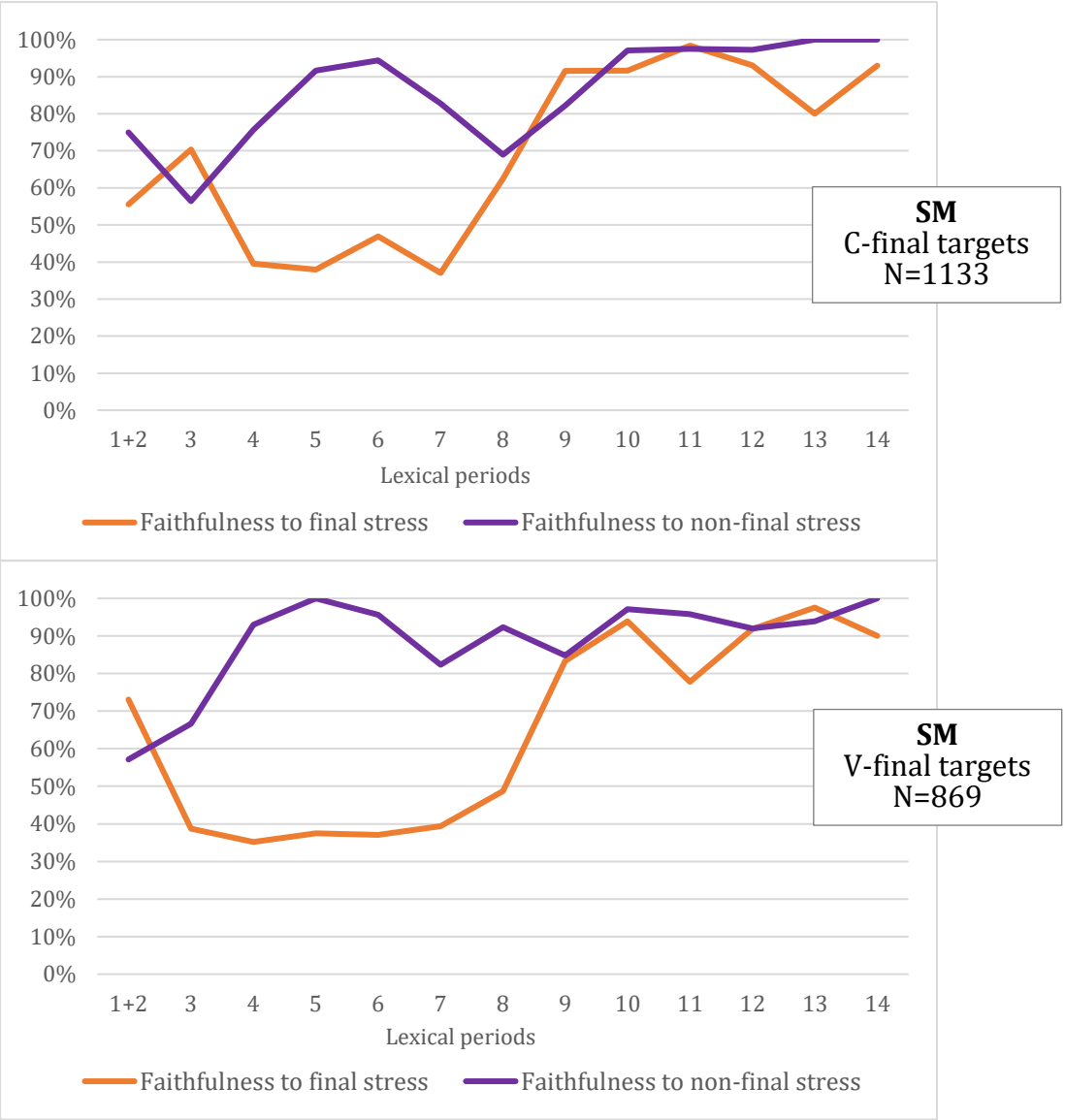


Figure 11 SM's faithfulness to the target's stress

These figures show that productions for targets with non-final stress were more faithful to stress than productions for targets with final stress during early speech, and this was true for both C-final and V-final targets. For SM (Figure 11), the difference in faithfulness to final stress vs. non-final stress was evident until the 8th period in C-final targets, and until the 9th period in V-final targets. For IM (Figure 10), the difference was evident in all 14 periods examined.

Another finding regarding productions corresponding to targets with non-final stress concerns the development of final codas. Figure 12 shows that for both children, there was a substantial period of time where they deleted final codas in outputs corresponding to C-final targets with non-final stress more than they did for targets with final stress. The circles in Figure 12 represent the period at which faithfulness to final codas had reached over 50%.

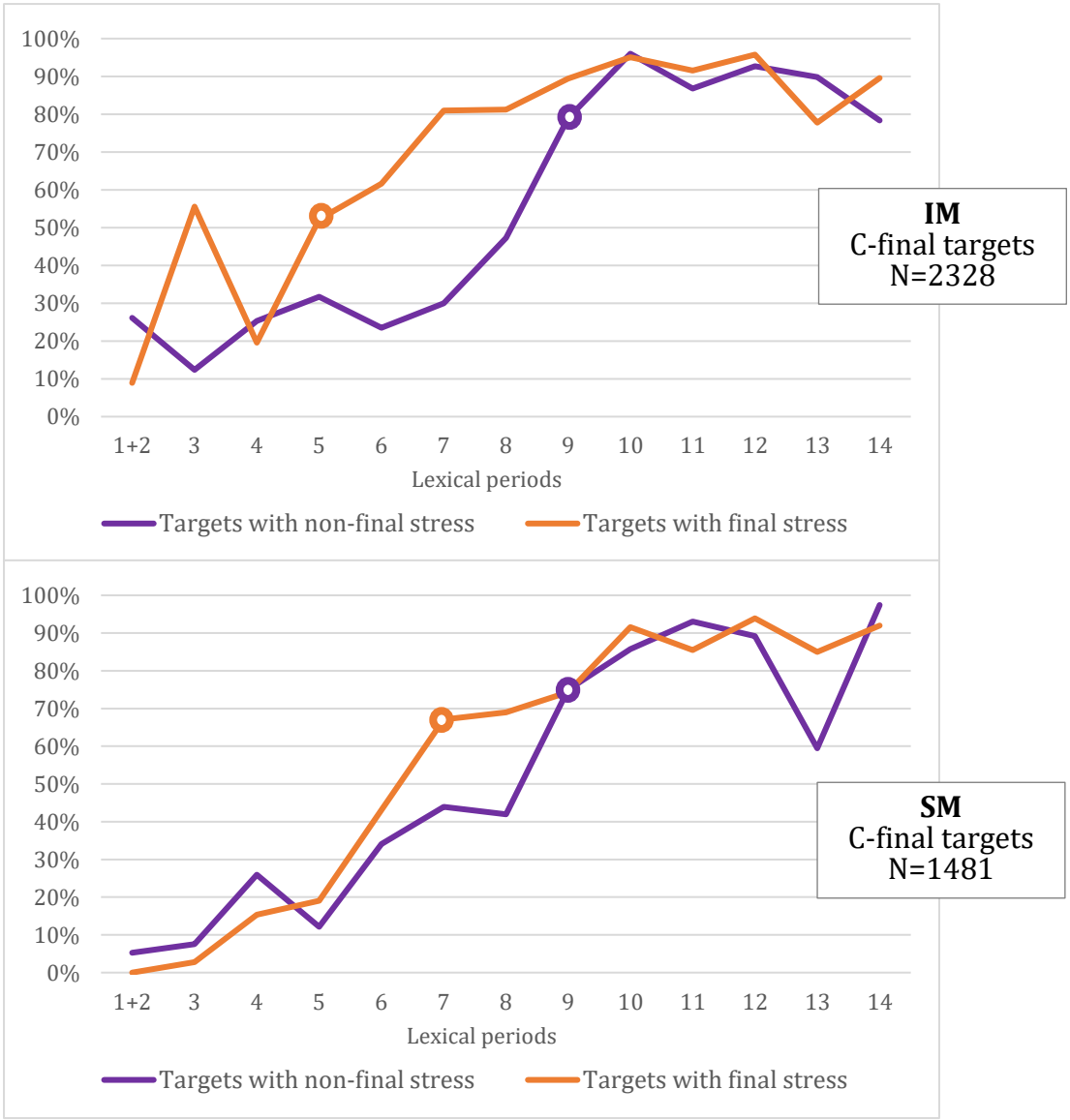


Figure 12 Faithfulness to final coda by the target's stress. The circle represents the period at which faithfulness to final coda reached over 50%.

Recall from §5.3 that children's early productions are coda-less, thus the deletion of the final coda during early stages is not surprising. However, while faithfulness to final codas had reached over 50% in outputs corresponding to targets with final stress during the 5th period for IM and the 7th period for SM, faithfulness to final codas in outputs for targets with non-final stress starts to increase only during the 9th period for both children. Interestingly, during the 9th period, the difference between V-final and C-final outputs for final stressed targets start to decrease.

I claim that this difference in faithfulness to final codas in outputs for targets with final vs. non-final stress is not arbitrary, but it is due to the moraicity of codas. Assuming that codas are moraic during early stages of language development, the final syllable in disyllabic C-final outputs is heavy, which would naturally attract stress. Since children prefer to produce the trochaic foot during early speech, and considering that targets bear

non-final stress, the deletion of the final coda is preferred over stress shift to the final syllable, which would yield the more marked iambic foot and an unfaithfulness to the target's stress. Thus, the fact that faithfulness to final codas in outputs for non-final stressed targets start to increase only when the difference between C-final and V-final outputs corresponding to targets with final stress decreases, is an additional reinforcement for the moraicity of codas during early speech. That is, codas in outputs with non-final stress are produced only when they are not moraic, as noted in Figure 13.

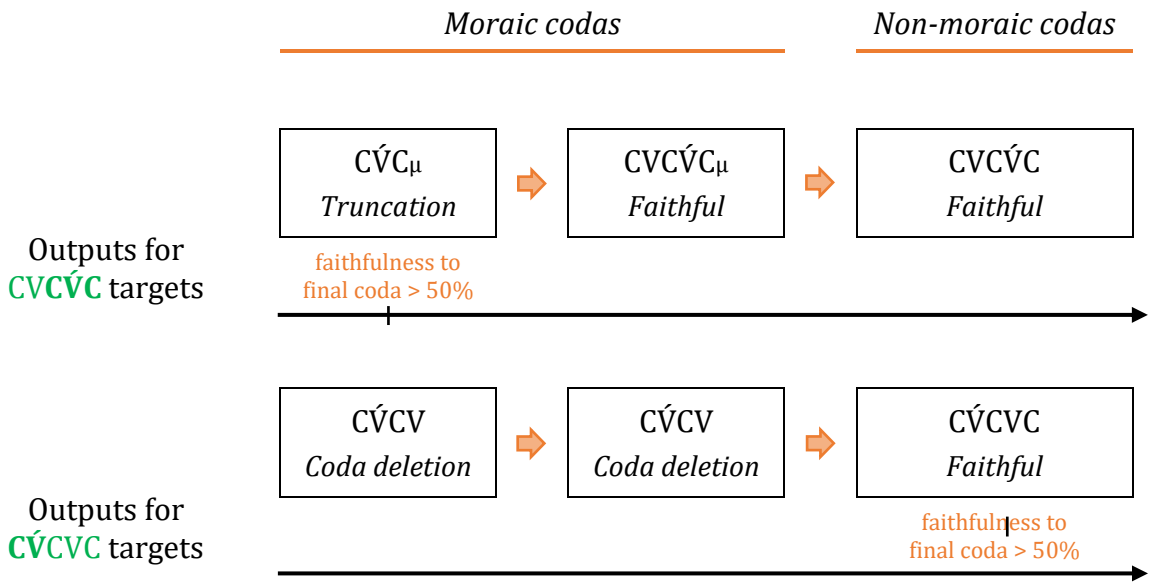


Figure 13 The development of outputs corresponding to C-final targets

To summarize, the results in this section show a different development path for V-final and C-final productions with regard to stress. Considering productions corresponding to targets with final stress, C-final outputs were significantly more faithful to final stress than V-final outputs, where in the latter stress shift is common. These results provide indication for an initial state of moraic codas and a quantity-sensitive system, which is different from the system Hebrew grammar employs. Recall from §4.2.3 that although there are several different analyses of Hebrew stress system, none of them claims the codas in Hebrew are currently moraic (see Bat-El 2018 for predictions regarding future development of Hebrew stress). The low faithfulness to final codas in outputs for non-final stressed targets, which increases only when the difference between C-final and V-final outputs corresponding to targets with final stress decreases, constitute as an additional reinforcement for the moraicity of codas during early speech. Nevertheless, as children are exposed to more input and have an increasing linguistic experience, the prosodic variation between C-final and V-final outputs decreases. This is where language-specific properties show their effect, making the children gradually more faithful to Hebrew's phonological patterns.

7.1.3. Stages of development

In the previous sections, the children's results were analyzed and explained by an initial state of moraic codas and a quantity sensitive system, where each section provided evidence from a different prosodic aspect – the minimal word (§7.1.1) and stress (§7.1.2). In this section, I incorporate these two aspects, analyzing the relevant stages of development.

The table below presents the stages of development of productions for final-stressed targets, starting from the onset of speech and up to the point where the children's productions are faithful to Hebrew stress patterns (IM has reached over 90% faithfulness in number of syllables and stress at the 18th period, and SM did so at the 14th period). At the focus of the current study are stages 2 and 3 (shaded), where the children's system is quantity sensitive.[12]

(14) Stages of development – outputs for targets with final stressed

Stage	***Productions for ...CVCÝ targets***	***Productions for ...CVCÝC targets***	
1	CV Sub-minimal	CV Sub-minimal	
2	[CÝCV]$_{Ft}$ Trochee	[CÝCV]$_{Ft}$ Trochee [CVC**μ**]$_{Ft}$	**Quantity sensitive** W-BY-P » DEPμ
3		[CÝCV]$_{Ft}$ Trochee [CVCÝC**μ**]$_{Ft}$ Uneven iamb	
4	[CVCÝ]$_{Ft}$ Even iamb	[CVCÝC]$_{Ft}$ Even iamb	**Quantity insensitive** DEPμ » W-BY-P

As specified in §7.1.1, following the initial sub-minimal stage (stage 1), children advance to the minimal-word stage (stages 2 and 3) where they produce binary feet. During stage 2, productions are bimoraic, either monosyllabic C-final – [CV$_{\mu}$C$_{\mu}$]$_{Ft}$, or disyllabic V-final – [CV$_{\mu}$CV$_{\mu}$]$_{Ft}$. During stage 3, children expend the C-final structure, and produce also disyllabic C-final words – [CV$_{\mu}$.CV$_{\mu}$C$_{\mu}$]$_{Ft}$. Note that throughout these stages, the minimal and maximal size of the words produced by the children is a foot – either moraic or syllabic. That is, the MINIMAL WORD constraint (see §3.1) functions as a minimal restriction as well as a maximal one.

[12] Assuming the initial stage of Markedness » Faithfulness, the system is quantity sensitive also in stage 1, but due to the absence of codas there is no evidence for such a system.

During the minimal word stage, children exhibit the trochaic bias, as they try to avoid the marked iambic structure. At the first phase of the minimal word stage (stage 2 in (14)), the trochaic bias is evident in all productions via truncation to monosyllabic (CVC) or stress shift (CV́CV). At the second phase (stage 3 in (14)), the trochaic bias is still present in V-final productions for final-stressed targets, where stress shift is employed. During the same phase, C-final productions are faithful to final stress. This is where children exhibit a quantity-sensitive system, because unlike V-final outputs, here the final syllable is heavy, and stress naturally falls on this prominent syllable. Following these stages, children gradually begin to be more faithful to their targets, where stress is mostly final regardless of syllable structure.

As for targets with non-final stress, following the sub-minimal stage, outputs are disyllabic V-final with non-final stress, for both C-final and V-final targets. Final codas are deleted in productions for C-final targets with non-final stress during this stage, and up to the point where codas are no longer considered as moraic. When children start to produce final codas for C-final targets, stress is still non-final (that is, faithful to the target word), since codas are not moraic and the children's system is no longer sensitive to weight.

(15) Stages of development – outputs for targets with non-final stressed

Stage	***Productions for …CV́CV targets***	***Productions for …CV́CVC targets***	
1	CV Sub-minimal		
2	$[CV́CV]_{Ft}$ Trochee		**Quantity sensitive** W-BY-P » DEPμ
3			
4	$[CV́CV]_{Ft}$ Trochee	$[CV́CVC]_{Ft}$ Trochee	**Quantity insensitive** DEPμ » W-BY-P

7.2. Formal Analysis

In this section, I present a formal analysis for the prosodic contrast between V-final and C-final productions which appeared during the children's early speech. The analysis accounts for the different stages of the development of the minimal word and the stress, until faithfulness to the targets is reached. As shown in §7.1.3, the development of the minimal word and the development of stress are integrated and may affect one another. However, for simplicity, the theoretical analysis is made separately for each prosodic aspect. In what follows I provide a brief background and establish the initial state of

moraic codas. Then, I turn to a formal analysis of the development of the minimal word (§7.2.1) and the development of stress (§7.2.2).

The formal analysis is couched within the framework Optimality Theory (OT; Prince and Smolensky 1993[2004]). According to OT, a grammar is an input-output mechanism which yields an optimal output from an input as a result of conflicting universal constraints. Constraints are divided into markedness and faithfulness: markedness constraints reflect universal markedness and bound the output's structure; faithfulness constraints require identity between the input and the output. Constraints can be violated to satisfy a higher-ranked constraint, but violation is required to be minimal. The analysis also implements Correspondence Theory (McCarthy and Prince 1995), which invokes a correspondence relation between elements in the input and the output. This relation is illustrated here within ANCHOR constraints.

I assume the Markedness » Faithfulness bias (Tesar and Smolensky 2000), according to which markedness constraints are ranked above faithfulness constraints at the initial state of acquisition (see §2.2). Children reach the final state via constraint demotion, where markedness constraints are gradually ranked below the relevant faithfulness constraints. The demotion of markedness constraints is gradual, as the children are exposed to more input of the target language.

Although in the absence of overt morphological paradigms, the underlying representation of the children's productions is not accessible for direct examination, I adopt the common assumption that the children's input is the adults' output (Tesar and Smolensky 2000). This assumption is supported by the children's ability to identify phonological contrasts in their input even if they merge them in their output (Smith 1973, Edwards 1974).

As discussed in §7, the Markedness » Faithfulness bias lead to moraic codas at the initial state of acquisition, which comes about by the interaction of two conflicting constraints:

(16) Constraints: coda moraicity

a. **W-BY-P** Coda consonants are moraic.
b. **DEPμ** No epenthesis of moras.

W-BY-P is a markedness constraint, which assures an assignment of a mora to codas. It conflicts with the faithfulness constraint DEPμ, which prohibits the addition of a moras in the output. To account for Markedness » Faithfulness bias, W-BY-P must outrank DEPμ at the initial state, resulting in moraic codas (17).

(17) Initial state: moraic codas

/CVCVC/	W-BY-P	DEPμ
..CVC	*!	
☞ ..CVCμ		*

This state is manifested in the children's grammar up to the point where they get enough input to determine that W-BY-P is not active in Hebrew and thus should be demoted below DEPμ (18).

(18) Target grammar: non-moraic codas

/CVCVC/	DEPμ	W-BY-P
☞ ..CVC		*
..CVCμ	*!	

In the following sections, I provide an analysis of the development of the minimal word and stress during the period of time where W-BY-P is ranked above DEPμ (as in (17)). Thus, in the following tableaux I do not consider candidates with non-moraic codas, except for the final stage in the development of stress, where W-BY-P is demoted (as in (18)). Keeping the ranking of (17) in mind, I now turn to the analysis of the minimal word development.

7.2.1. Minimal word analysis

In this section, I offer an analysis for the development of the minimal word. I address the two main stages in the development of the minimal word: the sub-minimal stage, where productions are mostly monosyllabic and monomoraic, and the minimal word stage, where productions form a binary foot (see §5.1). As shown in §7.1.3, the minimal word stage is divided into two sub-phases, in both productions are binary. All these stages are detailed below.

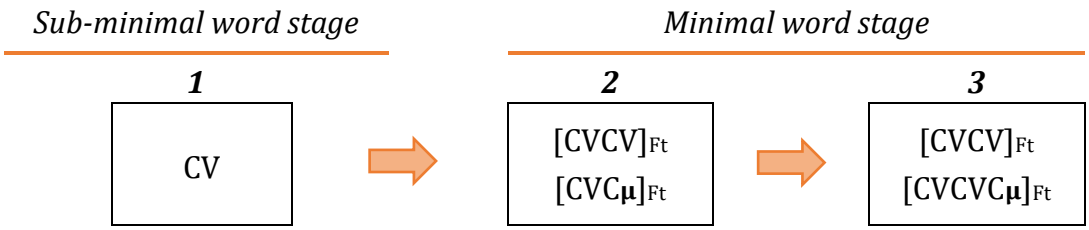


Figure 14 Stages of development up to the minimal word

The constraints relevant for the analysis of the minimal word are provided below:

(19) Constraints: minimal word development

a.	**ALIGN (σ, PRWD)**	The right and left edges of every syllable is aligned with the right and left edges of a PrWd (respectively).
b.	***CODA**	A syllable does not have a coda.
c.	**FTBIN**	Feet are binary (at the moraic or syllabic level).
d.	**R-ANCHOR**	Any segment at the right periphery of the output has a correspondent at the right periphery of the input.
e.	**MAX**	Do not delete segments.

Among the three markedness constraint (19a-c), **ALIGN** is responsible for monosyllabic outputs, where a violation is marked for every additional syllable that buffers between the edges of a syllable and the prosodic word (McCarthy and Prince 1993a); ***CODA** prohibits codas across the board, and **FTBIN** requires feet to be binary at the moraic level or at the syllable level (Prince and Smolensky 1993). Within the two faithfulness constraints (19d-e), **R-ANCHOR** accounts for the preservation of the input's right edge in children's productions during early speech (see §7.1.1), and **MAX** requires to preserve all segments. Recall that at the initial state, markedness constraints are ranked above faithfulness constraints, thus ALIGN, *CODA and FTBIN outrank R-ANCHOR and MAX.

As discussed in §7.1.1, the development of the word starts with the sub-minimal stage, where productions are monosyllabic and monomoraic for both C-final and V-final targets. These outputs require not only the ranking of Markedness » Faithfulness (ALIGN, *CODA and FTBIN » R-ANCHOR and MAX), but also a ranking among the markedness constraints; since productions are sub-minimal, FTBIN is ranked below ALIGN and *CODA. Recall that codas are moraic at this stage (see (17) above), and note that there is no direct evidence for FtBin » R-Anchor; this ranking is drawn from the Markedness » Faithfulness bias.

(20) Sub-minimal word stage: ***CV productions***

a. V-final targets

/CVCV/	ALIGN	*CODA	FTBIN	R-ANCHOR	MAX
☞ [CV]			*		**
[CVCμ]		*!		*	*
[CVCV]	*!*				

b. C-final targets

/CVCVC/	ALIGN	*CODA	FTBIN	R-ANCHOR	MAX
☞ [CV]			*	*	***
[CVCμ]		*!			**
[CVCV]	*!*			*	*
[CVCVCμ]	*!*	*			

c. Crucial ranking: ALIGN, *CODA » FTBIN » R-ANCHOR, MAX

Following the sub-minimal stage, children reach the minimal word stage where they produce bimoraic feet, either CVCμ or CVCV. Thus, ALIGN and *CODA are demoted below FTBIN. In addition, both ALIGN and *CODA are demoted below R-ANCHOR, since productions at this stage are typically faithful to the right edge of the target word.

(21) Minimal word stage: first phase

a. ***CVCV productions*** for V-final targets

/CVCV/	FTBIN	R-ANCHOR	ALIGN	*CODA	MAX
[CV]	*!				**
[CVCμ]		*!		*	*
☞ [CVCV]			**		

b. ***CVC productions*** for C-final targets

/CVCVC/	FTBIN	R-ANCHOR	ALIGN	*CODA	MAX
[CV]	*!	*			***
☞ [CVCμ]				*	**
[CVCV]		*!	**		*
[CVCVCμ]			*!*	*	

c. Crucial ranking: FTBIN, R-ANCHOR » ALIGN, *CODA » MAX

As noted above, the preservation of the right edge in the children's productions is accounted for by R-ANCHOR. However, recall from §7.1.1 that children sometimes delete the rightmost consonant in C-final targets and produce a CVCV output. The difference between CVC and CVCV outputs for C-final targets depends on the quality of the final coda in the target word. If that coda is a liquid (*l* or *ʁ*), it is likely to be deleted in the output, resulting in a CVCV production. This difference is accounted for by a specific restriction on liquids, demonstrated in the additional markedness constraint *LIQUID detailed below. *LIQUID conflicts with the faithfulness constraint IDENT, requiring that the values of a segment in the input would be preserved in the output (McCarthy and Prince 1995a).

(22) Constraints: minimal word development

a. ***LIQUID** No liquid consonants.

b. **IDENT** The specification for features of an input segment must be preserved in its output correspondent.

During these early stages of speech, children rarely produce liquids regardless of their position in the word, and thus *LIQUID is ranked above IDENT and R-ANCHOR. As noted in §7.1.1, children employ two strategies to respect *LIQUID – deletion (e.g. *kadu* for *kadúʁ* 'ball') and replacement (e.g. *goχ* for *lisgóʁ* 'to close INF'), thus IDENT and R-ANCHOR do not have crucial ranking. The grammar of these two strategies is presented below.

(23) Minimal word stage: L-final targets (L= liquid)

a. Liquid deletion – variation - ***CVCV and CVC productions***

/CVCVC$_L$/	FTBIN	*LIQUID	IDENT	R-ANCHOR	ALIGN	*CODA	MAX
[CV]	*!			*			***
[CVC$_{\mu L}$]		*!				*	**
☞ [CVC$_\mu$]			*			*	**
☞ [CVCV]				*	**		*
[CVCVC$_{\mu L}$]		*!			**	*	

b. Crucial ranking: FTBIN, *LIQUID » IDENT, R-ANCHOR » ALIGN, *CODA » MAX

The above tableaux account for the first phase of the minimal word stage, where productions are either CVC or CVCV (see Figure 14). The following tableaux in (24) account for the second phase of the minimal word stage, where productions for C-final targets expend from a monosyllabic CVC to a disyllabic CVCVC. This is made possible with the demotion of the markedness constraints *CODA, *LIQUID and ALIGN below the faithfulness constraint MAX. During the second phase of the minimal word stage, there are also CVCV productions for V-final targets. These productions are accounted for by the same ranking, as presented below. Since children are more faithful to final codas during this stage, *LIQUID is no longer relevant for the analysis and it does not appear in the tableaux.

(24) Minimal word stage: second phase

a. ***CVCV productions*** for V-final targets

/CVCV/	FTBIN	R-ANCHOR	MAX	ALIGN	*CODA
[CV]	*!		**		
[CVC$_\mu$]		*!	*		*
☞ [CVCV]				**	

b. ***CVCVC productions*** for C-final targets

/CVCVC/	FTBIN	R-ANCHOR	MAX	ALIGN	*CODA
[CV]	*!	*	***		
[CVC$_\mu$]			*!*		*
[CVCV]		*!	*	**	
☞ [CVCVC$_\mu$]				**	*

c. Crucial ranking: FTBIN, R-ANCHOR, MAX » ALIGN, *CODA

The constraint ranking and re-ranking in the development of the minimal word is depicted below, reflecting the gradual demotion of the markedness constraints (shaded) below the faithfulness constraints. Note that only ALIGN and *CODA are demoted; FTBIN preserves its position in the ranking as the analyzed stage is the minimal word stage.

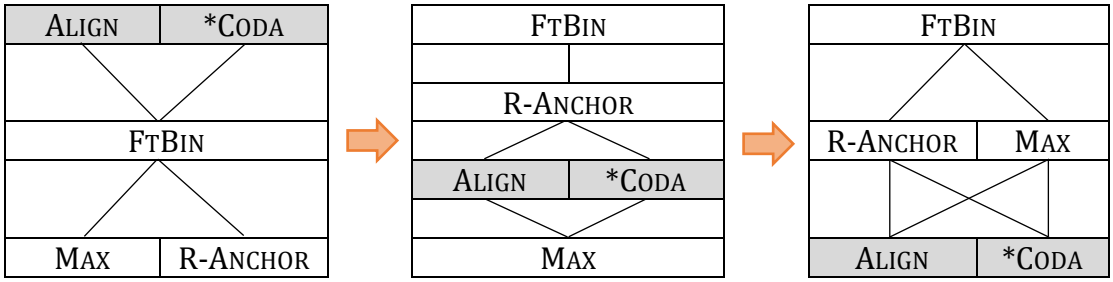


Figure 15 Minimal word analysis: ALIGN and * CODA are gradually demoted

7.2.2. Stress analysis

In this section I offer an analysis of the development of stress, and for this purpose I focus on disyllabic productions. Since evidence for moraic codas come from productions corresponding to targets with final stress, I start by providing an analysis for outputs corresponding to these targets, followed by an analysis for outputs corresponding to targets with non-final stress.

Four constraints are relevant for the analysis of stress given here:

(25) Constraints: stress development

a.	**W-TO-S**	Heavy syllables are stressed.
b.	**PARSEσ**	Syllables are parsed into feet.
c.	**TROCHEE**	The left edge of the head syllable coincides with the left edge of the foot.
d.	**FAITH STRESS**	The stressed syllable in the input is stressed in the output.

W-TO-S is a markedness constraint which imposes quantity-sensitivity, by requiring correlation between syllable weight and prominence (Prince 1990). **TROCHEE** (ALIGNL (HEADσ, FT)), also a markedness constraint, requires the prominent (i.e. stressed) syllable to be leftmost in the foot (McCarthy and Prince 1993a). **PARSEσ** is another markedness constraint, requiring that all syllables in the output are parsed into feet (Prince and Smolensky 1993). The faithfulness constraint **FAITH STRESS** ensures that the stressed syllable in the input would also be stressed in the output. Recall from §7.2 that the I assume that children's input is the adult's output, thus the feature of stress is part of the children's input. Since markedness constraints are ranked above faithfulness constraints at the initial state, PARSEσ, W-TO-S and TROCHEE are ranked above FAITH STRESS, until sufficient input indicates otherwise. Note that PARSEσ will appear in the tableaux only when relevant.

7.2.2.1 Outputs corresponding to targets with final stress: Recall from §5.3 that the first polysyllabic outputs are (C)V́CV, i.e. V-final disyllabic forms with penultimate stress, even when the target word is with final stress, thus displaying a preference for the trochaic foot (see §7.2.1). I consider this stage as the first stage in the development of stress analyzed here. On the following stage, there are also disyllabic outputs with final codas. At this stage, V-final productions still exhibit the trochaic bias, while C-final productions are faithful to final stress. Recall from §7.1.3 that these two stages are where children exhibit a quantity-sensitive system, where codas are moraic and CVC syllable is heavy. At the third stage of stress development, both C-final and V-final outputs are faithful to final stress. All three stages are detailed in Figure 16 below.

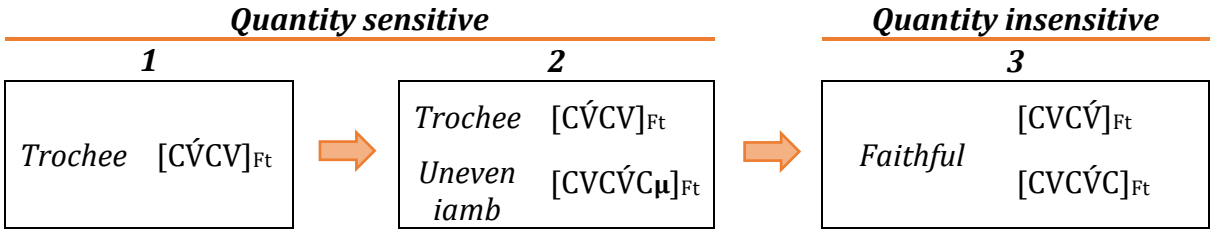


Figure 16 Stages of stress development: targets with final stress

As described above, in the first stage of stress development, disyllabic outputs are V-final with penultimate stress, displaying the preference for the trochaic foot. This is the case when the target is V-final and also when the target is C-final (26). This trochaic bias is described here with the markedness constraint TROCHEE, which is high ranked in the children's early grammar. The other markedness constraint W-TO-S is also high ranked according to the Markedness » Faithfulness bias at the initial state.

(26) First stage

a. ***CV́CV productions*** for V-final and C-final targets

/CVCV́C/	W-TO-S	TROCHEE	FAITH STRESS
☞ [CV́CV]			*
[CVCV́]		*!	
[CV́CVCμ]	*!		*
[CVCV́Cμ]		*!	

b. Crucial ranking: W-TO-S, TROCHEE » FAITH STRESS

Note that during this stage, C-final outputs can be ruled out by different constraints, including *CODA, and R-ANCHOR, as shown in the analysis of the minimal word (see §7.2.1).

During the second stage of stress development, V-final outputs (27a) still bear penultimate stress because TROCHEE is higher ranked than FAITH STRESS. During this stage, there are also disyllabic C-final outputs (27b) with final stress. Since codas are moraic at this stage, C-final syllables are heavy. In quantity sensitive systems, stress prefers to fall on a heavy syllable due to W-TO-S, thus final stress in C-final outputs is not a result of

faithfulness to the target, but to the sensitivity to the heavy final syllable. The high ranked PARSEσ ensures that the selected candidate is the one where all syllables in the output are parsed into feet, resulting in an uneven iambic foot. Although the elected candidate violates TROCHEE, it satisfies W-TO-S, which applies quantity sensitivity.

(27) Second stage

a. ***CV́CV productions*** for V-final targets

/CVCV́/	PARSEσ	W-TO-S	TROCHEE	FAITH STRESS
☞ [CV́CV]				*
[CVCV́]			*!	

b. ***CVCV́C productions*** for C-final targets[13]

/CVCV́C/	PARSEσ	W-TO-S	TROCHEE	FAITH STRESS
[CV́CVCμ]		*!		*
☞ [CVCV́Cμ]			*!	
CV[CV́Cμ]	*!			

c. Crucial ranking: PARSEσ, W-TO-S » TROCHEE » FAITH STRESS

During the third stage of stress development, children get sufficient data to determine that moras do not have a prosodic role in Hebrew, and thus reach the ranking of (18) where W-BY-P is demoted below DEPμ. During this stage, their outputs are faithful to final stress in both C-final and V-final forms, as the markedness constraint TROCHEE is gradually demoted below FAITH STRESS. Note that since codas are not moraic, all syllables bear the same weight, so W-TO-S is no longer relevant and thus not presented.

(28) Third stage

a. ***CVCV́ productions*** for V-final targets

/CVCV́/	FAITH STRESS	TROCHEE
[CV́CV]	*!	
☞ [CVCV́]		*!

b. ***CVCV́C productions*** for C-final targets

/CVCV́C/	FAITH STRESS	TROCHEE
[CV́CVC]	*!	
☞ [CVCV́C]		*

c. Crucial ranking: FAITH STRESS » TROCHEE

7.2.2.2 Outputs corresponding to targets with non-final stress: As noted in §7.1.2, the development of stress in outputs corresponding to targets with non-final stress begins

[13] Note that during this stage, other possible outputs for C-final targets (e.g. CVC and CVCV) are ruled out by the faithfulness constraints R-ANCHOR and MAX, as shown in the analysis of the minimal word (see §7.2.1). Thus, only CVCVC outputs are presented in this tableau.

with disyllabic V-final outputs with penultimate stress, for both V-final and C-final targets, i.e. codas are deleted. This stage occurs while the children's system is quantity sensitive. Recall from §7.1.2 that final codas are deleted in outputs for targets with non-final stress because children prefer to produce the trochaic foot, and they are not able to do so in C-final outputs while codas are moraic. Thus, in outputs for targets with non-final stress, final codas are produced only when they are no longer moraic. On the second stage of development, final codas are produced in disyllabic outputs with non-final stress, as the codas are not moraic and the children's system is not quantity sensitive. Both stages are detailed below.

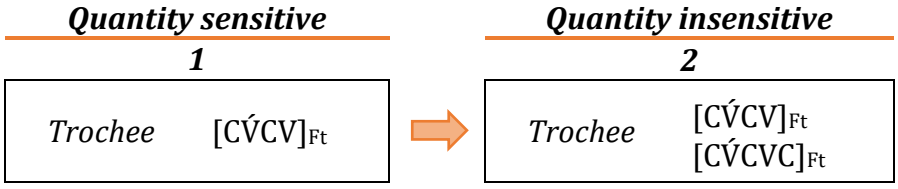


Figure 17 Stages of stress development: targets with non-final stress

As described above, during the first stage outputs are V-final when the target is V-final (29a) and also when the target is C-final (29b).

(29) First stage of the development of stress

a. ***CV́CV productions*** for V-final targets

/CV́CV/	W-TO-S	TROCHEE	FAITH STRESS
☞ [CV́CV]			
[CVCV́]		*!	*

b. ***CV́CV productions*** for C-final targets

/CV́CVC/	W-TO-S	TROCHEE	FAITH STRESS
☞ [CV́CV]			
[CVCV́]		*!	*
[CV́CVCμ]	*!		
[CVCV́Cμ]		*!	*

c. Crucial ranking: W-TO-S, TROCHEE » FAITH STRESS

During the second stage of the development of stress, codas are not moraic, therefore W-TO-S is no longer relevant, and children produce also C-final outputs with penultimate stress. This stage is parallel to the third stage in §7.2.2.1, where the markedness constraints W-TO-S and TROCHEE are demoted, and the faithfulness constraint FAITH STRESS is high ranked. Note that W-TO-S is not violated, as both syllables bear the same weight, and it is thus not presented in the tableaux.

(30) Second stage of the development of stress

a. ***CÝCV productions*** for V-final targets

/CÝCV/	FAITH STRESS	TROCHEE
☞ [CÝCV]		
[CVCÝ]	*!	*

b. ***CÝCVC productions*** for C-final targets

/CÝCVC/	FAITH STRESS	TROCHEE
☞ [CÝCVC]		
[CVCÝC]	*!	*

c. Crucial ranking: FAITH STRESS » TROCHEE

The analysis of stress development for both types of targets (final and non-final stress) and the gradual demotion of the markedness constraints (shaded) below the faithfulness constraint is illustrated below.

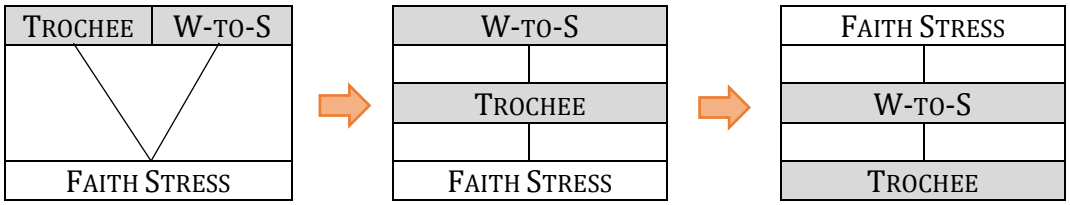


Figure 18 Stress analysis

8. Conclusions

This study addresses the role of universal grammar and language-specific effects in acquisition, focusing on the moraicity of word final codas in Hebrew. Moraic codas are the effect of the markedness constraint WEIGHT-BY-POSITION (W-BY-P; Hayes 1989, 1995), which adds a mora to a coda consonant. W-BY-P conflicts with the faithfulness constraint DEPμ, which prohibits the addition of moras. Hebrew is a quantity insensitive language, where *moras* do not have a prosodic role in the grammar and accordingly codas are not moraic (Bat-El 1993, Bat-El et al. 2019 and others). Hebrew-acquiring children are thus exposed to input in which DEPμ » W-BY-P, that is, input that does not provide evidence for moraic codas. In the absence of evidence for moraic codas, this study examines the question as to whether children nevertheless assume moraic codas during early speech.

This question brings out two contrasting predictions, made by two approaches to language acquisition: the *experience-dependent* approach and the *experience-independent* approach. Based on the input, the experience-dependent approach predicts that Hebrew acquiring children will not assume moraic codas, since they do not receive evidence for moraic codas from their ambient language. The experience-independent approach, however, predicts that children will assume moraic codas during early speech regardless of the moraicity status in their ambient language. This prediction is based on the Markedness » Faithfulness hypothesis (Tesar and Smolensky 2000), in which markedness constraints are ranked above faithfulness constraints in the initial state of language development, and thus W-BY-P is ranked above DEPμ, yielding an initial state of moraic codas.

The findings of this research, obtained from the early speech of two Hebrew acquiring boys, support the prediction of the experience-independent approach. The results showed a significant contrast between C-final vs. V-final words in the children's speech, a contrast which is based on syllable weight. This contrast was found in two prosodic aspects: the minimal word and stress.

With respect to the minimal word, which is addressed here by number of syllables, both children showed a phase in development where C-final outputs were monosyllabic (CVC) while V-final outputs were disyllabic ((C)V.CV). This contrast suggest that children analyze CVC as bimoraic, that is, as a binary foot, because this structure satisfies the MINIMAL WORD constraint (McCarthy and Prince 1986), known to be highly active in the development of the prosodic word (Demuth and Fee 1995). Crucially, while CVC outputs with a moraic coda correspond to the unmarked binary foot, monosyllabic CV outputs do

not. Thus, in order to satisfy the MINIMAL WORD constraint, V-final outputs are produced as disyllabic.

Also the findings regarding the development of stress revealed a contrast between C-final vs. V-final outputs. Considering disyllabic outputs corresponding to targets with final stress, outputs with a final coda (CV.CVC) were significantly more faithful to final stress than outputs ending with a vowel (CV.CV), where in the later stress shift was often evident. During the same period of time in which this contrast was present, final codas were often deleted in outputs corresponding targets with non-final stress, while in outputs corresponding targets with final stress final codas were usually preserved. These results provide indication for an initial state of moraic codas and a quantity-sensitive system. Assuming moraic codas, C-final outputs with final stress correspond to the uneven iambic foot, while V-final outputs with final stress correspond to the even iambic foot. Given the different foot structure of these words, the higher faithfulness to final stress in C-final productions is expected, since the uneven iamb is universally preferred and less marked than the even iamb, as stress naturally prefers to be hosted by a heavy syllable (Hayes 1995). The avoidance of producing final codas in outputs corresponding to targets with non-final stress also indicates coda moraicity, because children prefer to produce the trochaic foot, and they are not able to do so in C-final outputs while codas are moraic, as the final bimoraic syllable would naturally attract stress. Thus, children avoid producing final codas in outputs with non-final stress until codas are not moraic and their system is no longer quantity sensitive.

The patterns and phonological contrast found in the children's early speech are not a result of their input. Hebrew stress system does not employ a phonological distinction between C-final and V-final words, nor provides evidence for a weight contrast between CV and CVC syllables. The lack of contrast between C-final and V-final words is apparent in all kind of corpora, including CDS, as well as in the children's selection of targets.

If so, the findings suggest that Hebrew acquiring children analyze word final codas as moraic, which leads to the universal unmarked structures in both prosodic aspects examined. The findings thus indicate that in their early speech, children start from these unmarked structures, which manifest the children's productions regardless of the dominant structure in the ambient language. Nevertheless, as the children were exposed to more data and had an increasing linguistic experience, the phonological contrast found in their early speech gradually decreased, and their productions became more faithful to Hebrew phonological patterns. It should be taken into consideration that the findings presented here are based on the early speech of two children solely, and thus need to be further supported by data from additional children. Since I attribute these findings to a

universal initial state, which is predicted for all children, I expect future studies to show patterns similar to those found here.

The findings of this research provide an additional case study showing the emergence of universal principles during early speech. Under the phonological phenomenon of coda moraicity, Hebrew grammar grant the children an input that stands in counter to the initial state of the Universal Grammar (see §3). This difference between Hebrew grammar and Universal Grammar provided a unique opportunity to address the debate on the nature of the linguistic knowledge. The present study thus contributes to this debate, giving support to the small window of opportunity in which universals can emerge and show their effect in language acquisition. The gradual faithfulness of the children's productions to their targets, which increases over time, shows the integrated work of innate linguistic knowledge together with general cognitive mechanisms in the course of language learning.

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APPENDIX A

Periods of lexical development throughout the entire research period

Period	*Cumulative Lemmas*	IM	SM
1	~10	1;01:08	1;01:08
2	~50	1;04:01	1;04:12
3	~100	1;05:07	1;05:23
4	~150	1;06:04	1;06:23
5	~200	1;07:01	1;07:04
6	~250	1;08:04	1;08:04
7	~300	1;08:18	1;08:19
8	~350	1;09:03	1;09:15
9	~400	1;09:17	1;09:18
10	~450	1;10:12	1;10:15
11	~500	1;10:22	1;11:07
12	~550	1;10:27	1;11:18
13	~600	1;11:17	1;11:21
14	~650	1;11:19	2;00:01
15	~700	2;00:01	2;00:30
16	~750	2;00:30	2;01:12
17	~800	2;01:14	2;02:12
18	~850	2;02:12	2;03:14
19	~900	2;03:08	2;03:21
20	~950	2;03:15	2;03:29
21	~1000	2;03:28	2;04:13
22	~1050	2;04:07	2;04:20
23	~1100	2;04:19	2;06:03
24	~1150	2;05:29	2;07:15
25	~1200	2;06:07	2;08:19
26	~1250	2;07:15	2;09:14
27	~1300	2;09:14	2;09:24
28	~1350	2;09:24	2;11:20
29	~1400	2;11:11	2;11:24
30	~1450	2;11:24	-

APPENDIX B: Minimal-Word results

a. Truncated monosyllabic productions (tokens) corresponding to polysyllabic targets

IM	*Lexical periods*	*Polysyllabic targets*	*C-final outputs*		*V-final outputs*	
			Monosyllabic	*Polysyllabic*	*Monosyllabic*	*Polysyllabic*
	1	59	1	0	13	45
	2	193	13	1	67	112
	3	253	44	0	53	156
	4	194	27	3	33	131
	5	375	74	22	63	216
	6	193	41	15	13	124
	7	192	58	32	16	86
	8	489	169	65	36	219
	9	342	104	85	14	139
	10	268	41	123	17	87
	11	274	50	137	15	72
	12	294	35	143	34	82
	13	195	7	107	10	71
	14	417	12	225	11	169

SM	*Lexical period*	*Polysyllabic targets*	*C-final outputs*		*V-final outputs*	
			Monosyllabic	*Polysyllabic*	*Monosyllabic*	*Polysyllabic*
	1	28	0	0	17	11
	2	195	2	0	130	63
	3	171	5	0	57	109
	4	295	23	9	62	201
	5	149	10	5	35	99
	6	168	26	16	24	102
	7	191	30	49	28	84
	8	174	22	43	10	99
	9	181	16	67	3	95
	10	251	23	126	2	100
	11	182	10	90	1	81
	12	200	12	99	6	83
	13	195	20	71	11	93
	14	223	11	130	5	77

b. C-final vs. V-final productions (tokens) corresponding to C-final targets

IM	*Lexical periods*	*Targets*	*Outputs*			
		C-final	*C-final*		*V-final*	
	1	27	0	0%	27	100%
	2	54	12	22%	42	78%
	3	220	74	34%	146	66%
	4	154	46	30%	108	70%
	5	345	205	59%	140	41%
	6	147	84	57%	63	43%
	7	167	123	74%	44	26%
	8	467	347	74%	120	26%
	9	274	235	86%	39	14%
	10	217	206	95%	11	5%
	11	250	225	90%	25	10%
	12	212	202	95%	10	5%
	13	152	127	84%	25	16%
	14	302	262	87%	40	13%

SM	*Lexical period*	*Targets*	*Outputs*			
		C-final	*C-final*		*V-final*	
	1	12	0	0%	12	100%
	2	78	2	3%	76	97%
	3	102	6	6%	96	94%
	4	197	47	24%	150	76%
	5	125	31	25%	94	75%
	6	166	64	39%	102	61%
	7	144	90	63%	54	38%
	8	135	88	65%	47	35%
	9	122	98	80%	24	20%
	10	191	173	91%	18	9%
	11	134	117	87%	17	13%
	12	146	137	94%	9	6%
	13	136	105	77%	31	23%
	14	193	183	95%	10	5%

APPENDIX C: Stress results

a. Disyllabic productions (tokens) corresponding to targets with final stress

IM	*Lexical period*	*Final- stress targets*	*C-final outputs*		*V-final outputs*	
			Final stress	*Non-final stress*	*Final stress*	*Non-final stress*
	1	43	0	0	12	19
	2	123	1	0	30	35
	3	106	0	0	17	32
	4	96	0	0	20	44
	5	194	15	3	7	72
	6	125	7	4	9	58
	7	139	26	1	24	21
	8	307	11	19	18	87
	9	202	17	25	21	54
	10	190	29	51	22	42
	11	196	50	43	23	25
	12	168	19	77	4	29
	13	125	33	35	16	32
	14	269	113	55	39	44

SM	*Lexical period*	*Final- stress targets*	*C-final outputs*		*V-final outputs*	
			Final stress	*Non-final stress*	*Final stress*	*Non-final stress*
	1	11	0	0	4	0
	2	127	0	0	25	15
	3	99	0	0	31	27
	4	158	3	1	35	63
	5	70	1	1	19	32
	6	92	6	2	19	32
	7	126	17	21	16	33
	8	116	22	7	27	31
	9	115	36	5	53	7
	10	180	88	9	57	3
	11	115	52	0	44	11
	12	137	63	4	49	5
	13	123	48	7	44	7
	14	155	88	5	41	6

b. Disyllabic productions (tokens) corresponding to **C-final** targets with final stress

IM	*Lexical period*	*C-final targets with final stress*	*C-final outputs*		*V-final outputs*	
			Final stress	*Non-final stress*	*Final stress*	*Non-final stress*
	1	26	0	0	5	18
	2	30	0	0	9	8
	3	45	0	0	1	16
	4	51	0	0	5	31
	5	113	15	3	3	20
	6	73	7	3	3	22
	7	100	26	1	1	11
	8	208	10	19	3	26
	9	132	17	25	2	9
	10	122	29	51	2	4
	11	154	50	43	4	8
	12	118	19	77	0	2
	13	90	33	35	3	10
	14	192	112	55	7	6

SM	*Lexical period*	*C-final targets with final stress*	*C-final outputs*		*V-final outputs*	
			Final stress	*Non-final stress*	*Final stress*	*Non-final stress*
	1	5	0	0	2	0
	2	40	0	0	8	8
	3	36	0	0	19	8
	4	91	3	1	16	28
	5	42	1	1	10	17
	6	51	6	2	9	15
	7	82	17	20	3	14
	8	71	22	7	8	11
	9	70	36	5	18	0
	10	130	88	9	11	0
	11	69	52	0	9	1
	12	82	63	4	4	1
	13	80	48	7	4	6
	14	112	88	5	5	2

c. Faithfulness to final coda

IM	*Lexical period*	*C-final targets with final stress*	*C-final outputs*	*C-final targets with non-final stress*	*C-final outputs*
	1+2	56	5	23	6
	3	45	25	97	12
	4	51	10	75	19
	5	113	59	104	33
	6	73	45	34	8
	7	100	81	30	9
	8	208	169	127	60
	9	132	118	90	71
	10	122	116	50	48
	11	154	141	53	46
	12	118	113	68	63
	13	90	70	49	44
	14	192	172	74	58

SM	*Lexical period*	*C-final targets with final stress*	*C-final outputs*	*C-final targets with non-final stress*	*C-final outputs*
	1+2	45	0	38	2
	3	36	1	53	4
	4	91	14	54	14
	5	42	8	33	4
	6	51	22	47	16
	7	82	55	41	18
	8	71	49	31	13
	9	70	52	32	24
	10	130	119	35	30
	11	69	59	43	40
	12	82	77	37	33
	13	80	68	37	22
	14	112	103	39	38

APPENDIX D: Statistical analyses (*p < .05; **p < .01; ***p < .001)

In order to determine the significance of these results, the data of each child was entered to a generalized linear mixed-effects model (GLMM). Statistical analyses were performed with the `lmerTest` package (Kuznetsova, Brockhoff, and Christensen, 2017) implementation on R (R Development Core Team, 2020). Data were analyzed with the `glmer` function to fit a GLMM with a binomial distribution (see Baayen, Davidson, and Bates, 2008).

1. ***Outputs corresponding to polysyllabic targets*** (see Figure 5)

   The number of syllables in IM's and SM's outputs corresponding polysyllabic targets was affected by the final segment of the output, that is, there were significantly more V-final than C-final polysyllabic outputs, and more C-final than V-final monosyllabic outputs. In addition, the number of polysyllabic outputs increased with the lexical period, that is, the older the children get the more faithful they were in number of syllables.

	Fixed effects	*Estimate*	*SE*	*z*
IM	Lexical period	0.51	0.03	17.11 ***
	Final segment - output	2.64	0.20	12.95 ***
SM	Lexical period	0.48	0.03	14.83 ***
	Final segment - output	1.91	0.22	08.63 ***

2. ***Outputs corresponding to polysyllabic targets*** (see Table 4)

   The stress of the target significantly affected the number of syllables in the output: targets with final stress had significantly more monosyllabic outputs than polysyllabic outputs, while the opposite was true for targets with non-final stress.

	Fixed effects	*Estimate*	*SE*	*Z*
IM	Target stress	1.48	0.33	4.49 ***
SM	Target stress	0.77	0.26	2.97 **

3. Polysyllabic outputs corresponding to targets with final stress (see Figure 8)

   Stress patterns in IM's and SM's data were affected by the final segment in the output. Namely, there were significantly more C-final than V-final outputs with final stress, and more V-final than C-final outputs with non-final stress. That is, C-final outputs were significantly more faithful to final stress than V-final outputs were.

	Fixed effects	*Estimate*	*SE*	*Z*
IM	Final segment – output	-1.29	0.27	-4.81 ***
SM	Final segment – output	-0.94	0.27	-3.49 ***

APPENDIX E: CDS: types and tokens (Ben-David et al. 2008)

a. Numeric data

Types	*Final stress*	*Non-final stress*	*Total*
C-final words	328 75%	107 25%	435
V-final words	153 63%	91 37%	244

Tokens	*Final stress*	*Non-final stress*	*Total*
C-final words	923 73%	342 27%	1265
V-final words	713 64%	405 36%	1118

b. Statistical analyses (*$p < .05$; **$p < .01$; ***$p < .001$)

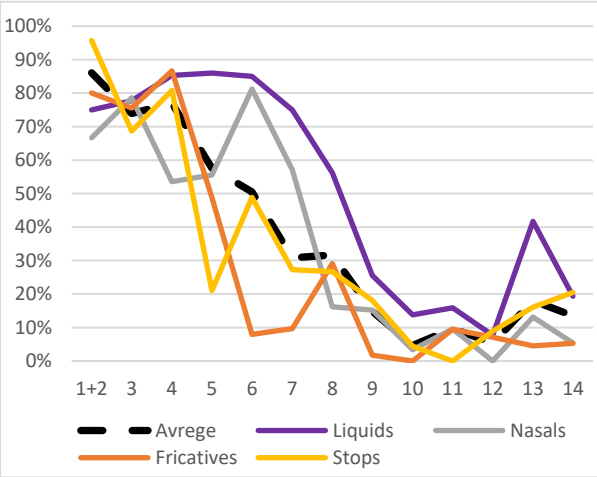
The difference between final vs. non-final stress is statistically significant for both word types in both types and tokens:

binomial test for C-final words (N=435 (types) / 1265 (tokens), p=0.5) = p<0.0001
binomial test for V-final words (N=244 (types) / 1118 (tokens) , p=0.5) = p<0.0001

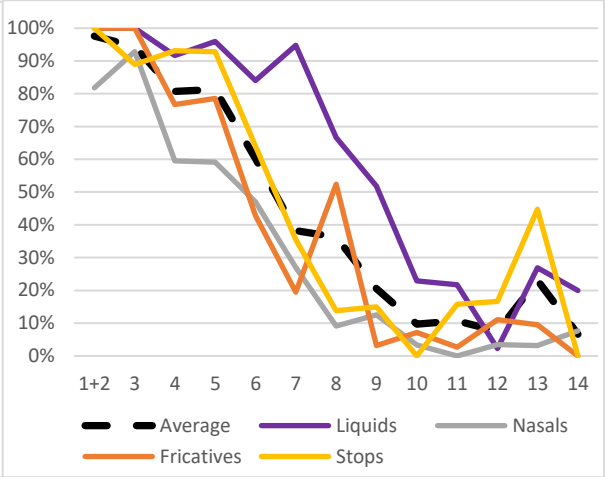
APPENDIX F

a. Percentage of deleted segment class out of targets of the same class, compared to the general deletion average (tokens).[14]

IM (N = 727 deleted final codas)

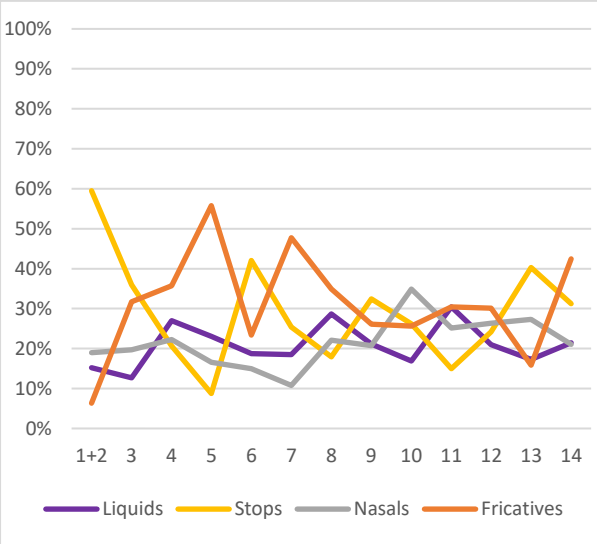


SM (N = 581 deleted final codas)

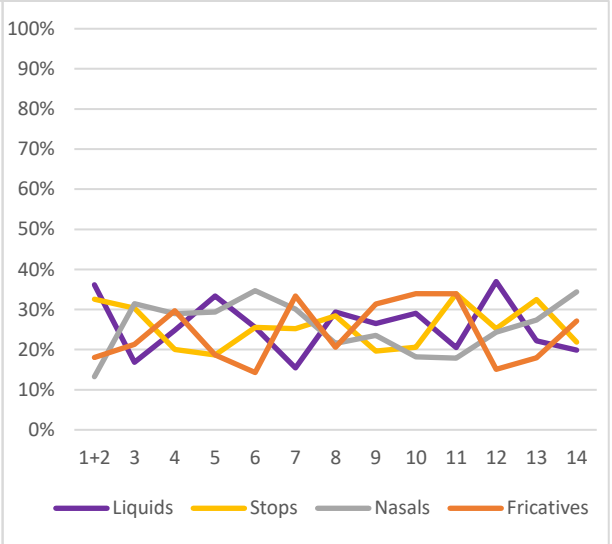


b. Distribution of codas in polysyllabic targets (tokens)

IM (N = 2328 polysyllabic C-final targets)[15]



SM (N = 1481 polysyllabic C-final targets)



[14] There was a period where IM deleted many nasal codas as well, and obstruents were rarely deleted. SM showed many deletions of stops and fricatives at certain periods, but both were not deleted as much as liquids. The inter-child variation between IM and SM in the deletion of other segments groups is not unusual, as children sometimes employ different strategies towards the unmarked structure during early acquisition (Stoel-Gammon and Cooper 1984; Ben-David 2001).

[15] At some periods, IM showed a high frequency of C-final words ending with stops (1st & 6th period) and fricatives (5th & 7th period), which may be attributed to the high frequency of obstruent codas in Hebrew, or to a selective choice based on general markedness of the segment groups. Since obstruents are less marked, they are selected more and less deleted (see §7.1.1).

תקציר

ישנן שתי גישות מרכזיות לרכישת שפה בספרות הבלשנית. גישה אחת טוענת כי תהליך רכישת השפה הוא *מבוסס-ניסיון* בלבד, כאשר רכישה מתבצעת באמצעות מנגנונים קוגניטיביים כלליים שאינם ספציפיים לשפה (Langacker 1987, Tomassello 2003). הגישה השנייה מציעה כי בנוסף לאלמנטים מבוססי-הניסיון של מנגנון הרכישה, ישנם גם אלמנטים *בלתי-תלויים בניסיון* אשר מתווים את תהליך הרכישה (Chomsky 1959, 1968, 1986).

גישות אלה מציעות ניבויים שונים ביחס לשאלה האם קודות הן מוראיות או לא בשלבים המוקדמים של רכישת עברית. עברית נחשבת לשפה שאינה רגישה לכובד, והיא אינה מספקת ראיות לקודות מוראיות (Bat-El 1993, Bat-El et al. 2019 among others). בהתבסס על קלט הילדים, גישת *הרכישה מבוססת-הניסיון* מנבאת שעיצורים בעמדת הקודה לא יהיו מוראים בשלבי הרכישה הראשונים של ילדים רוכשי עברית. לעומת זאת, גישת *הרכישה הבלתי-תלויה בניסיון* מנבאת קודות מוראיות; ניבוי זה מבוסס על הטיית אילוצי מסומננות » אילוצי נאמנות במצב התחילי של רכישת השפה (Markedness » Faithfulness bias, Tesar and Smolensky 2000) ודירוגם של שני אילוצים סותרים: WEIGHT-BY-POSITION (W-BY-P, Hayes 1989, 1995), אילוץ מסומננות המעניק מורה לעיצור בעמדת הקודה, ו- DEPμ, אילוץ נאמנות האוסר הוספת מורות. בהינתן הסטטוס התחילי של מסומננות » נאמנות, האילוץ W-BY-P מדורג מעל האילוץ DEPμ, דירוג המניב מצב תחילי של קודות מוראיות. מצב תחילי זה צפוי לבוא לידי ביטוי בדקדוק של ילדים ללא קשר לסטטוס המוראי של קודות בשפת האם שלהם.

מחקר זה בוחן את הסטטוס המוראי של קודות בנתונים המבוססים על קורפוס שבנוי מדיבורם הטבעי של שני ילדים רוכשי עברית בשלבים הראשונים של התפתחותם הפונולוגית. ממצאי המחקר מראים ניגוד משמעותי בין התפתחות של מילים המסתיימות בתנועה לעומת מילים המסתיימות בעיצור (קודה) בהפקותיהם המוקדמות של הילדים. אני מייחסת ניגוד זה למשקל השונה בין סוגי המילים, הנובע מהיותן של קודות מוראיות. ניגוד זה נמצא בשני היבטים פרוזודיים: המילה המינימלית והתפתחות הטעם.

ביחס למילה המינימלית, נמצא כי הפקות שהסתיימו בעיצור הופקו כ-חד הברתיות (CVC), בעוד שהפקות שהסתיימו בתנועה הופקו כ-דו הברתיות ((C)VCV), ללא תלות במבנה של מילת היעד. ממצאים אלה מעידים על קודות מוראיות, מאחר ותחת ניתוח מוראי, הן הפקות מסוג CVC והן הפקות מסוג (C)VCV מספקות את אילוץ המילה המינימלית (McCarthy and Prince 1986), הידוע כאילוץ פעיל בתהליך רכישה שפה (Demuth and Fee 1995). ביחס להתפתחות הטעם, וביחס להפקות דו-הברתיות, נמצא כי הפקות שהסתיימו בעיצור היו נאמנות יותר לטעם סופי (CVCV́C) מאשר הפקות שהסתיימו בתנועה, בהן הזחת טעם הייתה נפוצה (CV́CV). תחת ניתוח מוראי, נאמנותן של הפקות המסתיימות בעיצור לטעם סופי למעשה צפויה, מאחר ואלה יוצרות את הרגל היאמבית הפחות מסומננת (uneven iamb), לעומת הפקות המסתיימות בתנועה, אשר כשמופקות עם טעם סופי, יוצרות את המבנה היאמבי היותר מסומנן (even iamb) (Hayes 1995).

ממחקר זה עולה כי בשלבים המוקדמים של רכישת עברית, עיצור בעמדת הקודה לא רק מרחיב את מבנה ההברה בהפקותיהם של הילדים, אלא משמש גם כיחידה הנושאת משקל (מורה). בחינה של הלקסיקון, כמו גם קלט הילדים ומילות המטרה שלהם, מראה כי ממצאי המחקר לא נובעים מהקלט, מאחר וקלט זה אינו מעניק עדויות לקודות מוראיות בעברית. ממצאים אלה תומכים, אם כך, בגישה *הרכישה הבלתי-תלויה בניסיון*, ומעניקים עדות נוספת לתפקידם של עקרונות אוניברסלים בתהליך הרכישה.

ממצאי מחקר זה מנותחים במסגרת תיאוריית האופטימליות (Prince and Smolensky 1993), ומבוססים על הנחת המצב התחילי של מסומננות » נאמנות (Tesar and Smolensky 2000). הניתוח מראה את המעבר ההדרגתי של דקדוק הילדים ממערכת שרגישה לכובד, למערכת הנאמנה יותר ויותר לדפוסים הפונולוגיים של עברית. המעבר ההדרגתי מראה את ההשפעה של עקרונות אוניברסלים במהלך השלבים המוקדמים של רכישה, ואת השפעת העקרונות הספציפיים-לשפה בשלבים מאוחרים יותר של הרכישה.

אוניברסיטת תל-אביב TEL AVIV UNIVERSITY

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בית הספר לפילוסופיה, בלשנות ולימודי מדע
החוג לבלשנות

THE MARKEDNESS OVER FAITHFULNESS BIAS:
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חיבור זה מוגש כעבודת גמר לקראת התואר
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על ידי:
דניאלה יריב

העבודה הוכנה בהנחיית:
פרופ' אותי בת-אל פוקס

פברואר 2021